READINESS CERTIFICATION PRIOR TO FINAL JOBSITE OBSERVATION

To prevent the final job observation from occurring too early, we require that the Contractor review the completion status of the project and, by copy of this document, certify that the job is indeed ready for the final job observation. The following is a typical list of items that represent the degree of job completeness expected prior to your requesting a final job observation.

1. Penetrations fire sealed and labeled in accordance with specifications.
2. All air handling units operating and balanced.
3. All fans shall be operating and balanced.
4. All pumps, boilers and chillers operating and balanced.
5. All miscellaneous mechanical systems (unit heaters, fan coil units, cabinet heaters, etc.) operating.
6. All temperature control systems operating, programmed and calibrated.
7. Pipe insulation complete, pipes labeled and valves tagged.
8. Fire damper and fire/smoke damper access doors labeled in accordance with specifications.

Accepted by:

Prime Contractor _____

By _____ Date _____

Upon Contractor certification that the project is complete and ready for a final job observation, we require the Contractor to sign this agreement and return it to the Architect/Engineer so that the final observation can be scheduled.

It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineers for additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

END OF SECTION

SECTION 23 05 03 - THROUGH PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Through-Penetration Firestopping.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this Section.

B. Installer: Individuals performing work shall be certified by the manufacturer of the system selected for installation.

1.3 REFERENCES

A. UL 263 - Fire Tests of Building Construction and Materials

B. UL 723 - Surface Burning Characteristics of Building Materials

C. ANSI/UL 1479 - Fire Tests of Through Penetration Firestops

D. UL 2079 - Tests for Fire Resistance of Building Joint Systems

E. UL Fire Resistance Directory Through Penetration Firestop Systems (XHEZ)

F. Intertek / Warnock Hersey - Directory of Listed Products

G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials

H. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Firestops

I. The Building Officials and Code Administrators National Building Code

J. NFPA 5000 - Building Construction Safety Code

K. CBC California Building Code

1.4 SUBMITTALS

A. Submit under provisions of Section 23 05 00 .

B. Submit Firestopping Installers Certification for all installers on the project.

C. Shop Drawings: Submit for each condition requiring firestopping. Include descriptions of the specific penetrating item, actual wall/floor construction, manufacturer's installation instructions, and UL or Intertek / Warnock Hersey Assembly number.

D. Through-Penetration Firestop System Schedule: Indicate locations of each through-penetration firestop system, along with the following information:

1. Types of penetrating items.
2. Types of constructions penetrated, including fire-resistance ratings and, where applicable, thicknesses of construction penetrated.
3. Through-penetration firestop systems for each location identified by firestop design designation of qualified testing and inspecting agency.
4. F ratings for each firestop system.

E. Maintain a notebook on the job site at all times that contains copies of approved submittals for all through penetration firestopping to be installed. Notebook shall be made available to the Authority Having Jurisdiction at their request and turned over to the Owner at the end of construction as part of the O&M Manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store, protect and handle products on site. Accept material on site in factory containers and packing. Inspect for damage. Protect from deterioration or damage due to moisture, temperature changes, contaminants, or other causes. Follow manufacturer's instructions for storage.

B. Install material prior to expiration of product shelf life.

1.6 PERFORMANCE REQUIREMENTS

A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

1. Fire-resistance-rated walls including fire partitions, fire barriers, and smoke barriers.
2. Fire-resistance-rated horizontal assemblies including floors, floor/ceiling assemblies, and ceiling membranes of roof/ceiling assemblies.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per UL 1479:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.

2. L-Rated Systems: Provide through-penetration firestop systems with L-ratings of not more than 5.0 cfm/sq. ft at both ambient temperature and 400°F for smoke barriers.

C. For through-penetration firestop systems exposed to light, traffic, moisture, or physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

E. For through-penetration firestop systems in air plenums, provide products with flame-spread and smoke-developed indexes of less than 25 and 50, respectively, as determined per ASTM E 84.

1. Adhesives and Sealants: All sealers, adhesives, and sealants shall comply with the low emitting material limits of the following standards:CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions VOC from Indoor Sources Using Environmental Chambers Version 1.1.
2. South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications. All adhesives and sealants wet-applied on site shall comply with the applicable chemical content requirements of SCAQMD Rule 1168.
3. South Coast Air Quality Management District Rule SCAQMD 1113 - Wet Applied Paints and Coatings. All paints and coatings wet-applied on site must meet the applicable VOC limits of SCAQMD Rule 1113.

1.7 MEETINGS

A. Pre-installation meeting: A pre-installation meeting shall be scheduled and shall include the General Contractor and all Subcontractors associated with the installation of systems penetrating fire barriers, Firestopping Manufacturer's Representative, and the Owner.

1. Review foreseeable methods related to firestopping work.
2. Tour representative areas where firestopping is to be installed; inspect and discuss each type of condition and each type of substrate that will be encountered, and preparation to be performed by other trades.

1.8 WARRANTY

A. Provide one year warranty on parts and labor.

B. Warranty shall cover repair or replacement of firestop systems which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability, or appear to deteriorate in any manner not clearly specified by the manufacturer as an inherent quality of the material.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the through-penetration firestop systems indicated for each application that are produced by one of the following manufacturers. All firestopping systems installed shall be provided by a single manufacturer.

1. 3M; Fire Protection Products Division.
2. Hilti, Inc.
3. Dow Corning Corp.

2.2 THROUGH PENETRATION FIRESTOP SYSTEMS

A. Provide materials and systems classified by or listed by Intertek / Warnock Hersey to provide firestopping equal to time rating of construction being penetrated.

B. All firestopping materials shall be free of asbestos, lead, PCB's, and other materials that would require hazardous waste removal.

C. Firestopping shall be flexible to allow for normal penetrating item movement due to expansion and contraction.

D. Firestopping systems for plumbing and wet pipe sprinkler piping shall be moisture resistant.

E. Provide firestopping systems capable of supporting floor loads where systems are exposed to possible floor loading or traffic.

F. Provide firestopping systems allowing continuous insulation for all insulated pipes.

G. Provide firestopping systems classified by UL or listed by Intertek / Warnock Hersey for penetrations through all fire rated construction. Firestopping systems shall be selected from the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory Category XHEZ based on substrate construction and penetrating item size and material and shall fall within the range of numbers listed:

1. Combustible Framed Floors and Chase Walls - 1 or 2 Hour Rated:

a. F Rating = Floor/Wall Rating
b. L Rating = Penetrations in Smoke Barriers

| Penetrating Item | UL System No. |
|---|---|
| No Penetrating Item | FC 0000-0999* |
| Metallic Pipe or Conduit | FC 1000-1999 |
| Non-Metallic Pipe or Conduit | FC 2000-2999 |
| Electrical Cables | FC 3000-3999 |
| Cable Trays | FC 4000-4999 |
| Insulated Pipes | FC 5000-5999 |

| Penetrating Item | UL System No. |
|---|---|
| Bus Duct and Misc. Electrical | FC 6000-6999 |
| Duct without Damper and Misc. Mechanical | FC 7000-7999 |
| Multiple Penetrations | FC 8000-8999 |

*Alternate method of firestopping is patching opening to match original rated construction.

2. Non-Combustible Framed Walls - 1 or 2 Hour Rated:

   a. F Rating = Wall Rating
   b. L Rating = Penetrations in Smoke Barriers

| Penetrating Item | UL System No. |
|---|---|
| No Penetrating Item | WL 0000-0999* |
| Metallic Pipe or Conduit | WL 1000-1999 |
| Non-Metallic Pipe or Conduit | WL 2000-2999 |
| Electrical Cables | WL 3000-3999 |
| Cable Trays | WL 4000-4999 |
| Insulated Pipes | WL 5000-5999 |
| Bus Duct and Misc. Electrical | WL 6000-6999 |
| Duct without Damper and Misc. Mechanical | WL 7000-7999 |
| Multiple Penetrations | WL 8000-8999 |

*Alternate method of firestopping is patching opening to match original rated construction.

3. Concrete or Masonry Floors and Walls - 1 or 2 Hour Rated:

   a. F Rating = Wall/Floor Rating
   b. L Rating = Penetrations in Smoke Barriers

| Penetrating Item | UL System No. |
|---|---|
| No Penetrating Item | CAJ 0000-0999* |
| Metallic Pipe or Conduit | CAJ 1000-1999 |
| Non-Metallic Pipe or Conduit | CAJ 2000-2999 |
| Electrical Cables | CAJ 3000-3999 |
| Cable Trays | CAJ 4000-4999 |
| Insulated Pipes | CAJ 5000-5999 |
| Bus Duct and Misc. Electrical | CAJ 6000-6999 |
| Duct without Damper and Misc. Mechanical | CAJ 7000-7999 |
| Multiple Penetrations | CAJ 8000-8999 |

*Alternate method of firestopping is patching opening to match original rated construction.

H. Any opening in walls or floors not covered by the listed series of numbers shall be coordinated with the firestopping manufacturer.

I. Any openings in floors or walls not described in the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory, or outlined in manufacturer's information shall be sealed in a manner agreed upon by the Firestopping Manufacturer, Owner, and the Authority Having Jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Ensure all surfaces that contact seal materials are free of dirt, dust, grease, oil, rust, or loose materials. Clean and repair surfaces as required. Remove laitance and form-release agents from concrete.

B. Ensure substrate and penetrating items have been permanently installed prior to installing firestopping systems. Ensure penetrating items have been properly spaced and have proper clearance prior to installing firestopping systems.

C. Surfaces to which sealing materials are to be installed must meet the selected UL or Intertek / Warnock Hersey system substrate criteria.

D. Prime substrates where recommended in writing by through-penetration firestop system manufacturer. Confine primer to area of bond.

3.2 INSTALLATION

A. In existing construction, provide firestopping of openings prior to and after installation of penetrating items. Remove any existing coatings on surfaces prior to firestopping installation. Temporary firestopping shall consist of packing openings with fire resistant mineral wool for the full thickness of substrate, or an alternate method approved by the Authority Having Jurisdiction. All openings shall be temporarily firestopped immediately upon their installation and shall remain so until the permanent UL or listed by Intertek / Warnock Hersey listed firestopping system is installed.

B. Install penetration seal materials in accordance with printed instructions of the UL or Intertek / Warnock Hersey Fire Resistance Directory and with the manufacturer's printed application instructions.

C. Install dams as required to properly contain firestopping materials within openings and as required to achieve required fire resistance rating. Remove combustible damming after appropriate curing.

3.3 CLEANING AND PROTECTING

A. Clean excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not cause damage.

B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

3.4 IDENTIFICATION

A. Provide and install labels adjacent to each firestopping location. Label shall be provided by the firestop system supplier and contain the following information in a contrasting color:

1. The words "Warning - Through Penetration Firestop System - Do Not Disturb. Notify Building Management of Any Damage."
2. Firestop System Supplier; UL or listed by Intertek / Warnock Hersey system number; date installed; contractor name and phone number; manufacturer's representative name, address, and phone number.

3.5 INSPECTION

A. All penetrations shall be inspected by the manufacturer's representative to ensure proper installation.

B. Access to firestop systems shall be maintained for examination by the Authority Having Jurisdiction at their request.

C. Proceed with enclosing through-penetration firestop system with other construction only after inspection reports are issued and firestop installations comply with requirements.

D. The contractor shall allow for visual destructive review of 5% of installed firestop systems (minimum of one) to prove compliance with specifications and manufacturer's instructions and details. Destructive system removal shall be performed by the contractor and witnessed by the Architect/Engineer and manufacturer's factory representative. The Architect/Engineer shall have sole discretion of which firestop system installations will be reviewed. The contractor is responsible for all costs associated with this requirement including labor and material for removing and replacing the installed firestop system. If any firestop system is found to not be installed per manufacturer's specific instructions and details, all firestop systems are subject to destructive review and replacement at the Architect/Engineer's discretion and the contractor's expense.

END OF SECTION

SECTION 23 05 13 - MOTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Phase and Three Phase Electric Motors.

1.2 REFERENCES

A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

D. ANSI/IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators.

E. ANSI/NEMA MG 1 - Motors and Generators.

F. ANSI/NFPA 70 - National Electrical Code.

G. Energy Independence and Security Act of 2007.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00. Include nominal efficiency and power factor for all premium efficiency motors. Efficiencies must meet or exceed the nominal energy efficiency levels presented below.

B. Submit shop drawings for all three phase motors.

C. Submit motor data with equipment when motor is installed by the manufacturer at the factory.

D. Submit shaft grounding rings or brushes or ceramic bearings for all motors as required.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof coverings. For extended outdoor storage, follow manufacturer's recommendations for equipment and motor.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data including assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in the manufacture of commercial and industrial motors and accessories, with a minimum of three years documented manufacturing experience.

PART 2 - PRODUCTS

2.1 MOTORS - GENERAL CONSTRUCTION AND REQUIREMENTS

A. Refer to the drawings for required electrical characteristics. Voltage is generally specified and scheduled as distribution voltage. Motor submittals may be based on utilization voltage if it corresponds to the correct distribution voltage.

| Distribution/Nominal Voltage | Utilization Voltage |
|---|---|
| 120 | 115 |
| 208 | 200 |
| 240 | 230 |
| 277 | 265 |
| 480 | 460 |

B. Design motors for continuous operation in 40ºC environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

C. Visible Nameplate: Indicating horsepower, voltage, phase, hertz, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, insulation class.

D. Electrical Connection: Boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

E. Unless otherwise indicated, motors 3/4 HP and smaller shall be single phase, 60 hertz, open drip-proof or totally enclosed fan-cooled type.

F. Unless otherwise indicated, motors 1 HP and larger shall be three phase, 60 hertz, squirrel cage type, NEMA Design Code B (low current in-rush, normal starting torque), open drip-proof or totally enclosed fan-cooled type.

G. Each contractor shall set all motors furnished by him.

H. All motors shall have a minimum service factor of 1.15.

I. All motors shall have ball or roller bearings with a minimum L-10 fatigue life of 150,000 hours in direct-coupled applications and 50,000 hours for belted applications. Belted rating shall be based on radial loads and pulley sizes called out in NEMA MG1-14.43.

J. Bearings shall be sealed type for 10 HP and smaller motors. Bearings shall be regreasable type for larger motors.

K. Aluminum end housings are not permitted on motors 15 HP or larger.

L. Motor Driven Equipment:

1. No equipment shall be selected or operate above 90% of its motor nameplate rating. Motor size may not be increased to compensate for equipment with efficiency lower than that specified.
2. If a larger motor than specified is required on equipment, the contractor supplying the equipment is responsible for all additional costs due to larger starters, wiring, etc.

M. Provide all belted motors with a means of moving and securing the motor to tighten belts. Motors over 2 HP shall have screw type tension adjustment. Motors over 40 HP shall have dual screw adjusters. Slide bases shall conform to NEMA standards.

N. Motors for fans and pumps 1/12 HP or greater and less than 1 HP shall be electronically-commutated motors or shall have a minimum motor efficiency of 70% when rated in accordance with DOE 10 CFR 431. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of varying motor speed.

2.2 ELECTRICALLY COMMUTATED MOTORS (ECM)

A. Motor shall be variable speed, constant torque, brushless DC motor for direct-drive applications. Electronics shall be encapsulated for moisture protection and shall integral surge protection. Motor shall be pre-wired for specific voltage and phase.

B. Motor frame shall be NEMA 48; UL recognized components shall be provided for the motor construction.

C. All EC motors shall be a minimum of 85% efficient at all speeds.

D. Motors shall be permanently lubricated; utilize ball bearings to match with the connected driven equipment.

E. Provide motor with on-board motor control module. Motor speed shall be limited to provide electronic over current protection. Starter shall provide soft start to reduce inrush current and shall be controllable from 20% to 100% of full rated speed.

F. Operational mode shall be as scheduled and shall be one of the following:

1. Constant Flow
2. Constant Temperature
3. Constant Pressure

2.3 PREMIUM EFFICIENCY MOTORS (INCLUDING MOST 3-PHASE GENERAL PURPOSE MOTORS)

A. All motors, unless exempted by EPAct legislation that became federal law on December 19, 2010, shall comply with the efficiencies listed in that standard, which are reprinted below. These match the 2010 NEMA premium efficiency ratings. All ratings listed are nominal full load efficiencies, verified in accordance with IEEE Standard 112, Test Method B. Average expected (not guaranteed minimum) power factors shall also be at least the following:

| | Full-Load Efficiencies % | | | | | |
|---|---|---|---|---|---|---|
| | Open Drip-Proof | | | Totally Enclosed Fan Cooled | | |
| HP | 1200 rpm | 1800 rpm | 3600 rpm | 1200 rpm | 1800 rpm | 3600 rpm |
| 1.0 | 82.5 | 85.5 | 77.0 | 82.5 | 85.5 | 77.0 |
| 1.5 | 86.5 | 86.5 | 84.0 | 87.5 | 86.5 | 84.0 |
| 2.0 | 87.5 | 86.5 | 85.5 | 88.5 | 86.5 | 85.5 |
| 3.0 | 88.5 | 89.5 | 85.5 | 89.5 | 89.5 | 86.5 |
| 5.0 | 89.5 | 89.5 | 86.5 | 89.5 | 89.5 | 88.5 |
| 7.5 | 90.2 | 91.0 | 88.5 | 91.0 | 91.7 | 89.5 |
| 10.0 | 91.7 | 91.7 | 89.5 | 91.0 | 91.7 | 90.2 |
| 15.0 | 91.7 | 93.0 | 90.2 | 91.7 | 92.4 | 91.0 |
| 20.0 | 92.4 | 93.0 | 91.0 | 91.7 | 93.0 | 91.0 |
| 25.0 | 93.0 | 93.6 | 91.7 | 93.0 | 93.6 | 91.7 |

B. Motor nameplate shall be noted with the above ratings.

2.4 MOTORS ON VARIABLE FREQUENCY DRIVES

A. All motors driven by VFDs shall be premium efficiency type.

B. Motors shall be designed for use with VFDs in variable torque applications with 1.15 service factor. Motors shall not be equipped with auxiliary blowers.

C. Motors driven by VFDs shall have Class F or H insulation and be designated by the motor manufacturer to be suitable for inverter duty service in accordance with NEMA MG 1 Section IV, "Performance Standards Applying to All Machines," Part 31 "Definite-Purpose Inverter-Fed Polyphase Motors.

D. All 480 volt motors driven by VFDs shall be provided with shaft grounding rings or grounding brushes or ceramic bearings as a means to protect bearings from adverse shaft currents.

1. Providing grounding rings internal to the motor housing is an acceptable solution, provided the motor is affixed with a label clearly indicating the presence of a grounding assembly. The grounding ring shall be listed for 40,000 hours of motor service and shall be accessible via the drive endplate.

2. Motor shafts 2" and larger require shaft grounding on the drive end and the non-drive end. This Contractor shall ensure (via field observation and measurement) that the shaft is effectively grounded upon startup.

2.5 MOTORS FOR WET OR CORROSIVE DUTY

A. Where noted for wet and/or corrosive duty, motors shall be designed for severe duty with cast-iron frame, epoxy finish, stainless steel nameplate, polymer shaft seal, corrosion resistant fasteners and fan, moisture resistant windings, and non-wicking leads.

2.6 SHEAVES

A. All sheaves shall conform to NEMA Standard MG1-14.42, which lists minimum diameters and maximum overhangs. Locate motors to minimize overhang.

B. When replacing sheaves, use sheaves of at least the originally supplied sizes.

C. Contractor responsible for motor shall also be responsible for replacement sheaves. Coordinate with testing and balancing of the equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

B. For flexible coupled drive motors, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Align shafts to manufacturer's requirements or within 0.002 inch per inch diameter of coupling hub.

C. For belt drive motors, mount sheaves on the appropriate shafts per manufacturer's instructions. Use a straight edge to check alignment of the sheaves. Reposition sheaves as necessary so the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so the belt(s) can be added, and tighten the base so the belt tension is in accordance with the drive manufacturer's recommendations. Frequently check belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

END OF SECTION

SECTION 23 05 29 - HVAC SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers, Supports, and Associated Anchors.

B. Equipment Bases and Supports.

C. Sleeves and Seals.

D. Flashing and Sealing of Equipment and Pipe Stacks.

E. Cutting of Openings.

F. Escutcheon Plates and Trim.

1.2 REFERENCES

A. ANSI/ASME B31.1 - Power Piping.

B. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

C. MSS SP 69 - Pipe Hangers and Supports - Selection and Application.

D. MSS SP 89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

E. MSS SP-127 - Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, Application

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00. Include plastic pipe manufacturers' support spacing requirements.

1.4 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves and hanger inserts to General Contractor for placement into formwork.

PART 2 - PRODUCTS

2.1 HANGER RODS

A. Hanger rods for single rod hangers shall conform to the following:

| | Hanger Rod Diameter | |
|---|---|---|
| Pipe Size | Column #1 | Column #2 |
| 2-1/2" and smaller | 3/8" | 3/8" |
| 3" through 3-5/8" | 3/8" | 3/8" |
| 4" and 5" | 1/2" | 1/2" |
| 6" | 3/4" | 5/8" |

Column #1: Steel pipe.
Column #2: Copper, plastic and fiberglass reinforced pipe.

B. Rods for double rod hangers may be reduced one size. Minimum rod diameter is 3/8 inches.

C. Hanger rods and accessories used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

D. All hanger rods, nuts, washers, clevises, etc., in damp areas shall have ASTM A123 hot-dip galvanized finish applied after fabrication. This applies to the following areas:

1. Animal occupied areas.

2.2 PIPE AND STRUCTURAL SUPPORTS

A. General:

1. Pipe hangers, clamps, and supports shall conform to Manufacturers Standardization Society MSS SP-58, 69, 89, and 127 (where applicable).
2. On all insulated piping, provide at each support an insert of same thickness and contour as adjoining insulation, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. Refer to insulation specifications for materials and additional information.

B. Vertical Supports:

1. Support and laterally brace vertical pipes at every floor level in multi-story structures, unless otherwise noted by applicable codes, but never at intervals over 15 feet. Support vertical pipes with riser clamps installed below hubs, couplings, or lugs. Provide sufficient flexibility to accommodate expansion and contraction to avoid compromising fire barrier penetrations or stressing piping at fixed takeoff locations.

a. Products:

1) Eaton Fig B3373 Series
2) nVent 510 Series

3) Anvil Fig. 90

2. Cold Pipe: Place restrained neoprene mounts beneath vertical pipe riser clamps to prevent sweating of cold pipes. Select neoprene mounts based on the weight of the pipe to be supported. Insulate over mounts.

   a. Products:

      1) Mason RBA, RCA or RDA
      2) Mason BR

3. Wall supports shall be used where vertical height of structure exceeds minimum spacing requirements. Install wall supports at same spacing as hangers or strut supports along vertical length of pipe runs. Wall supports shall be coordinated with the Structural Engineer.
4. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

C. Hangers and Clamps:

1. Oversize all hangers, clamps, and supports on insulated piping to allow insulation and jacket to pass through unbroken. This applies to both hot and cold pipes.
2. Hangers in direct contact with bare copper pipe shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, nVent Cushion Clamp or Eaton Vibra-Clamp within their temperature limits of -65°F to +275°F.
3. On all insulated piping, provide a semi-cylindrical metallic shield and vapor barrier jacket.

4. Unless otherwise indicated, hangers shall be as follows:

   a. Clevis Type: Service: Bare Metal Pipe, Rigid Plastic Pipe, Insulated Cold Pipe, Insulated Hot Pipe - 3 inches and Smaller:

      1) Products: Bare Steel, Plastic or Insulated Pipe:

         a) Anvil Fig. 260
         b) Eaton Fig. 3100
         c) nVent Model 400

      2) Products: Bare Copper Pipe:

         a) Eaton Fig. B3104F or B3100CTC
         b) Anvil Fig. CT65
         c) nVent Fig. 402

   b. Adjustable Swivel Ring Type: Service: Bare Metal Pipe - 4 inches and Smaller:

1) Products: Bare Steel Pipe:

a) Anvil Fig. 69
b) Eaton Fig. B3170NF
c) nVent Model FCN

2) Products: Bare Copper Pipe:

a) Eaton Fig. B3170CTC
b) nVent 102A0 Series
c) Anvil Fig. CT-69

5. Support may be fabricated from U-channel strut or similar shapes. Piping less than 4" in diameter shall be secured to strut with clamps of proper design and capacity as required to maintain spacing and alignment. Strut shall be independently supported from hanger drops or building structure. Size and support shall be per manufacturer's installation requirements for structural support of piping. Clamps shall not interrupt piping insulation.

a. Strut used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.
b. Strut used in damp areas listed in hanger rods shall have ASTM A123 hot-dip galvanized finish applied after fabrication.

6. Unless otherwise indicated, pipe supports for use with struts shall be as follows:

a. Clamp Type: Service: Bare Metal Pipe, Rigid Plastic Pipe, Insulated Cold Pipe, Insulated Hot Pipe - 3 inches and smaller:

1) Clamps in direct contact with copper pipe shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, nVent Cushion Clamp or Eaton Vibra-Clamp.
2) Pipes subject to expansion and contraction shall have clamps oversized to allow limited pipe movement.
3) Products: Bare Steel, Plastic or Insulated Pipe:

a) Unistrut Fig. P1100 or P2500
b) Eaton Fig. B2000 or B2400
c) Anvil Fig. AS1200

4) Products: Bare Copper Pipe:

a) Eaton Fig. BVT
b) nVent CADDY Cushion Clamp

D. Upper (Structural) Attachments:

1. Unless otherwise shown, upper attachments for hanger rods or support struts shall be as follows:

a. Steel Structure Clamps: C-Type Wide Flange Beam Clamps (for use on top and/or bottom of wide flanges. Not permitted for use with bar-joists.):

1) Products:

a) Anvil Fig. 86
b) Eaton Fig. B3033/B3034

b. Concentrically Loaded Open Web Joist Hangers (for use with bar joists):

1) Products:

a) MCL. M1, M2 or M3

c. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

d. Steel Structure Welding:

1) Unless otherwise noted, hangers, clips, and auxiliary support steel may be welded in lieu of bolting, clamping, or riveting to the building structural frame. Take adequate precautions during all welding operations for fire prevention and protecting walls and ceilings from smoke damage.

e. Wood Anchors: Tension wood rod hanger for suspending 3/8" threaded rod. Zinc plated carbon steel.

1) Minimum allowable tension loads for Douglass Fir/Southern Pine:

a) 3/8" diameter rod; 2-1/2" shank: 600 lb/590 lb.
b) Load values are based on full shank penetration into wood member. Minimum edge distance 3/4". Minimum end distance 3-1/4".

2) Limitations:

a) Truss: Do not hang from wood trusses without truss manufacturer or Structural Engineer’s approval.
b) Sheetrock/Gypsum Ceiling: When drilling through non-wood materials (e.g., sheet rock, gypsum, etc.), increase shank length by depth of non-wood materials.
c) Plywood Flooring/Roofing: Do not hang from plywood floor or roofing.
d) Spacing: Refer to wood structure spacing of hangers.

3) Products:

a) Simpson RWV

b) DeWALT
c) ITI Sammys GT25

2.3 FOUNDATIONS, BASES, AND SUPPORTS

A. Basic Requirements:

1. Furnish and install foundations, bases, and supports (not specifically indicated on the Drawings or in the Specifications of either the General Construction or Mechanical work as provided by another Contractor) for mechanical equipment.
2. All concrete foundations, bases and supports, shall be reinforced. All steel bases and supports shall receive a prime coat of zinc chromate or red metal primer. After completion of work, give steel supports a final coat of gray enamel.

B. Concrete Bases (Housekeeping Pads):

1. Unless shown otherwise on the drawings, concrete bases shall be nominal 4 inches thick and shall extend 3 inches on all sides of the equipment (6 inches larger than factory base), except where pad extension would interfere with working space at equipment control panels and electrical panels.
2. Where a base is less than 12 inches from a wall, extend the base to the wall to prevent a "dirt-trap".
3. Concrete materials and workmanship required for the Contractor's work shall be provided by the Contractor. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6"x6", W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at 28 days (be 20 MPa strength).
4. Equipment requiring bases is as follows:

   a. Air Handling Unit
   b. Fans

C. Supports:

1. Provide sufficient clips, inserts, hangers, racks, rods, and auxiliary steel to securely support all suspended material, equipment and conduit without sag.
2. Hang heavy equipment from concrete floors or ceilings with Architect/Engineer-approved concrete inserts, furnished and installed by the Contractor whose work requires them, except where indicated otherwise.

D. Grout:

1. Grout shall be non-shrinking premixed (Master Builders Company "Embecco"), unless otherwise indicated on the drawings or approved by the Architect/Engineer.
2. Use Mix No. 1 for clearances of 1" or less, and Mix No. 2 for all larger clearances.
3. Grout under equipment bases, around pipes, at pipe sleeves, etc., and where shown on the drawings.

2.4 OPENINGS IN FLOORS, WALLS AND CEILINGS

A. Exact locations of all openings for the installation of materials shall be determined by the Contractor and given to the General Contractor for installation or construction as the structure is built.

B. Coordinate all openings with other Contractors.

C. Hire the proper tradesman and furnish all labor, material and equipment to cut openings in or through existing structures, or openings in new structures that were not installed, or additional openings. Repair all spalling and damage to the satisfaction of the Architect/Engineer. Make saw cuts before breaking out concrete to ensure even and uniform opening edges.

D. Said cutting shall be at the complete expense of each Contractor. Failure to coordinate openings with other Contractors shall not exempt the Contractor from providing openings at Contractor's expense.

E. Do not cut structural members without written approval of the Architect or Structural Engineer.

F. Exposed Housing Penetrations: Seal pipes with surface temperature below 150°F, penetrating housings with conical stepped, white silicone, EPDM or neoprene pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots or Pipetite.

2.5 ROOF PENETRATIONS

A. Roof Curb Enclosure: Provide weatherproof roof curb and enclosure for pipe and duct penetrations. Refer to drawings for details.

B. Conical Pipe Boot: Seal pipes with surface temperature below 150°F penetrating single-ply roofs with conical stepped, UV-resistant silicone, EPDM or neoprene pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots or Pipetite. Color: White shall match roofing material.

C. Break insulation only at the clamp for pipes between 60°F and 150°F. Seal outdoor insulation edges watertight.

2.6 SLEEVES AND LINTELS

A. Each Contractor shall provide sleeves and lintels for all duct and pipe openings required for the Contractor's work in masonry walls and floors, unless specifically shown as being by others.

B. Fabricate all sleeves from standard weight black steel pipe or as indicated on the drawings. Provide continuous sleeve. Cut or split sleeves are not acceptable.

C. Fabricate all lintels for masonry walls from structural steel shapes or as indicated on the drawings. Have all lintels approved by the Architect or Structural Engineer.

D. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.

E. Sleeves shall not penetrate structural members or masonry walls without approval from the Structural Engineer. Sleeves shall then comply with the Architect/Engineer's design.

F. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

G. Install all sleeves concentric with pipes. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.

H. Where pipes rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (e.g., foam, rubber, asphalt-coated fiber, bituminous-impregnated felt, or cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

I. Size sleeves large enough to allow expansion and contraction movement. Provide continuous insulation wrapping.

J. Wall Seals ("Link-Seals"):

1. Where shown on the drawings, pipes passing through walls, ceilings, or floors shall have their annular space (sleeve or drilled hole - not tapered hole made with knockout plug) sealed by properly sized sealing elements consisting of a synthetic rubber material compounded to resist aging, ozone, sunlight, water and chemical action.
2. Sleeves, if used, shall be standard weight steel with primed finish and waterstop/anchor continuously welded to sleeve. If piping carries only fluids below 120°F, sleeves may be thermoplastic with integral water seal and textured surface.
3. Sleeves shall be at least 2 pipe sizes larger than the pipes.
4. Pressure shall be maintained by stainless steel bolts and other parts. Pressure plates may be of composite material for Models S and OS.
5. Sealing element shall be as follows:

| Model | Service | Element Material | Temperature Range |
|---|---|---|---|
| S | Standard (Stainless) | EPDM | -40°F to 250°F |
| T | High/Low Temperature (Steam) | Silicone | -67°F to 400°F |
| T | Fire Seals (1 hour) | Silicone | -67°F to 400°F |
| FS | Fire Seals (3 hours) | Silicone | -67°F to 400°F |
| OS | Oil Resistant/Stainless | Nitrile | -40°F to 210°F |

6. Manufacturers:

   a. Thunderline Corporation "Link-Seals"
   b. Metraflex Company (cold service only)

2.7 ESCUTCHEON PLATES AND TRIM

A. Fit escutcheons to all insulated or uninsulated exposed pipes passing through walls, floors, or ceilings of finished rooms.

B. Escutcheons shall be heavy gauge, cold rolled steel, copper coated under a chromium plated finish, heavy spring clip, rigid hinge and latch.

C. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms. This includes pipe openings.

2.8 PIPE PENETRATIONS

A. Seal all pipe penetrations. Seal non-rated walls and floor penetrations with grout or caulk. Backing material may be used.

B. Seal fire rated wall and floor penetrations with fire seal system as specified.

2.9 PIPE ANCHORS

A. Provide all items needed to allow adequate expansion and contraction of all piping. All piping shall be supported, guided, aligned, and anchored as required.

B. Repair all piping leaks and associated damage. Pipes shall not rub on any part of the building.

2.10 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.1 HVAC SUPPORTS AND ANCHORS

A. General Installation Requirements:

1. Install all items per manufacturer's instructions.
2. Coordinate the location and method of support of piping systems with all installations under other Divisions and Sections of the Specifications.
3. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

4. Supports shall extend directly to building structure. Do not support piping from duct hangers unless coordinated with sheet metal contractor prior to installation. Do not allow lighting or ceiling supports to be hung from piping supports.

B. Supports Requirements:

1. Where building structural steel is fireproofed, all hangers, clamps, auxiliary steel, etc., which attach to it shall be installed prior to application of fireproofing. Repair all fireproofing damaged during pipe installation.
2. Set all concrete inserts in place before pouring concrete.
3. Furnish, install and prime all auxiliary structural steel for support of piping systems that are not shown on the Drawings as being by others.
4. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.
5. Hangers for horizontal piping shall have adequate means of vertical adjustment for alignment.

C. Pipe Requirements:

1. Support all piping and equipment, including valves, strainers, traps and other specialties and accessories to avoid objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or building structure during erection, cleaning, testing and normal operation of the systems.
2. Do not, however, restrain piping to cause it to snake or buckle between supports or to prevent proper movement due to expansion and contraction.
3. Support piping at equipment and valves so they can be disconnected and removed without further supporting the piping.
4. Piping shall not introduce strains or distortion to connected equipment.
5. Parallel horizontal pipes may be supported on trapeze hangers made of structural shapes and hanger rods; otherwise, pipes shall be supported with individual hangers.
6. Trapeze hangers may be used where ducts interfere with normal pipe hanging.
7. Provide additional supports where pipe changes direction, adjacent to flanged valves and strainers, at equipment connections and heavy fittings.
8. Provide at least one hanger adjacent to each joint in grooved end steel pipe with mechanical couplings.

D. Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs. or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3' spacing between loads.
2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

    a. The hanger is attached within 6" from a web/chord joint.
    b. Additional L2x2x1/4 web reinforcement is installed per manufacturer's requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.
4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Architect/Engineer.

E. After piping and insulation installation are complete, cut hanger rods back at trapeze supports so they do not extend more than 3/4" below bottom face of lowest fastener and blunt any sharp edges.

F. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (limitation not required with concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and architectural items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

G. Do not exceed the manufacturer's recommended maximum load for any hanger or support.

H. Steel/Concrete Structure: Spacing of hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

1. Steel and Fiberglass (Std. Weight or Heavier - Liquid Service):

a. Maximum Spacing:

1) 1-1/4" & under: 7'-0"
2) 1-1/2": 9'-0"
3) 2": 10'-0"
4) 2-1/2": 11'-0"
5) 3": 12'-0"
6) 4" & larger: 12'-0"

2. Steel (Std. Weight or Heavier - Vapor Service):

a. Maximum Spacing:

1) 1/2" and under: 6'-0"
2) 3/4" to 1": 8'-0"
3) 1-1/4" and under: 9'-0"
4) 1-1/2": 10'-0"
5) 2" & larger: 10'-0"

3. Hard Drawn Copper & Brass (Liquid Service):

a. Maximum Spacing:

1) 3/4" and under: 5'-0"
2) 1": 6'-0"
3) 1-1/4": 6'-0"

4) 1-1/2" 6'-0"
5) 2": 8'-0"
6) 2-1/2": 9'-0"
7) 3": 10'-0"
8) 4": 10'-0"
9) 6": 10'-0"

4. Hard Drawn Copper & Brass (Vapor Service):

a. Maximum Spacing:

1) 3/4" & under: 6'-0"
2) 1": 6'-0"
3) 1-1/4": 6'-0"
4) 1-1/2": 6'-0"
5) 2": 10'-0"
6) 2-1/2" & larger: 10'-0"

5. Plastic Pipe:

a. Hangers shall be spaced based on the piping system manufacturer's instructions or, if no system instructions are available, space hangers at 4'-0" maximum centers.

6. Ultra-Flexible Pipe, Flexible Hose, and Soft Copper Tubing:

a. Continuous channel with hangers maximum 8'-0" OC.

l. Wood Structure: Spacing of hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

1. Steel and Fiberglass (Std. Weight or Heavier - Liquid Service):

a. Maximum Spacing:

1) 1-1/4" & under: 7'-0"
2) 1-1/2": 9'-0"
3) 2": 10'-0"
4) 2-1/2": 11'-0"
5) 3": 12'-0"
6) 4" through 6": 12'-0"8": 9'-0"10": 6'-0"12": 4'-0"

2. Steel (Std. Weight or Heavier - Vapor Service):

a. Maximum Spacing:

1) 1/2" and under: 6'-0"
2) 3/4" to 1": 8'-0"
3) 1-1/4" and under: 9'-0"
4) 1-1/2": 10'-0"

5) 2" & larger: 10'-0"
6) 3": 12'-0"
7) 4" through 8": 12'-0"
8) 10": 9'-0"
9) 12": 6'-0"

3. Hard Drawn Copper & Brass (Liquid Service):

a. Maximum Spacing:

1) 3/4" & under: 5'-0"
2) 1": 6'-0"
3) 1-1/4": 6'-0"
4) 1-1/2": 6'-0"
5) 2": 8'-0"
6) 2-1/2": 9'-0"
7) 3": 10'-0"
8) 4": 10'-0"
9) 6": 10'-0"

4. Hard Drawn Copper & Brass (Vapor Service):

a. Maximum Spacing:

1) 3/4" & under: 6'-0"
2) 1": 6'-0"
3) 1-1/4": 6'-0"
4) 1-1/2": 6'-0"
5) 2": 10'-0"
6) 2-1/2" & larger: 10'-0"

5. Plastic Pipe:

a. Hangers shall be spaced based on the piping system manufacturer's instructions or, if no system instructions are available, space hangers at 4'-0" maximum centers.

6. Ultra-Flexible Pipe, Flexible Hose, and Soft Copper Tubing:

a. Continuous channel with hangers maximum 8'-0" OC.

J. Installation of hangers shall conform to MSS SP-58, 69, and 89.

END OF SECTION

SECTION 23 05 48 - HVAC VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Vibration Isolation.

B. Flexible Connectors.

1.2 SUBMITTALS

A. Submit shop drawings per Section 23 05 00 and the Vibration Isolation Submittal Form at the end of this section.

B. Vibration isolation submittals may be included with equipment being isolated, but must comply with this section.

C. Isolator submittals shall include:

1. Equipment served
2. Type of Isolator
3. Load in Pounds per Isolator
4. Recommended Maximum Load for Isolator
5. Spring Constants of Isolators (for Spring Isolators)
6. Load vs. Deflection Curves (for Neoprene Isolators)
7. Specified Deflection
8. Deflection to Solid (at least 150% of calculated deflection)
9. Loaded (Operating) Deflection
10. Free Height
11. Loaded Height
12. Kx/Ky (horizontal to vertical stiffness ratio - for spring isolators)
13. Materials and Coatings
14. Spring Diameters

D. Make separate calculations for each isolator on equipment where the load is not equally distributed.

E. Flexible connector shop drawings shall include overall face-to-face length and all specified properties.

F. Submit calculations by a licensed Structural Engineer substantiating that equipment mountings and foundations, and their seismic restraints, can meet the required external forces "G" load for all rigidly and resiliently supported equipment without failure and permanent displacement. Submit similar calculations for life safety equipment restraints for "G" loading. Restrain all resiliently mounted piping with cable seismic bracing per HCAI series OPM pre-approval.

G. Contractor shall provide seismic bracing calculations stamped by a licensed California Structural Engineer for all suspended utilities.

1. Contractor to submit shop drawings showing the following:

a. All seismic bracing locations and type of restraint being used.
b. Maximum seismic loads shall be indicated on the shop drawings for each brace location.
c. Manufacturer's seismic restraint layout on contractor shop drawings to be stamped by a licensed California Structural Engineer for all suspended utilities.

PART 2 - PRODUCTS

2.1 BASIC CONSTRUCTION AND REQUIREMENT

A. Vibration isolators shall have either known undeflected heights or other markings so deflection under load can be verified.

B. All isolators shall operate in the linear portion of their load versus deflection curve. The linear portion of the deflection curve of all spring isolators shall extend 50% beyond the calculated operating deflection (e.g., 3" for 2" calculated deflection). The point of 50% additional deflection shall not exceed the recommended load rating of the isolator.

C. The lateral to vertical stiffness ratio (Kx/Ky) of spring isolators shall be between 0.8 and 2.0.

D. All neoprene shall have UV resistance sufficient for 20 years of outdoor service.

E. All isolators shall be designed or treated for corrosion resistance. Steel bases shall be cleaned of welding slag and primed for interior use, and hot dip galvanized after fabrication for exterior use. All bolts and washers over 3/8" diameter located outdoors shall be hot dip galvanized per ASTM A153. All other bolts, nuts and washers shall be zinc electroplated. All ferrous portions of isolators, other than springs, for exterior use shall be hot dip galvanized after fabrication. Outdoor springs shall be neoprene dipped or hot dip galvanized. All damage to coatings shall be field repaired with two coats of zinc rich coating.

F. Equip all mountings used with structural steel bases with height-saving brackets. Bottoms of the brackets shall be 1-1/2" to 2-1/2" above the floor or housekeeping pad, unless shown otherwise on the drawings. Steel bases shall have at least four points of support.

G. Provide motor slide rails for belt-driven equipment per Section 23 05 13.

H. All isolators, except M1, shall have provision for leveling.

I. Construction criteria and standards of seismic restraint design for suspended pipes, ducts and mechanical equipment shall be per the International Seismic Application Technology (ISAT) HCAI OPM #0485. (877)999-ISAT or Mason.

2.2 MOUNTINGS

A. Type M4:

1. Use restrained spring mountings for equipment with operating weight different from the installed weight such as chillers and boilers, and equipment exposed to the wind such as cooling towers.
2. Spring isolators shall be free-standing with 1/4" neoprene acoustical friction pads.
3. All units shall have bolt holes and be bolted down. Prevent short circuiting with neoprene bushings and washers between bolts and isolators.
4. All mountings shall have leveling bolts.
5. Housings with vertical resilient limit stops shall prevent spring extension when weight is removed. Housings shall serve as blocking during erection and the installed and operating heights shall be the same.
6. Maintain a minimum clearance of 1/2" around restraining bolts and between the housings and the springs so as not to interfere with the spring action.
7. Limit stops shall be out of contact during normal operation.
8. Select isolators for equipment subjected to wind loads in conformance with ASCE 7-02.
9. Manufacturers:

    a. Mason "SLRS"
    b. Kinetics "FLS"

2.3 HANGERS

A. Type H3:

1. Vibration hangers shall have a steel spring in a neoprene cup with a grommet to prevent short circuiting of the hanger rod.
2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.
3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the grommet and short circuiting the spring.
4. Provide end connections for hanging ductwork or piping.
5. Hangers shall be capable of holding the load at a fixed elevation during installation. They shall have a secondary adjustment to transfer the load to the spring and maintain the same position.
6. Deflection shall be indicated by a pointer and scale.
7. Manufacturer:

    a. Mason "30N"
    b. Kinetics "SFH"
    c. Vibro Acoustics "SHR"

2.4 FLEXIBLE CONNECTORS (NOISE AND VIBRATION ELIMINATORS)

A. Type FC2:

1. Stainless steel flexible connectors with corrugated stainless steel hose body and stainless steel braided casing.
2. Rated for minimum working pressures of 150 psi at 70°F and 100 psi at 800°F .
3. Sizes 2" and under shall have steel threaded connections.
4. Sizes 2-1/2" and over shall have 150 lb. steel flanges.
5. Suitable for 1/2" permanent misalignment.
6. Manufacturers:

    a. Mason or Mercer "BSS-GU"
    b. Metraflex "ML"

2.5 VIBRATION ISOLATION CURBS

A. Spring Isolated Curbs:

1. Provide factory fabricated vibration isolated curb consisting of an upper floating section resting on a rigid rectangular steel tube structure containing adjustable steel vibration isolation springs.
2. Roof Mounting Curb: Curb height as shown on drawings, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.
3. Vibration Isolation:

    a. Isolators shall consist of free standing, unhoused laterally stable steel springs.
    b. Springs shall be zinc electroplated.
    c. Springs shall rest on a minimum of 1/4" neoprene pad.
    d. Springs shall provide a minimum of 1-1/2" deflection calculated based on final assembled loads.

4. Provide continuous wood nailing strip and counter flashing along entire perimeter of the curb.
5. Provide continuous air and water seal, such as an EPDM bellows, around the entire curb.
6. Curb assembly shall withstand 125#/sf lateral wind loading against the supported equipment.
7. Coordinate internal structural cross framing with ductwork and piping routed in the curb.
8. Manufacturers:

    a. Mason Industries, Inc. - Type RSC
    b. ThyCurb - Vibro Curb II
    c. Kinetics - SSR.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Provide vibration isolation as indicated on the drawings and as described herein.

C. Clean the surface below all mountings that are not bolted down and apply adhesive cement equal to Mason Type WG between mounting and floor. If movement occurs, bolt mountings down. Isolate bolts from baseplates with neoprene washers and bushings.

D. All static deflections listed in the drawings and specifications are the minimum acceptable actual deflection of the isolator under the weight of the installed equipment - not the maximum rated deflection of the isolator.

E. Support equipment to be mounted on structural steel frames with isolators under the frames or under brackets welded to the frames. Where frames are not needed, fasten isolators directly to the equipment.

F. Where a specific quantity of hangers is noted in these specifications, it shall mean hanger pairs for support points that require multiple hangers, such as rectangular ducts or pipes supported on a strut rack.

3.2 PIPE ISOLATION

A. Install flexible connectors in all piping connected to vibration producing equipment. This includes all fans, base-mounted pumps, compressors, etc. Absence of flexible connectors on piping diagrams does not imply that they are not required.

B. Use Type FC2 for all other services. FC2 shall be installed parallel with equipment shafts.

C. Provide sufficient piping flexibility for vibrating refrigerant equipment, or furnish flexible connectors with appropriate temperature and pressure ratings.

D. Vibration isolators shall not cause any change in position of piping that will result in stresses in connections or misalignment of shafts or bearings. Equipment and piping shall be maintained in a rigid position during installation. Do not transfer load to the isolators until the installation is complete and under full operational load. Hanger H3 and Mounting M4 may be used instead of other products for this purpose.

E. Support piping to prevent extension of flexible connectors.

3.3 VIBRATION ISOLATION SCHEDULE

A. AHU Fans:

1. Isolator Type: M3 and/or TR1
2. Static Deflection: Refer to ASHRAE Table

3. Flexible Connections: Per Section 23 33 00

B. Packaged HVAC Unit (less than 10 HP):

1. Base Type: NA
2. Isolator Type: M3 or H2 or H3
3. Static Deflection: 0.75"
4. Flexible Connections: Per Section 23 33 00

C. Condensing Unit (Roof Mounted):

1. Base Type: NA
2. Isolator Type: M4
3. Static Deflection: 1.5"
4. Flexible Connections: NA

END OF SECTION

SECTION 23 05 50 - SEISMIC REQUIREMENTS FOR EQUIPMENT AND SUPPORTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Seismic Requirements.

1.2 QUALITY ASSURANCE

A. General:

1. The contractor shall retain a specialty consultant or equipment manufacturer to develop a seismic restraint and support system and perform seismic calculations in accordance with these specifications, state, and local codes.
2. Items used for seismic restraint of equipment and systems shall be specifically manufactured for seismic restraint.
3. These requirements are beyond those listed in Section 23 05 29 of these specifications. Where a conflict arises between the seismic requirements of this section and any other section, the Architect/Engineer shall be immediately notified for direction to proceed.

B. Manufacturer:

1. System Supports/Restraints: Company specializing in the manufacture of products specified in this Section.
2. Equipment: Each company providing equipment that must meet seismic requirements shall provide certification included in project submittals the equipment supplied for the project meets or exceeds the seismic requirements of the project.

C. Testing Agency: An independent testing agency, acceptable to Authorities Having Jurisdiction, with experience and capability to conduct the testing indicated.

D. Installer: Company specializing in performing the work of this Section.

1.3 REFERENCES

A. California Building Code (CBC)

B. ASHRAE - A Practical Guide to Seismic Restraint.

C. ASCE 7-16, Chapter 13.

D. SMACNA - Seismic Restraint Manual Guidelines for Mechanical Systems.

E. NFPA 13 - Installation of Sprinkler Systems.

F. NFPA 14 - Standpipe and Hose Systems.

1.4 SUBMITTALS

A. Submit under provisions of Section 23 05 00.

B. Submittal to Code Official

1. Contractor shall submit copies of the seismic shop drawings to the governing code authority for approval.

C. Shop Drawings:

1. Calculations, restraint selections, and installation details shall be designed and sealed by a Professional Structural Engineer licensed in the state where the project is located experienced in seismic restraint design and installation.
2. Coordination Drawings: Plans and sections drawn to scale, coordinating seismic bracing of mechanical components with other systems and equipment in the vicinity, including other seismic restraints.
3. Manufacturer's Certifications: Professional Structural Engineer licensed in the state where the project is located shall review and approve manufacturer's certifications of compliance.
4. System Supports/Restraints - Submit for each condition requiring seismic bracing:

    a. Calculations for each seismic brace and detail utilized on the project.
    b. Plan drawings showing locations and types of seismic braces on contractor fabrication/installation drawings.
    c. Cross-reference between details and plan drawings to indicate exactly which brace is being installed at each location. Details provided are to clearly indicate attachments to structure, correctly representing the fastening requirements of bracing.
    d. Clear indication of brace design forces and maximum potential component forces at attachment points to building structure for confirmation of acceptability by the Structural Engineer of Record.

5. Equipment - Submit for each piece of equipment supplied:

    a. Certification that the equipment supplied for the project meets or exceeds the seismic requirements specified.
    b. Specific details of seismic design features of equipment and maximum seismic loads imparted to the structural support.
    c. Engineering calculations and details for equipment anchorage and support structure.

D. A seismic restraint designer shall be provided whether or not exceptions listed in the applicable building code are met. If seismic restraints are not provided for a system that requires seismic bracing, the seismic designer shall submit a signed and sealed letter to the Architect/Engineer and Authorities Having Jurisdiction stating the exceptions, along with code reference, utilized for each item. Seismic designer shall review system installation for general conformance to the exception requirements stated in the code and document, in writing, the system has been installed in accordance to the exception.

1.5 TESTING AND INSPECTION

A. Special Inspection and Testing shall be done in accordance with Chapter 17 of the California Building Code.

B. The Owner shall employ a Special Inspection Agency to perform the duties and responsibilities specified in Section 1704 and 1705.

C. Work performed on the premises of a fabricator approved by the building official need not be tested and inspected. The fabricator shall submit a certificate of compliance that the work has been performed in accordance with the approved plans and specifications to the building official and the Architect and Engineer of Record.

D. The Special Inspection Agency shall furnish inspection reports to the building official, the Owner, the Architect, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work. A final signed report stating whether the work requiring special inspection was, to the best of the Special Inspection Agency's knowledge, in conformance with the approved plans and specifications shall be submitted.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site. Accept material on site in factory containers and packing. Inspect for damage. Protect from damage and contamination by maintaining factory packaging until installation. Follow manufacturer's instructions for storage.

1.7 DESIGN REQUIREMENTS

A. This project is subject to the seismic bracing requirements of the California Building Code, 2022 edition.

B. The following criteria are applicable to this project:

1. Seismic Use Group: III
2. Occupancy Category: III
3. Risk Category: IV
4. Seismic Importance Factor: $I_E$ = 1.25Seismic Design Category: D
5. Component Amplification Factors (ap) and Component Response Modification Factors (Rp) shall be taken from Table 1621.3r in CBC 2016 for the individual equipment or system being restrained.

6. Component Importance Factors (Ip) shall be taken from Section 1621.1.6 in CBC 2016 for the individual equipment or system being restrained.
7. The total height of the structure and the height of the system to be restrained within the structure shall be determined in coordination with architectural plans and the General Contractor.

C. Forces shall be calculated with the above requirements and Equation of CBC 2022 unless exempted by 13.1.4.Equipment shall meet California Building Code and ASCE 7 seismic qualification requirements in concurrence with ICC ES AC156 Acceptance Criteria for Seismic Qualification by Shake-Table Testing of Nonstructural Components and Systems.

D. All seismic anchorage and bracing shall comply with FM Global Property Loss Prevention Data Sheet 1-11, Fire Following Earthquakes.

1.8 COORDINATION

A. Coordinate layout and installation of seismic bracing with building structural systems and architectural features, and with mechanical, fire-protection, electrical and other building features in the vicinity.

B. Coordinate concrete bases with building structural system.

1.9 WARRANTY

A. Provide one-year warranty on parts and labor for manufacturer defects and installation workmanship.

PART 2 - PRODUCTS

2.1 SUPPLIERS

A. Following is a partial list of manufacturer/supplier contact information for seismic restraints:

1. B-Line Systems, Inc. (800) 851-7415, www.b-line.com.
2. Unistrut Corporation http://www.unistrut.us/
3. Kinetics Noise Control (877) 457-2695, www.kineticsnoise.com.
4. Mason Industries, Inc. www.mason-ind.com.
5. Loos & Co., Inc. (800) 321-5667, www.loosnaples.com.
6. Tolco (909) 737-5599, www.tolco.com
7. ISAT 877.523.6060, www.isatsb.com
8. Vibro-Acoustics (416) 291-7371 , https://virs.vibro-acoustics.com/

2.2 SEISMIC DESIGN CRITERIA

A. This section describes the requirements for seismic restraint of systems and equipment related to continued operation of the facility after a design seismic event.

B. Definitions

1. Stay in Place:

a. All systems and equipment shall be anchored and restrained such that the anchoring system is intended not to fail and equipment and/or system components will not fall.

2.3 SEISMIC BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS

A. General:

1. Seismic restraint designer shall coordinate all attachments with the Structural Engineer of Record; refer to submittal requirements.
2. The seismic restraint design shall be based on actual equipment data obtained from manufacturer's submittals or the manufacturer. The equipment manufacturer shall verify and provide written certification the attachment points on the equipment can accept the combination of seismic, weight, and other imposed loads.
3. Design analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
4. Analysis shall detail anchoring methods, bolt diameter, embedment, and weld length.
5. All seismic restraint devices shall be designed to accept without failure the forces calculated per the applicable building code.
6. All seismic restraints and combination isolator/restraints shall have verification of their seismic capabilities witnessed by an independent testing agency.

B. Friction from gravity loads shall not be considered resistance to seismic forces.

C. Fire protection systems shall meet the requirements of NFPA-13 and NFPA-14 for the building seismic requirements.

D. Housekeeping Pads:

1. Reinforced housekeeping pads shall be provided to handle shear, tension, and compression forces with proper reinforcement, doweling, and attachments connecting the pad to the structural slab.

2.4 SEISMIC RESTRAINT AND CONSTRUCTION OF EQUIPMENT

A. Equipment supplied for the project shall be designed to meet the requirements of lateral forces calculated using the applicable code and method described above.

B. The following is a partial list of equipment that shall be restrained and that shall be constructed to meet seismic forces described in this section:

1. Air Handling Units

2.5 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoors and Damp Locations: Galvanized steel.
3. Corrosive Locations: Stainless steel.

2.6 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICC Evaluation Service or another agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type. Comply with IBC, ACI and ICC ES requirements for cracked concrete anchors.

C. Concrete Inserts: Steel-channel type.

D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM F3125, Grade A 325.

E. Welding Lugs: Comply with MSS SP-69, Type 57.

F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.7 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch cross section, formed from 0.1046-inch-thick steel, with 9/16-by-7/8-inch slots at a maximum of 2 inches o.c. in webs, and flange edges turned toward web.

1. Materials for Channel: ASTM A 1011, GR 33.
2. Materials for Fittings and Accessories: ASTM A 635, ASTM A 576, or ASTM A 36.
3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.

4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

B. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.

1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
2. Wire Rope Cable: Comply with ASTM A 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

C. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Refer to the applicable code sections and Authority Having Jurisdiction for the exact seismic restraint requirements of piping, ductwork, conduit, equipment, etc.

B. Layout of transverse and longitudinal bracing shall follow recommendations of approved design standards listed in Part 1 of this specification section.

C. All rigid floor mounted equipment shall have a resilient media between the equipment mounting hole and the anchor bolt in concrete.

D. All seismic restraint systems shall be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

E. Installation of seismic restraints shall not cause any change in position of equipment, piping, or ductwork, resulting in stresses or misalignment.

F. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.

G. Do not install any equipment, piping, duct, or conduit that makes rigid connections with the building unless isolation is not specified.

H. Coordinate work with all other trades to avoid rigid contact with the building. Any conflicts with other trades that will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions shall be brought to the Architect/Engineer's attention prior to specific equipment selection.

I. Prior to installation, bring to the Architect/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.

J. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or International Code Council approved seismic anchors for installation in concrete.

K. Cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment, ductwork, piping, or conduit.

L. Cable assemblies shall be installed taut on non-isolated systems. Solid braces may be used in place of cables on rigidly attached systems only.

M. Do not install cables over sharp corners.

N. Brace support rods when necessary to accept compressive loads. Welding of compression braces to the vertical support rods is not acceptable.

O. Provide reinforced clevis bolts when required.

P. The vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not acceptable.

Q. Post-Installed anchors shall be provided to meet seismic requirements.

R. Vertical pipe risers flexibly supported to accommodate thermal motion and/or pipe vibration shall be guided to maintain pipe stability and provide horizontal seismic restraint.

S. Seismic restraints shall be mechanically attached to the system. Looping restraints around the system is not acceptable.

T. Piping crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the pipe, equipment connections, or support connections. Pipe offsets, loops, anchors, and guides shall be installed as required to provide required motion capability and limit motion of adjacent piping.

U. Brace all terminal units with water coils as required by the building code and provide flexible connection to the coil if bracing is required.

V. Independently brace duct mounted equipment (terminal units, in-line fans, etc.) and the associated suspended ductwork.

W. Do not brace a system to two different structures such as a wall and a ceiling.

X. Provide appropriately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire seal systems in fire-rated walls.

Y. Positively attach all roof mounted equipment to roof curbs. Positively attach all roof curbs to building structure.

Z. Exposed seismic supports in occupied areas shall be guarded or covered to protect occupants.

AA. Coordinate seismic bracing of architecturally exposed ductwork with the Architect/Engineer.

3.2 SEISMIC RESTRAINT EXCLUSIONS

A. Refer to the applicable code sections and Authority Having Jurisdiction for allowable exclusions.

END OF SECTION

SECTION 23 05 53 - HVAC IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Identification of products installed under Division 23.

1.2 REFERENCES

A. ANSI/ASME A13.1 - Scheme for the Identification of Piping Systems.

B. ASTM B-1, B-3, and B-8 for copper conductors.

C. ASTM D-1248 for Polyethylene Extrusion Materials, ICEA S-70-547 Weatherproof Resistant Polyethylene Conductors, ICEA S-61-402/NEMA WC5 Thermoplastic Insulated Wire & Cable, ICEA S-95-658/NEMA WC70 Non-Shielded 0 - 2kV Cables.

D. CGA Pamphlet C-9, Standard Color-Marking of Compressed Gas Cylinders for Medical Use.

E. UL 1581 Standard for Electrical Wires, Cables, and Flexible Cords.

1.3 SUBMITTALS

A. Include valve chart and schedule listing valve tag number, location, function, and valve manufacturer's name and model number.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 3M

B. Seton

C. W.H. Brady

2.2 MATERIALS

A. General:

1. Plastic Nameplates: Laminated three-layer phenolic with engraved black, 1/4" minimum letters on light contrasting background.
2. Brass Tags: Brass background with engraved black letters. Tag size minimum 1-1/2" square or 1-1/2" round.

B. Pipe Markers:

1. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Marker lengths and letter sizes shall be at least the following:

| OD of Pipe or Insulation | Marker Length | Size of Letters |
|---|---|---|
| Up to and including 1-1/4" | 8" | 1/2" |
| 1-1/2" to 2" | 8" | 3/4" |
| 2-1/2" to 6" | 12" | 1-1/4" |
| 8" to 10" | 24" | 2-1/2" |
| Over 10" | 32" | 3-1/2" |

Plastic tags may be used for outside diameters under 3/4"

2. Vinyl Pipe Markers: Colored vinyl with permanent pressure sensitive adhesive backing.

C. Ceiling Markers:

1. Label Style:

a. The intent is for the ceiling labels to be inconspicuous but easy to find and read while standing underneath. The labels shall be located on the grid T-bar nearest the ceiling tile that can be removed to provide the best access to the serviceable side of equipment or to valves. An arrow can be used to point to the tile needing removal.
b. The label tape shall be approximately 1/2" wide with all capitalized letters approximately 3/16" tall.
c. Ceiling grid labels shall be made with a label maker with durable adhesive labels having a clear background and black letters.
d. Equipment labels shall be as designated on the drawings (e.g., FCU-606B, etc.).
e. Valve labels shall be designated by the size, service, and the valve tag number (e.g., 1-1/4" CW #123, 2" HWS #234, etc.). A single longer label can be used to identify multiple valves using spaces between the descriptors if the valves are located close together and have the same service (e.g., HWS and HWR valves serving the same equipment or CW, HW, and HWC lines serving the same restroom, etc.).
f. Fire, fire/smoke and smoke dampers shall be labeled consistent with the type (e.g., Fire Damper, Fire/Smoke Damper, etc.).

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Degrease and clean surfaces to receive adhesive for identification materials.

C. Valves:

1. All valves (except shutoff valves at equipment) shall have numbered tags.
2. Provide or replace numbered tags on all existing valves that are connected to new systems or that have been revised.
3. Provide all existing valves used to extend utilities to this project with numbered tags. Review tag numbering sequence with the Owner prior to ordering tags.
4. Secure tags with heavy duty key chain and brass "S" link or with mechanically fastened plastic straps.
5. Attach to handwheel or around valve stem. On lever operated valves, drill the lever to attach tags.
6. Number all tags and show the service of the pipe.
7. Provide one Plexiglas framed valve directory listing all valves, with respective tag numbers, uses and locations. Mount directory in location chosen by the Architect/Engineer.

D. Pipe Markers:

1. Adhesive Backed Markers: Use Brady Style 1, 2, or 3 on pipes 3" diameter and larger. Use Brady Style 4, 6, or 8 on pipes under 3" diameter. Similar styles by other listed manufacturers are acceptable. Secure all markers at both ends with a wrap of pressure sensitive tape completely around the pipe.
2. Snap-on Markers: Use Seton "Setmark" on pipes up to 5-7/8" OD. Use Seton "Setmark" with nylon or Velcro ties for pipes 6" OD and over. Similar styles by other listed manufacturers are acceptable.

3. Apply markers and arrows in the following locations where clearly visible:

    a. At each valve.
    b. On both sides of walls that pipes penetrate.
    c. At least every 20 feet along all pipes.
    d. On each riser and each leg of each "T" joint.
    e. At least once in every room and each story traversed.

E. Equipment:

1. All equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function such as air handling units, exhaust fans, filters, reheat coils, dampers, etc.; shall have nameplates or plastic tags listing name, function, and drawing symbol. Do not label exposed equipment in public areas.
2. Fasten nameplates or plastic tags with stainless steel self-tapping screws or permanently bonding cement.
3. Mechanical equipment that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the manufacturer stating that the equipment complies with the requirements of ASHRAE 90.1.

F. Miscellaneous:

1. Attach self-adhesive vinyl labels at all duct access doors used to reset fusible links or actuators on fire, fire/smoke, or smoke dampers. Lettering shall be a minimum of 1/2" high. Labels shall indicate damper type.
2. Provide engraved plastic tags at all hydronic or steam system make-up water meters.

3.2 SCHEDULE

A. Pipes to be marked shall be labeled with text as follows, regardless of which method or material is used:

1. CONDENSATE DRAIN: White lettering; green background
2. REFRIGERANT LIQUID: White lettering; purple background
3. REFRIGERANT SUCTION: White lettering; purple background
4. REFRIGERANT HOT GAS: White lettering; purple background

B. Ductwork and Fan Systems: All fans, filters housings, and access doors shall be labeled with text as follows:

1. SUPPLY AIR: White lettering; green background
2. RETURN AIR: White lettering; green background
3. GENERAL EXHAUST AIR: Black lettering; yellow background
4. VENTILATION AIR: White lettering; green background
5. RELIEF Black lettering; yellow background

C. Ceiling Markers:

1. FCU-##
2. FSD
3. SMOKE DETECTOR
4. MOTOR OPERATED DAMPERS
5. CONTROL VALVES
6. CLEAN OUT Condensate
7. BRANCH SELECTOR (VRF System)

END OF SECTION

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Testing, adjusting, and balancing of air systems.

B. Measurement of final operating condition of HVAC systems.

1.2 QUALITY ASSURANCE

A. Agency shall be a company specializing in the adjusting and balancing of systems specified in this section with minimum three years' experience. Perform work under supervision of AABC Certified Test and Balance Engineer, NEBB Certified Testing, Balancing and Adjusting Supervisor, SMARTA Certified Air and Hydronic Balancer, or TABB Certified Supervisor.

B. Work shall be performed in accordance with the requirements of the references listed at the start of this section.

1.3 REFERENCES

A. AABC - National Standards for Total System Balance, Seventh Edition.

B. ADC - Test Code for Grilles, Registers, and Diffusers.

C. AMCA - Publication 203-90; Field Performance Measurement of Fan Systems.

D. ASHRAE - 2019 HVAC Applications Handbook; Chapter 39, Testing, Adjusting and Balancing.

E. ASHRAE/ANSI - Standard 111-2008; Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC&R Systems.

F. NEBB - Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems, Ninth Edition, 2019.

G. SMACNA - HVAC Systems; Testing, Adjusting and Balancing (latest edition).

H. TABB - International Standards for Environmental Systems Balance.

1.4 SUBMITTALS

A. Submit copies of report forms, balancing procedures, and the name and qualifications of testing and balancing agency for approval within 30 days after award of Contract.

B. Electronic Copies:

1. Submit a certified copy of test reports to the Architect/Engineer for approval. Electronic copies shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Copies that are not legible will be returned to the Contractor for resubmittal. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
2. Electronic file size shall be limited to a maximum of 10MB. Larger files shall be divided into files that are clearly labeled as "1 of 2", "2 of 2", etc.
3. All text shall be searchable.
4. Bookmarks shall be used. All bookmark titles shall be an active link to the index page and index tabs.

1.5 REPORT FORMS

A. Submit reports on AABC, SMACNA or NEBB forms. Use custom forms approved by the Architect/Engineer when needed to supply specified information.

B. Include in the final report a schematic drawing showing each system component, including balancing devices, for each system. Each drawing shall be included with the test reports required for that system. The schematic drawings shall identify all testing points and cross-reference these points to the report forms and procedures.

C. Refer to PART 4 for required reports.

1.6 WARRANTY/GUARANTEE

A. The TAB Contractor shall include an extended warranty of 90 days after owner receipt of a completed balancing report, during which time the Owner may request a recheck of terminals, or resetting of any outlet, coil, or device listed in the test report. This warranty shall provide a minimum of 24 manhours of onsite service time. If it is determined that the new test results are not within the design criteria, the balancer shall rebalance the system according to design criteria.

B. Warranty/Guarantee must meet one of the following programs: TABB International Quality Assurance Program, AABC National Project Performance Guarantee, NEBB's Conformance Certification.

1.7 SCHEDULING

A. Coordinate schedule with other trades. Provide a minimum of seven days' notice to all trades and the Architect/Engineer prior to performing each test.

B. Project will be constructed in phases. Provide balancing report after each phase is complete.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All procedures must conform to a published standard listed in the References article of this section. All equipment shall be adjusted in accordance with the manufacturer's recommendations. Any system not listed in this specification but installed under the contract documents shall be balanced using a procedure from a published standard listed in the References article.

B. The Balancing Contractor shall incorporate all pertinent documented construction changes (e.g. submittals/shop drawings, change orders, RFIs, ASIs, etc.) and include in the balancing report.

C. Recorded data shall represent actual measured or observed conditions.

D. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing is complete, close probe holes and patch insulation with new materials as specified. Restore vapor barrier and finish as specified.

E. Permanently mark setting of valves, dampers, and other adjustment devices allowing for settings to be restored. Set and lock memory stops.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, plugging test holes, and restoring thermostats to specified settings.

G. The Balancing Contractor shall measure terminal air box air flow, and the TCC shall adjust DDC readout to match. Refer to Section 23 09 00 for additional information.

H. Installations with systems consisting of multiple components shall be balanced with all system components operating.

3.2 EXAMINATION

A. Before beginning work, verify that systems are complete and operable. Ensure the following:

1. General Equipment Requirements:

   a. Equipment is safe to operate and in normal condition.
   b. Equipment with moving parts is properly lubricated.
   c. Temperature control systems are complete and operable.
   d. Proper thermal overload protection is in place for electrical equipment.
   e. Direction of rotation of all fans and pumps is correct.
   f. Access doors are closed and end caps are in place.

2. Duct System Requirements:

a. All filters are clean and in place. If required, install temporary media.
b. Duct systems are clean and free of debris.
c. Fire/smoke and manual volume dampers are in place, functional and open.
d. Air outlets are installed and connected.
e. Duct system leakage has been minimized.

3. Pipe System Requirements:

a. Coil fins have been cleaned and combed.
b. Hydronic systems have been cleaned, filled, and vented.
c. Strainer screens are clean and in place.
d. Shutoff, throttling and balancing valves are open.

B. Report any defects or deficiencies to Architect/Engineer.

C. Promptly report items that are abnormal or prevent proper balancing.

D. If, for design reasons, system cannot be properly balanced, report as soon as observed.

E. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to the Architect/Engineer for spot checks during testing.

B. Instruments shall be calibrated within six months of testing performed for project, or more recently if recommended by the instrument manufacturer.

3.4 INSTALLATION TOLERANCES

A. ± 10% of scheduled values:

1. Adjust air inlets and outlets to ± 10% of scheduled values.

B. + 5% of scheduled values

1. Adjust outdoor air intakes to within + 5% of scheduled values.

C. Adjust supply, return, and exhaust air-handling systems to +10% / -5% of scheduled values.

3.5 ADJUSTING

A. After adjustment, take measurements to verify balance has not been disrupted or that disruption has been rectified.

B. Once balancing of systems is complete, at least one damper or valve must be 100% open.

C. After testing, adjusting and balancing are complete, operate each system and randomly check measurements to verify system is operating as reported in the report. Document any discrepancies.

D. Contractor responsible for each motor shall also be responsible for replacement sheaves. Coordinate with contractor.

3.6 SUBMISSION OF REPORTS

A. Fill in test results on appropriate forms.

PART 4 - SYSTEMS TO BE TESTED, ADJUSTED AND BALANCED

4.1 GENERAL REQUIREMENTS

A. Title Page:

1. Project name.
2. Project location.
3. Project Architect.
4. Project Engineer (IMEG Corp.).
5. Project General Contractor.
6. TAB Company name, address, phone number.
7. TAB Supervisor's name and certification number.
8. TAB Supervisor's signature and date.
9. Report date.

B. Report Index

C. General Information:

1. Test conditions.
2. Nomenclature used throughout report.
3. Notable system characteristics/discrepancies from design.
4. Test standards followed.
5. Any deficiencies noted.
6. Quality assurance statement.

D. Instrument List:

1. Instrument.
2. Manufacturer, model, and serial number.
3. Range.
4. Calibration date.

4.2 AIR SYSTEMS

A. Duct Leakage Test:

1. Air system and fan.
2. Leakage class.
3. Test pressure.
4. Construction pressure.
5. Flow rate (cfm): specified and actual.
6. Leakage (refer to Section 23 31 00 in the specifications): specified and actual.
7. Statement that fire dampers, reheat coils and other accessories were included in the test.
8. Pass or Fail.
9. Test performed by.
10. Test witnessed by.

B. Air Moving Equipment:

1. General Requirements:

a. Drawing symbol.
b. Location.
c. Manufacturer, model, arrangement, class, discharge.
d. Fan RPM.
e. Multiple RPM fan curve with operating point marked. (Obtain from equipment supplier).
f. Final frequency of motor at maximum flow rate (on fans driven by VFD).

2. Flow Rate:

a. Supply flow rate (cfm): specified and actual.
b. Return flow rate (cfm): specified and actual.
c. Outside flow rate (cfm): specified and actual.
d. Exhaust flow rate (cfm): specified and actual.

3. Pressure Drop and Pressure:

a. Filter pressure drop: specified and actual.
b. Total static pressure: specified and actual. (Indicate if across fan or external to unit).
c. Inlet pressure.
d. Discharge pressure.

C. Fan Data:

1. Drawing symbol.
2. Location.
3. Manufacturer and model.
4. Flow rate (cfm): specified and actual.
5. Total static pressure: specified and actual. (Indicate measurement locations).

6. Inlet pressure.
7. Discharge pressure.
8. Fan RPM.

D. Electric Motors:

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps in each phase.

E. Air Terminal (Inlet or Outlet):

1. Drawing symbol.
2. Room number/location.
3. Terminal type and size.
4. Velocity: specified and actual.
5. Flow rate (cfm): specified and actual.
6. Percent of design flow rate.

F. Air Terminal Unit (Terminal Air Box) Data:

1. General Requirements:

a. Drawing symbol.
b. Location.
c. Manufacturer and model.
d. Size.
e. Type: constant, variable, single, dual duct.

2. Flow Rate:

a. Cooling maximum flow rate (cfm): specified and actual.
b. Heating maximum flow rate (cfm): specified and actual.
c. Minimum flow rate (cfm): specified and actual.
d. Water flow rate (gpm): specified and actual with system performance adjusted as follows:

1) Adjust heating water system pump to maintain maximum system differential pressure.
2) Set calibrated balance valve fully open.
3) Command terminal air box control valve to fully open.
4) Measure heating coil flow using calibrated balance valve.
5) Note: Commanding terminal air box control valve to be fully open shall be done on a valve-by-valve basis. Do not command all control valves to be fully open at the same time, as the heating water system may not have sufficient capacity.
6) Note: After Balancing of all terminal air boxes is complete, release the heating water pump to automatically reset the system DP based on control valve position per sequence of operation requirements.

3. Temperature:

    a. Entering air temperature: specified and actual.
    b. Leaving air temperature (in minimum airflow/heating mode): specified and actual.
    c. Entering water temperature: specified and actual.
    d. Leaving water temperature: specified and actual.

4. Pressure Drop and Pressure:

    a. Inlet static pressure during testing cooling maximum airflow rate (maximum and minimum).
    b. Water pressure drop: specified and actual.

END OF SECTION

SECTION 23 07 13 - DUCTWORK INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ductwork Insulation.

B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork insulation application with five years minimum experience. When requested, installer shall submit manufacturer's certificate indicating qualifications.

B. Materials:

1. Listed and labeled for flame spread/smoke developed rating of no more than 25/50 when tested per ASTM E84 or UL 723 as required by code.
2. Fungal Resistance: No growth when tested in accordance with ASTM G21 (antifungal test).
3. Rated velocity on coated air side for air erosion in accordance with UL 181 at 5,000 fpm minimum.

C. Adhesives: UL listed, meeting NFPA 90A/90B requirements.

1.3 REFERENCES

A. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

B. ANSI/ASTM C553 - Mineral Fiber Blanket and Felt Insulation.

C. ANSI/ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

D. ASTM E84 - Surface Burning Characteristics of Building Materials.

E. ASTM E136 - Standard Test Method for the Behavior of Materials in a Vertical Tube Furnace at 750°C.

F. ASTM E814 - Fire Tests of Through Penetrations Firestops.

G. ASTM E2336-04 - Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems.

H. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

I. National Commercial & Industrial Insulation Standards - 1999 Edition - as published by Midwest Insulation Contractors Association and endorsed by National Insulation Contractors Association.

J. NFPA 96 - Standard for the Installation of Equipment for Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment.

K. NFPA 255 - Surface Burning Characteristics of Building Materials.

L. UL - XHEZ - Through Penetration Firestop Systems.

M. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.

N. UL 263 - Full Scale External Fire Tests with Hose Stream.

O. UL 723 - Surface Burning Characteristics of Building Materials.

P. UL 1479 - Fire Tests of Through Penetrations Firestops.

Q. California Title 24 - Building Energy Efficiency Standards

R. CMC California Mechanical Code

1.4 SUBMITTALS

A. Submit manufacturer's product data and installation instructions.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Type A: Flexible Fiberglass - Outside Wrap; ANSI/ASTM C553; commercial grade; 0.28 / 0.26 (Out-Of-Package/Installed-Compressed 25%) maximum 'K' value at 75°F; foil scrim Kraft facing, 1.0 lb./cu. ft. density. Submit both "Out of Package" and "Installed-Compressed 25%" K and R-values.

B. Type C: Flexible Fiberglass Liner; ANSI/ASTM C1071; 0.28 maximum 'K' value at 75°F; 1.5 lb/cu ft minimum density; coated air side for 5000 fpm air velocity.

| | | R-VALUE PER THICKNESS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | THICKNESS | 0.5 | 1 | 1.5 | 2 | 2.5 | 3 | 4 | 5 |
| TYPE | K-FACTOR | R-VALUE | | | | | | | |
| Flexible Fiberglass Outside Wrap | 0.28 | | | 5.4 | 7.1 | 8.9 | 10.7 | 14.3 | 17.9 |
| Semi-Rigid Fiberglass Board Wrap | 0.25 | | | 6.0 | 8.0 | 10.0 | 12.0 | 16.0 | 20.0 |
| Flexible Fiberglass Liner | 0.28 | 1.8 | 3.6 | 5.4 | 7.1 | 8.9 | 10.7 | 14.3 | 17.9 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Rigid fiberglass liner | 0.23 | 4.3 | 6.5 | 8.7 | 10.9 | 13.0 | 17.4 | 21.7 |
| Double Wall Ductwork | 0.27 | 3.7 | 5.6 | 7.4 | 9.3 | 11.1 | 14.8 | 18.5 |
| Flexible High Temp Rigid Preformed Fiberglass Acoustical Liner | 0.23 | 4.3 | 6.5 | 8.7 | 10.9 | 13.0 | 17.4 | 21.7 |

2.2 JACKETS

A. Vapor Barrier Jackets: Kraft reinforced foil scrim vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 25 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

2.3 JACKET COVERINGS

A. Aluminum Jackets: ASTM B209; 0.016" thick; smooth or embossed stucco finish with Z edge seams and aluminum bands for outdoor use. Where colored jacket covers are called for, provide factory-applied hard film acrylic paint in color selected by Architect.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install materials in accordance with manufacturer's instructions, codes, and industry standards.

B. Install materials after ductwork has been tested.

C. Clean surfaces for adhesives.

D. Provide insulation with vapor barrier when air conveyed may be below ambient temperature.

E. Exterior Duct Wrap - Flexible, Type A:

1. Apply with edges tightly butted.
2. Cut slightly longer than perimeter of duct to insure full thickness at corners. Do not wrap excessively tight.
3. Seal joints with adhesive backed tape.
4. Apply so insulation conforms uniformly and firmly to duct.
5. Seal all penetrations of the vapor barrier by strap hangers or slip cable hangers with adhesive backed tape.
6. Provide high-density insulation inserts on rectangular ducts at trapeze duct hangers to prevent crushing of insulation. Provide high-density insulation inserts with clamp-on round ducts requiring two (2) rods or straps to prevent crushing of insulation. Maintain continuous vapor barrier through the hanger.

7. Tape all joints with Royal Tapes #RT 350 (216-439-7229), Venture Tape 1525CW, or Compac Type FSK. No substitutions will be accepted without written permission from the Architect/Engineer.
8. Press tape tightly to the duct covering with a squeegee for a tight continuous seal. Fish mouths and loose tape edges are not acceptable.
9. Staples may be used, but must be covered with tape.
10. Vapor barrier must be continuous.
11. Mechanically fasten on 12" centers at bottom of ducts over 24" wide and on all sides of vertical ducts.

F. Interior Insulation - Flexible Duct Liner, Type C:

1. Observation of Duct Lining:

   a. After installation of ductwork, Architect/Engineer may select random observation points in each system.

      1) At each observation point, cut and remove an 18" x 18" section of ductwork and liner for verification of installation.
      2) Random observation points based on one opening per 75 lineal ft. of total duct run.

   b. When any of the observation points shows non-compliance, additional points will be designated by the Architect/Engineer, and observation repeated.
   c. If 20% of points observed do not comply, remove and replace all lined ducts and repeat tests. Where replacement is not required, correct all non-compliances.
   d. At end of observation, repair all duct lining and observation holes by installing standard, insulated, hinged access doors per Section 23 33 00.
   e. Paint or finish to match adjacent duct surfaces.

2. Impale on spindle anchors welded or mechanically fastened to the duct. Adhesive or glue fastened anchors are not acceptable. Maximum anchor spacing per SMACNA Duct Construction Standards or manufacturer's recommendations, whichever is more restrictive. Locate pins less than 3" from corners and at intervals not over 6" around the perimeter at leading and trailing edges. Locate pins within 3" of transverse joints and at intervals not over 16" long the length of the duct. Pins must be long enough to prevent compressing the insulation.
3. In addition to anchors, secure liner with UL listed adhesive covering over 90% of the duct surface.
4. Install per the latest edition of the SMACNA Manual.
5. Leading edges shall be covered as follows:

   a. For duct velocities below 3000 fpm, coat leading edges with adhesive. Neatly butt liner without gaps at transverse joints. Cut liner flush with end of the duct section for tight joints with no exposed duct. If adhesive is shop installed, field apply additional adhesive to the end of each duct section for complete adhesion of the liner. Protect edges from dirt and debris.

b. For duct velocities above 3000 fpm, cover leading edges with metal nosing. Use nosing on upstream edges of each section of duct. If the duct can be installed in either direction, provide nosing on each end or clearly mark the duct to allow visual verification after installation. Verify duct velocities based on the scheduled air flow rates and determine where metal nosing is required.
c. Install metal nosing in the following locations (regardless of velocity):

1) The first three fittings downstream of all fans.
2) At all duct liner interruptions. This includes fire dampers, access doors, branch connections, and all other locations where the edge of the liner is exposed.
3) Trailing edges of transverse joints do not require metal nosings.

6. Overlap liner at longitudinal joints. Make longitudinal joints at corners of the duct unless the duct size does not allow this. Coat longitudinal joints with adhesive at velocities over 2500 fpm.
7. Seal all damaged duct liner with adhesive and glass cloth. Do not damage duct liner surface coatings.
8. Duct dimensions given are net inside dimensions. Increase sheet metal to allow for insulation thickness.

G. Continue insulation with vapor barrier through penetrations unless code prohibits.

H. Provide 2" wide, 24" high, 26 gauge, galvanized sheet metal corner protection angles for all externally insulated ductwork extending to a floor or curb.

3.2 SCHEDULE

A. Refer to Section 23 31 00 for scheduling of insulation.

B. Unless noted otherwise, HVAC plenums and unit housings not pre-insulated at factory shall be insulated to geographical R-value requirements based on California Title 24, R-4.2, R-6 or R-8.

END OF SECTION

SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping Insulation.

B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with five years minimum experience.

B. Materials: Listed and labeled for flame spread/smoke developed rating of no more than 25/50 when tested per ASTM E84 or UL 723 as required by code. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

C. Products shall not contain asbestos, lead, mercury, or mercury compounds.

D. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Adhesives and Sealants: All sealers, adhesives, and sealants shall comply with the low emitting material limits of the following standards:

1. CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions VOC from Indoor Sources Using Environmental Chambers Version 1.1.
2. South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications. All adhesives and sealants wet-applied on site shall comply with the applicable chemical content requirements of SCAQMD Rule 1168.
3. South Coast Air Quality Management District Rule SCAQMD 1113 - Wet Applied Paints and Coatings. All paints and coatings wet-applied on site must meet the applicable VOC limits of SCAQMD Rule 1113.

1.3 REFERENCES

A. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

B. ANSI/ASTM C195 - Mineral Fiber Thermal Insulation Cement.

C. ANSI/ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.

D. ANSI/ASTM C534 - Elastomeric Foam Insulation.

E. ANSI/ASTM C547 - Mineral Fiber Preformed Pipe Insulation.

F. ANSI/ASTM C552 - Cellular Glass Block and Pipe Thermal Insulation.

G. ASTM C449 - Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement.

H. ASTM C591 - Unfaced Preformed Rigid Cellular Polyisocyanurate Insulation.

I. ASTM C578 - Preformed Cellular Polystyrene Thermal Insulation.

J. ASTM C1126 - Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation.

K. ASTM C1729 - Standard Specification for Aluminum Jacketing for Insulation.

L. ASTM C1767 - Standard Specification for Stainless Steel Jacketing for Insulation.

M. ASTM E84 - Surface Burning Characteristics of Building Materials.

N. NFPA 255 - Surface Burning Characteristics of Building Materials.

O. UL 723 - Surface Burning Characteristics of Building Materials.

P. National Commercial & Industrial Insulation Standards - 1999 Edition - as published by Midwest Insulation Contractors Association and endorsed by National Insulation Contractors Association.

Q. California Title 24 - Building Energy Efficiency Standards.

1.4 SUBMITTALS

A. Submit product data per Section 23 05 00. Include product description, list of materials and thickness for each service, and locations.

PART 2 - PRODUCTS

2.1 INSULATION

A. Type A: Glass fiber; ANSI/ASTM C547; 0.24 maximum 'K' value at 75°F; non-combustible. All-purpose polymer or polypropylene service jacket, listed and labeled at no more than 25/50 when tested per ASTM E84 or UL 723 as required by code.

B. Type B: Flexible elastomeric foam insulation; closed-cell, sponge or expanded rubber (polyethylene type is not permitted); ANSI/ASTM C534, Grade 1 Type I for tubular materials; flexible plastic; 0.25 maximum 'K' value at 75°F, listed and labeled at no more than 25/50 when tested per ASTM E84 or UL 723 as required by code. Maximum 1" thick per layer where multiple layers are specified.

2.2 VAPOR BARRIER JACKETS

A. All-purpose polymer or polypropylene service jacket vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 50 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

2.3 JACKET COVERINGS

A. Aluminum Jackets: ASTM C1729; 0.016" thick (thicker where required by ASTM C1729); stucco embossed finish with Z edge seams and aluminum bands for outdoor use. Where colored jacket covers are called for, provide factory-applied hard film acrylic paint in color selected by Architect.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install insulation after piping has been tested. Pipe shall be clean, dry and free of rust before applying insulation.

B. Patch and repair torn insulation. Paint to match adjacent insulation surface.

3.2 INSTALLATION

A. General Installation Requirements:

1. Install materials per manufacturer's instructions, building codes and industry standards.
2. Continue insulation with vapor barrier through penetrations. This applies to all insulated piping. Maintain fire rating of all penetrations.
3. All piping and insulation that does not meet 25/50 that is in an air plenum shall have written approval from the Authority Having Jurisdiction and the local fire department for authorization and materials approval. If approval has been allowed, the non-rated material shall be wrapped with a product that has been listed and labeled having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested as a composite in accordance with ASTM E84 or UL 723.
4. On 1" and smaller piping routed through metal wall studs, provide a plastic grommet to protect the piping. The piping shall be insulated between the wall studs, and the insulation shall butt up to each stud.

B. Insulated Piping Operating Below 60°F:

1. Insulate fittings, valves, unions, flanges, flexible connections, flexible hoses, and expansion joints. Seal all penetrations of vapor barrier.
2. On piping operating below 60°F in locations that are not mechanically cooled (e.g., penthouses, mechanical rooms, tunnels, chases at exterior walls, etc.), Type B insulation shall be used.
3. All balance valves and strainers with fluid operating below 60°F shall be insulated with a removable plug wrapped with vapor barrier tape to allow access for reading and adjusting of the balancing valve and cleaning and servicing of the balancing valve.

C. Insulated Piping Operating Between 60°F and 140°F:

1. Do not insulate flanges and unions, but bevel and seal ends of insulation at such locations. Insulate all fittings, valves and strainers.

D. Insulated Piping Operating Above 140°F:

1. Insulate fittings, valves, flanges, float & thermostatic steam traps, and strainers. On gate valves, the insulation shall be extended to cover the entire valve bonnet, leaving only the portion of the stem that is above the bonnet and valve operator exposed.
2. All balance valves with fluid operating above 140°F shall be insulated and an opening shall be left in the insulation to allow for reading and adjusting the valve.
3. The use of removable insulation jackets is acceptable for insulating large and non-cylindrical shaped piping components (e.g., check valves, pressure regulating valves, calibrated balance valves, gate valve bonnets, F&T traps, strainers, line sets, and the like).

E. Refrigerant Piping:

1. On refrigerant piping (25°F and above) and not required to meet the 25/50 flame/smoke, provide at each strut or clevis support an insulation coupling to support pipe and to accept insulation thickness of adjoining insulation, to prevent insulation from sagging and crushing. The coupling shall be suitable for planned temperatures, use with specified pipe material, and shall be a 360°, one-piece cylindrical segment. Use mechanical fasteners where coupling cannot be installed on pipe during installation. Contractor shall apply adhesive to ends of insulation entering insulation coupling to maintain vapor barrier.

F. Exposed Piping:

1. Locate and cover seams in least visible locations.
2. Where exposed insulated piping extends above the floor, provide a sheet metal guard around the insulation extending 12" above the floor. Guard shall be 0.016" cylindrical smooth or stucco aluminum and shall fit tightly to the insulation.

3.3 SUPPORT PROTECTION

A. Provide a shield on all insulated piping at each support between the insulation jacket and the support.

B. On all insulated piping greater than 1-1/2", provide shield with insulation insert of same thickness and contour as adjoining insulation at each support, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. Inserts shall be as follows:

1. The insert shall be suitable for planned temperatures, be suitable for use with specific pipe material, and shall be a minimum 180° cylindrical segment the same length as metal shields. Inserts shall be:

   a. Molded hydrous calcium silicate (only use for pipes with operating temperatures above 90°F, with a minimum compressive strength of 100 psi is acceptable for pipe sizes 14" and below. For pipe sizes larger than 14", provide rolled steel plate in addition to the shield.
   b. As an alternative to separate pipe insulation insert and saddle, properly sized manufactured integral rigid insulation insert and shield assemblies may be used.

      1) Products:

         a) Buckaroo CoolDry
         b) Cooper/B-Line Fig. B3380 through B3384
         c) Pipe Shields A1000, A2000

   c. Insulation Couplings:

      1) Molded thermoplastic slip coupling, -65°F to 275°F, sizes up to 4-1/8" OD, and receive insulation thickness up to 1". Suitable for use indoors or outdoors with UV stabilizers. Vertical insulation riser clamps shall have a 1,000lb vertical load rating. On cold pipes operating below 60°F, cover joint and coupling with vapor barrier mastic to ensure continuous vapor barrier.
      2) Horizontal Strut Mounted Insulated Pipe Manufacturers:

         a) Klo-Shure or equal

      3) Vertical Manufacturers:

         a) Manufacturers: Klo-Shure Titan or equal

   d. Rectangular blocks, plugs, or wood material are not acceptable.
   e. Temporary wood blocking may be used by the Piping Contractor for proper height; however, these must be removed and replaced with proper inserts by the Insulation Contractor. Refer to Supports and Anchors specification section for additional information.

C. Neatly finish insulation at supports, protrusions, and interruptions.

D. Install metal shields between all hangers or supports and the pipe insulation. Shields shall be galvanized sheet metal, half-round with flared edges. Adhere shields to insulation. On cold piping, seal the shields vapor-tight to the insulation as required to maintain the vapor barrier, or add separate vapor barrier jacket.

E. Shields shall be at least the following lengths and gauges:

| Pipe Size | Shield Size |
|---|---|
| 1/2" to 3-1/2" | 12" long x 18 gauge |
| 4" | 12" long x 16 gauge |
| 5” to 6" | 18" long x 16 gauge |
| 8” to 14" | 24" long x 14 gauge |
| 16” to 24" | 24" long x 12 gauge |

F. Ferrous hot piping 4 inches and larger, provide steel saddle at rollers as described in Section 23 05 29 "HVAC Supports and Anchors".

G. Minimum 1/4" rolled galvanized steel plates shall be provided in addition to the sleeves as reinforcement on large pipes to reduce point loading on roller, trapeze hanger and strut support locations depending on insulation compressive strength. Refer to section above for exact locations.

3.4 INSULATION

A. Type A Insulation:

1. All Service Jackets: Seal all longitudinal joints with self-seal laps using a single pressure sensitive adhesive system. Do not staple.
2. Insulation without self-seal lap may be used if installed with Benjamin Foster 85-20 or equivalent Chicago Mastic, 3M or Childers lap adhesive.
3. Apply insulation with laps on top of pipe.
4. Fittings, Valve Bodies and Flanges: For 4" and smaller pipes, insulate with 1 lb. density insulation wrapped under compression to a thickness equal to the adjacent pipe insulation. For pipes over 4", use mitered segments of pipe insulation. Finish with preformed plastic fitting covers. Secure fitting covers with pressure sensitive tape at each end. Overlap tape at least 2" on itself. For pipes operating below 60°F, seal fitting covers with vapor retarder mastic in addition to tape.

B. Type B Insulation:

1. Install per manufacturer's instructions or ASTM C1710.
2. Elastomeric Cellular Foam: Where possible, slip insulation over the open end of pipe without slitting. Seal all butt ends, longitudinal seams, and fittings with adhesive. At elbows and tees, use mitered connections. Do not compress or crush insulation at cemented joints. Joints shall be sealed completely and not pucker or wrinkle. Paint the outside of outdoor insulation with two coats of latex enamel paint recommended by the manufacturer.
3. Insulation Installation on Straight Pipes and Tubes:

a. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
b. Insulation must be installed in compression to allow for expansion and contraction. Insulation shall be pushed onto the pipe, never pulled. Stretching of insulation may result in open seams and joints.

4. Insulation Installation on Valves and Pipe Specialties:

a. Install preformed sections of same material as straight segments of pipe insulation when available.
b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3.5 JACKET COVER INSTALLATION

A. Metal Covering:

1. Provide vapor barrier as specified for insulation type. Cover with aluminum jacket covering with seams located on the bottom of horizontal piping. Include fittings, joints and valves.
2. Seal all interior and exterior butt joints with metal draw bands and sealant. Seal all exterior joints watertight.
3. Interior joints do not need to be sealed.
4. Use metal covering on the following pipes:

a. All exposed piping in finished spaces unless noted otherwise on the drawings.
b. All exposed piping in unfinished areas as noted on drawings (e.g., storage rooms, janitor's closets, utility rooms, etc.).
c. All exposed piping in mechanical or equipment rooms below 8'-0" above floor.
d. All exposed piping in mechanical rooms that is subject to damage from normal operations. (Example: Piping that must be stepped over routinely.)
e. All exposed piping in tunnels designated as passageways, equipment access or egress.

3.6 SCHEDULE

A. Refer to drawings for insulation schedule.

END OF SECTION

SECTION 23 08 00 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 23 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in the Commissioning Plan (Cx Plan). Refer to Section 01 91 00.

C. Commissioning requires the participation of the Division 23 Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 23 Contractor shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CxA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Refer to the Cx Plan in the appendix of Section 01 91 00.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All the following sections apply to the Work of this section.

1. Section 01 78 23 - Operations and Maintenance
2. Section 01 79 00 - Demonstration and Training
3. Section 01 91 00 - Commissioning
4. Section 22 08 00 - Commissioning of Plumbing
5. Section 26 08 00 - Commissioning of Electrical

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division. This equipment includes, but is not limited to, the following:

1. Handheld temperature and relative humidity meter.
2. Infrared thermometer gun.
3. Analog differential pressure gauge and associated tubing.
4. Portable computer with access to the building automation system.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of +/- 0.1°F.
2. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
3. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

C. Refer to Section 01 91 00 for additional Division 23 requirements.

PART 3 - EXECUTION

A. Refer to the Cx Plan in the appendix of Section 01 91 00.

END OF SECTION

SECTION 23 09 00 - CONTROLS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Complete System of Automatic Controls.

B. Control Devices, Components, Wiring and Material.

C. Instructions for Owners.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five years' experience.

B. TCC: Company specializing in the work of this section with minimum five years temperature control experience.

C. Technician: Minimum five years' experience installing commercial temperature control systems.

D. TCCs are limited to firms regularly employing a minimum of five full-time temperature control technicians within 100 miles of the job site.

E. Control low (24V) and control line (120V) voltage wiring, conduit, and related switches and relays required for the automatic control and/or interlock of motors and equipment, including final connection, are to be furnished and installed under this section. Materials and installation to confirm to Class 1 or 2, California Administrative Code Title 24, Article E725, and as restricted under the Division 26 Electrical of these specifications.

1.3 REFERENCES

A. AMCA 500 - Test Methods for Louvers, Dampers and Shutters.

B. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. ANSI/ASHRAE Standard 135-2001: BACnet® - A Data Communication Protocol for Building Automation and Control Networks, including all amendments.

D. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 volts Maximum).

E. ANSI/NFPA 70 - National Electrical Code.

F. ANSI/NFPA 90A - Installation of Air-Conditioning and Ventilation Systems.

G. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality.

H. ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, Air Conditioning.

I. ANSI/ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

J. ANSI/ASTM B32 - Solder Metal.

K. ASTM B280 - Seamless Copper Tube for Air Conditioning & Refrigeration Field Service.

L. ASTM D1693 - Environmental Stress - Cracking of Ethylene Plastics.

1.4 SUBMITTALS

A. Equipment Coordination:

1. The Controls Contractor shall obtain approved equipment submittals from other contractors to determine equipment wiring connections, to choose appropriate controllers, and to provide programming.
2. Control valve selections shall be based on flow rates shown in approved shop drawings.
3. Coordinate the control interface of all equipment with the equipment manufacturers prior to submittal submission.

B. Shop Drawings:

1. Submit shop drawings per Section 23 05 00. In addition, submit an electronic copy of the shop drawings in Adobe Acrobat (.pdf) format to the Owner for review.
2. Cross-reference all control components and point names in a single table located at the beginning of the submittal with the identical nomenclature used in this section.
3. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol.
4. System Architecture: Provide riser diagrams of wiring between central control unit and all control panels. This shall include specific protocols associated with each level within the architecture. Identify all interface equipment between CPU and control panels. The architecture shall include interface requirements with other systems including, but not limited to, security systems, lighting control, fire alarm, elevator status, and power monitoring system.
5. Diagrams shall include:

a. Wiring diagrams and layouts for each control panel showing all termination numbers.

b. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
c. Identification of all control components connected to emergency power.
d. Schematic diagrams for all field sensors and controllers.
e. A schematic diagram of each controlled system. The schematics shall have all control points labeled. The schematics shall graphically show the location of all control elements in the system.
f. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the control system schematic, label it with the same name. Label all terminals.
g. A tabular instrumentation list for each controlled system. The table shall show element name, type of device, manufacturer, model number and product data sheet number.
h. All installation details and any other details required to demonstrate that the system will function properly.
i. All interface requirements with other systems.

6. The network infrastructure shall conform to the published guidelines for wire type, length, number of nodes per channel, termination, and other relevant wiring and infrastructure criteria as published. The number of nodes per channel shall be no more than 80% of the defined segment (logical or physical) limit in order to provide future system enhancement with minimal infrastructure modifications.
7. Sequences: Submit a complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system. The wording of the control sequences in the submittal shall match verbatim that included in the construction documents to ensure there are no sequence deviations from that intended by the Architect/Engineer. Clearly highlight any deviations from the specified sequences on the submittals.
8. Points List Schedule: Submit a complete points list of all points to be connected to the TCS and FMCS. The points list for each system controller shall include both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, the location of the I/O device, and reference drawings. Where a control point is the same as that shown on the control system schematic, label it with the same name. Points list shall specifically identify alarms, trends, event history, archive, totalization, graphic points, and all mapped points from other systems (security systems, lighting control, fire alarm, etc.). Provide points lists, point naming convention, and factory support information for systems provided and integrated into the FMCS.
9. Damper Schedule: Schedule shall include a separate line for each damper and a column for each of the damper attributes:

a. Damper Identification Tag.
b. Location.
c. Damper Type.
d. Damper Size.
e. Duct Size.

f. Arrangement.
g. Blade Type.
h. Velocity.
i. Pressure Drop.
j. Fail Position.
k. Actuator Identification Tag.
l. Actuator Type.
m. Mounting.

10. Valve Schedule: Valve manufacturer shall size valves and create a valve schedule. Schedule shall include a separate line for each valve and a column for each of the valve attributes:

    a. Valve Identification Tag.
    b. Location.
    c. Valve Type.
    d. Valve Size.
    e. Pipe Size.
    f. Configuration.
    g. Flow Characteristics.
    h. Capacity.
    i. Valve $C_V$.
    j. Design Pressure Drop.
    k. Pressure Drop at Design Flow.
    l. Fail Position.
    m. Close-off Pressure.
    n. Valve and Actuator Model Number and Type.

11. Indoor modular air handling units (Section 23 73 13) provided under this project will have piezometer type sensors mounted at fan inlets by fan manufacturer. Fan manufacturer will provide fan specific flow coefficients and equations that can be used to calculate fan airflow based on measured pressure differential at fan inlet. TCC shall provide the following:

    a. Quantity of pressure transducers so that each individual fan is served by a dedicated pressure transducer. Each pressure transducer shall have a range that is selected based on scheduled maximum airflow for each fan. TCC shall submit a schedule that shows the following calculations for each fan/pressure transducer:

        1) Pressure drop at maximum scheduled airflow for each fan using fan manufacturer's flow coefficient.
        2) Recommended transducer range.

    b. Pneumatic tubing as required to interconnect all piezometer type sensors and pressure transducer. **Note: Where UV lamps are installed upstream of supply fan inlets, only copper tubing shall be used.**
    c. Fasteners and supports as required to securely attached tubing, pressure transducers, conduits, wiring, and the like for a complete installation.

12. Airflow Measuring Station Schedule:

    a. The manufacturer's authorized representative shall prepare the airflow measuring station submittal, or review and approve in writing the submittal prepared by the TCC prior to submission to the Architect/Engineer and prior to installation. The representative shall review air handling equipment submittals and duct fabrication drawings to ensure that all AFMS locations meet the appropriate parameters to achieve proper installation and the specified accuracy. Comply with all manufacturer's installation requirements including straight up and downstream duct lengths. Install airflow straighteners if required by the manufacturer based on installation constraints. The Architect/Engineer shall be notified for approval of any deviations.
    b. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.
    c. Submit installation, operation, and maintenance documentation.

13. Product Data Sheets: Required for each component that includes: unique identification tag that is consistent throughout the submittal, manufacturer's description, technical data, performance curves, installation/maintenance instructions, and other relevant items. When manufacturer's literature applies to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements.
14. Provide PICS files indicating the BACnet functionality and configuration of each device.
15. Provide documentation of submitted products that have been tested and listed by the BACnet Testing Laboratory (BTL), or provide a letter on the manufacturer's company letterhead indicating the anticipated date by which testing is expected to be completed. If, for any reason, BTL testing and listing has not been completed, a written commitment to upgrade installed controls to a version that meets BTL testing and listing requirements if problems are found during BTL testing is required.
16. Graphic Display: Include a sample graphic of each system and component identified in the points list with a flowchart (site map) indicating how the graphics are to be linked to each other for system navigation.
17. Software: A list of operating system software, operator interface software, color graphic software, and third-party software.
18. Control System Demonstration and Acceptance: Provide a description of the proposed process, along with all reports and checklists to be used.
19. Clearly identify work by others in the submittal.
20. Quantities of items submitted may be reviewed but are the responsibility of the Contractor to verify.

C. Operation and Maintenance Manual:

1. In addition to the requirements of Section 23 05 00, submit an electronic copy of the O&M manuals in PDF format.
2. Provide three complete sets of manuals.
3. Each O&M manual shall include:

    a. Table of contents with indexed tabs dividing information as outlined below.
    b. Definitions: List of all abbreviations and technical terms with definitions.
    c. Warranty Contacts: Names, addresses, and 24-hour telephone numbers of contractors installing equipment and controls and service representatives of each.
    d. Licenses, Guarantees, and Warranties: Provide documentation for all equipment and systems.
    e. System Components: Alphabetical list of all system components, with the name, address, and telephone number of the vendor.
    f. Operating Procedures: Include procedures for operating the control systems; logging on/off; enabling, assigning, and reporting alarms; generating reports; collection, displaying, and archiving of trended data; overriding computer control; event scheduling; backing up software and data files; and changing setpoints and other variables.
    g. Programming: Description of the programming language (including syntax), statement descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the editor.
    h. Engineering, Installation, and Maintenance: Explain how to design and install new points, panels, and other hardware; recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions; how to debug hardware problems; and how to repair or replace hardware. A list of recommended spare parts.
    i. Original Software: Complete original issue CDs for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
    j. Software: One set of CDs containing an executable copy of all custom software created using the programming language, including the setpoints, tuning parameters, and object database.
    k. Graphics: A glossary or icon symbol library detailing the function of each graphic icon and graphics creation and modification. One set of CDs containing files of all color graphic screens created for the project.

D. Training Manual:

1. Provide a course outline and training manuals for each training class.

E. Record Documents:

1. Submit record documentation per Section 23 05 00.

2. Provide a complete set of "as-built" drawings and application software on CDs. Provide drawings as AutoCAD™ or Visio™ compatible files. Provide two copies of the "as-built" drawings with revisions clearly indicated in addition to the documents on compact disk. All as-built drawings shall also be installed on the FMCS server in a dedicated directory. Provide all product data sheets in PDF format.
3. Submit two hard copies and one electronic copy of as-built versions of the shop drawings, including product data and record drawings with revisions clearly indicated. Provide floor plans showing actual locations of control components including panels, thermostats, sensors, and hardware.
4. Provide all completed testing and commissioning reports and checklists, along with all trend logs for each system identified in the points lists.
5. Submit printouts of all graphic screens with current values (temperatures, pressures, etc.) to the Architect/Engineer verifying completion and proper operation of all points.

1.5 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

B. Factory-Mounted Components: Where control devices specified in this section are indicated to be factory mounted on equipment, arrange for shipping control devices to unit manufacturer.

1.6 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Control Valves.

B. Flow Switches.

C. Temperature Sensor Sockets.

D. Gauge Taps.

E. Automatic Dampers.

F. Flow Meters.

1.7 AGENCY AND CODE APPROVALS

A. All products shall have the following agency approvals. Provide verification that the approvals exist for all submitted products with the submittal package.

1. UL-916; Energy Management Systems.
2. C-UL listed to Canadian Standards Association C22.2 No. 205-M1983 "Signal Equipment."
3. EMC Directive 89/336/EEC (European CE Mark).
4. FCC, Part 15, Subpart J, Class A Computing Devices.

1.8 ACRONYMS

A. Acronyms used in this specification are as follows:

1. B-AAC BACnet Advanced Application Controller
2. B-ASC BACnet Application Specific Controller
3. BTL BACnet Testing Laboratories
4. DDC Direct Digital Controls
5. FMCS Facility Management and Control System
6. GUI Graphic User Interface
7. IBC Interoperable BACnet Controller
8. IDC Interoperable Digital Controller
9. LAN Local Area Network
10. NAC Network Area Controller
11. ODBC Open DataBase Connectivity
12. OOT Object Oriented Technology
13. OPC Open Connectivity via Open Standards
14. PICS Product Interoperability Compliance Statement
15. PMI Power Measurement Interface
16. POT Portable Operator's Terminal
17. TCC Temperature Control Contractor
18. TCS Temperature Control System
19. WAN Wide Area Network
20. WBI Web Browser Interface

1.9 SUMMARY

A. Provide new standalone FMCS for this project.

B. TCC shall furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS) and Facility Management and Control System (FMCS) using Direct Digital Controls as shown on the drawings and as described herein.

C. All labor, material, equipment and software not specifically referred to herein or on the plans that is required to meet the intent of this specification shall be provided without additional cost to the Owner.

D. The Owner shall be the named license holder of all software associated with any and all incremental work on the project.

1.10 SYSTEM DESCRIPTION

A. The entire TCS shall be comprised of a network of interoperable, standalone digital controllers communicating via the following protocol to an NAC. Temperature Control System products shall be as specified below.

B. The FMCS shall include Network Area Controller or Controllers (NAC) within each facility. The NAC shall connect to the Owner's local or wide area network, depending on configuration. Provide access to the system, either locally in each building or remotely from a central site or sites, through standard Web browsers, via the Internet, and/or via local area network.

C. Provide materials and labor necessary to connect factory supplied control components.

D. Provide central and remote hardware, software, and interconnecting wire and conduit.

E. The FMCS shall include automated alarming software capable of calling e-mail compatible cellular telephones and pagers. The e-mail alarm paging system shall be able to segregate users, time schedules, and equipment and be capable of being programmed by the Owner.

F. For the dedicated configuration tool provided, it is preferable that it be launched from within the applicable Network Management Software. If not, include any software required for controller configuration as a leave-behind tool with enough license capability to support the installation.

G. For each operator workstation provided, furnish one legal copy of all software tools, configuration tools, management tools, and utilities used during system commissioning and installation. All tools shall be readily available in the market. Contractor shall convey to the Owner all software tools and their legal licenses at project closeout.

1.11 SOFTWARE LICENSE AGREEMENT

A. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job-specific configuration documentation, data files, configuration tools, and application-level software developed for the project. This shall include, but is not limited to, all custom, job-specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, FMCS Server(s), and any related LAN/WAN/intranet and/or Internet connected routers and devices. Provide the Owner with all required IDs and passwords for access to any component or software program. The Owner shall determine which organizations shall be named in the SI organization ID ("orgid") of all software licenses. Owner shall be free to direct the modification of the "orgid" in any software license, regardless of supplier.

1.12 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It is this Contractor's responsibility to check the Contract Documents for possible conflicts between the Work of this section and that of other crafts in equipment location; pipe, duct and conduit runs; electrical outlets and fixtures; air diffusers; and structural and architectural features.

1.13 WARRANTY

A. Refer to Section 23 05 00 for warranty requirements.

B. Within the warranty period, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by this Contractor at no expense to the Owner.

C. Warranty requirements include furnishing and installing all FMCS software upgrades issued by the manufacturer during the one-year warranty period.

D. Update all software and back-ups during warranty period and all user documentation on the Owner's archived software disks.

1.14 WARRANTY ACCESS

A. The Owner shall grant to this Contractor reasonable access to the TCS and FMCS during the warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. BACnet Protocol:

1. Siemens Building Technologies: APOGEE (Basis of Design) County Standard - No Substitutions

2.2 SYSTEM ARCHITECTURE

A. General:

1. The Temperature Control System (TCS) and Facility Management Control System (FMCS) shall consist of a network of interoperable, standalone digital controllers, a computer system, graphic user interface software, printers, network devices, valves, dampers, sensors, and other devices as specified herein.
2. The installed system shall provide secure password access to all features, functions and data contained in the overall FMCS.

B. Open, Interoperable, Integrated Architectures:

1. All components and controllers supplied under this Division shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data are not acceptable.

2. The supplied system must be able to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs are not acceptable.
3. Hierarchical or "flat" topologies are required to have system response times as indicated below and to manage the flow and sharing of data without unduly burdening the customer's internal intranet network.

    a. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
    b. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.3 NETWORKS

A. The Local Area Network (LAN) shall be a 100 megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and SOAP. Provide support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local server.

B. Local area network minimum physical and media access requirements:

1. Ethernet; IEEE Standard 802.3.
2. Cable; 100 Base-T, UTP-8 wire, Category 6.
3. Minimum throughput; 100 Mbps.

C. Communication conduits shall not be installed closer than six feet from 110VAC or higher transformers or run parallel within six feet of electrical high-power cables. Route the cable as far from interference generating devices as possible. Where communication wire must cross 110VAC or higher wire, it must do so at right angles.

D. Ground all shields (earth ground) at one point only to eliminate ground loops. Provide all shield grounding at the controller location, with the shield at the sensor/device end of the applicable wire being left long and "safed" off in an appropriate manner.

E. There shall be no power wiring more than 30 VAC rms run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, run all communication wiring and signal wiring using separate twisted pairs (24awg) in accordance with the manufacturer's wiring practices.

2.4 REMOTE NETWORK ACCESS

A. For Local Area Network installations, provide access to the LAN from a remote location via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP.

2.5 NETWORK AREA CONTROLLER (NAC)

A. The TCC shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of NACs required depends on the type and quantity of devices provided under Divisions 23 and 26. The TCC shall determine the quantity and type of devices.

B. Each NAC shall provide the interface between the LAN or WAN and the field control devices and shall provide global supervisory control functions over the control devices connected to the NAC. It shall execute application control programs to provide:

1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of all controller data.
7. Network Management functions.

C. The Network Area Controller shall provide the following hardware features as a minimum:

1. One Ethernet Port - 10/100 Mbps.
2. One RS-232 port.
3. One RS-485 port.
4. Battery backup.
5. Flash memory for long-term data backup. (If battery backup or flash memory is not supplied, the controller shall contain a hard disk with at least 1 gigabyte storage capacity.)
6. The NAC must be capable of operation over a temperature range of 32°F to 122°F.
7. The NAC must be capable of withstanding storage temperatures of between 0°F and 158°F.
8. The NAC must be capable of operation over a humidity range of 5% RH to 95% RH, non-condensing.

D. The NAC shall provide multiple user access to the system and support for ODBC or SQL. Databases resident on the NAC shall be ODBC-compliant or must provide an ODBC data access mechanism to read and write data stored within it.

E. The NAC shall support standard Web browser access via the Internet or an intranet and a minimum of five (5) simultaneous users.

F. Event Alarm Notification and Actions:

1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a LAN, remote via dial-up telephone connection, or WAN.
3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:

    a. Alarm
    b. Normal

4. Provide for the creation of a minimum of eight alarm classes with different routing and acknowledgement properties, e.g. security, HVAC, Fire, etc.
5. Provide timed (scheduled) routing of alarms by class, object, group, or node.
6. Provide alarm generation from binary object "runtime" and/or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

G. Treat control equipment and network failures as alarms and annunciated.

H. Annunciate alarms in any of the following manners as defined by the user:

1. Screen message text.
2. E-mail of the complete alarm message to multiple recipients. Provide the ability to route and e-mail alarms based on:

    a. Day of week.
    b. Time of day.
    c. Recipient.

3. Pagers via paging services that initiate a page on receipt of e-mail message.
4. Graphic with flashing alarm object(s).
5. Printed message, routed directly to a dedicated alarm printer.

I. The FMCS shall record the following for each alarm:

1. Time and date.
2. Location (building, floor, zone, office number, etc.).
3. Equipment tag.
4. Acknowledge time, date, and user who issued acknowledgement.
5. Number of occurrences since last acknowledgement.

J. Give defined users proper access to acknowledge any alarm.

K. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.

L. Provide a "query" feature to allow review of specific alarms by user-defined parameters.

M. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

N. An error log to record invalid property changes or commands shall be provided and available for review by the user.

2.6 BACNET FMCS

A. The intent of this specification is to provide a peer-to-peer networked, standalone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices in the system. Adherence to industry standards including the latest ANSI/ASHRAE Standard 135 (BACnet) to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP) and/or RS-485 (BACnet MSTP).

C. Interoperable BACnet Controller (IBC):

1. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the latest ANSI/ASHRAE Standard 135. Provide IBCs for unit ventilators, fan coils, heat pumps, terminal air boxes (TAB) and other applications. The application control program shall reside in the same enclosure as the input/output circuitry that translates the sensor signals. Provide a PICS document showing the installed system's compliance level to ANSI/ASHRAE Standard 135. Minimum compliance is Level 3.
2. The IBCs shall be listed by the BACnet Testing Laboratory (BTL) as follows:

    a. BACnet Building Controller(s) (B-BC).
    b. BACnet Advanced Application Controller(s) (B-ACC).
    c. BACnet Application Specific Controller(s) (B-ASC).

3. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.

4. Each IBC sensor shall connect directly to the IBC and shall not use any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.
5. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable) require a 10% spare point capacity to be provided for all applications. Store all control sequences within or programmed into the IBC in non-volatile memory that does not depend on a battery to be retained.
6. The Contractor supplying the IBCs shall provide documentation for each device, with the following information at a minimum:

    a. BACnet Device; MAC address, name, type and instance number.
    b. BACnet Objects; name, type and instance number.

7. It is the responsibility of the Contractor to ensure that the proper BACnet objects are provided in each IBC.

D. Object Libraries:

1. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
2. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
3. In addition to the standard libraries specified here, the system supplier shall maintain an on-line accessible (over the Internet) library, available to all registered users, to provide new or updated objects and applications as they are developed.
4. All control objects shall conform to the control objects specified in the BACnet specification.
5. The library shall include applications or objects for the following functions, at a minimum:

    a. Scheduling Object: The schedule must conform to the schedule object as defined in the BACnet specification, providing seven-day plus holiday and temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphic sliders to speed creation and selection of on-off events.
    b. Calendar Object: The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphic "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.

c. Override Object: Provide override object that is capable of restarting equipment turned off by other energy saving programs to maintain occupant comfort or for equipment protection.
d. Start-Stop Time Optimization Object: Provide a start-stop time optimization object to start equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled unoccupied time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start-stop time object properties based on historical performance.
e. Demand Limiting Object: Provide a demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, gas, etc.). The object shall be able to monitor a demand value and predict (using a sliding window prediction algorithm) the demand at the end of the user-defined interval period (1 to 60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user-defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment setpoints to provide the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the setpoint, display a message on the user's screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to provide both equipment protection and occupant comfort.

6. The library shall include control objects for the following functions:

a. Analog Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
b. Analog Output Object: Minimum requirement is to comply with the BACnet standard for data sharing.
c. Binary Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment runtime by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.

d. Binary Output Object: Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as start-to-start delay must be provided. Incorporate the BACnet Command Prioritization priority scheme to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide 16 levels of priority as a minimum. Systems not employing the BACnet method of contention resolution are not acceptable.
e. PID Control Loop Object: Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable to allow proportional control only, or proportional with integral control, or proportional, integral and derivative control.
f. Comparison Object: Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
g. Math Object: Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.
h. Custom Programming Objects: Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including, but not limited to, math and logic functions and string manipulation. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for reuse.
i. Interlock Object: Provide an interlock object that provides a means of coordination of objects within a piece of equipment, such as an air handler or other similar types of equipment. An example is to link the return fan to the supply fan such that, when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming, thereby eliminating nuisance alarms during the off period.
j. Temperature Override Object: Provide an object whose purpose is to override a binary output to an "on" state in the event a user-specified high or low limit value is exceeded. Link this object to the desired binary output object as well as to an analog object for temperature monitoring to cause the override to be enabled. This object will execute a start command at the Temperature Override level of start/stop command priority, unless changed by the user.

k. Composite Object: Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the "contained" application that are represented on the graphic shell of this container.

7. The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). Provide the following as part of the standard library included with the programming software:

   a. LonMark/LonWorks Devices: These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific objects to facilitate simple integration of these devices. Support all network variables defined in the LonMark profile. The device manufacturer shall provide information (type and function) regarding network variables not defined in the LonMark profile.
   b. For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file, resource file, and documentation for the device to facilitate device integration.
   c. For BACnet devices, provide the following objects:

      1) Analog In.
      2) Analog Out.
      3) Analog Value.
      4) Binary.
      5) Binary In.
      6) Binary Out.
      7) Binary Value.
      8) Multi-State In.
      9) Multi-State Out.
      10) Multi-State Value.
      11) Schedule Export.
      12) Calendar Export.
      13) Trend Export.
      14) Device.

   d. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.
   e. For BACnet devices, provide the following support at a minimum:

      1) Segmentation.
      2) Segmented Request.
      3) Segmented Response.
      4) Application Services.
      5) Read Property.
      6) Read Property Multiple.
      7) Write Property.

8) Write Property Multiple.
9) Confirmed Event Notification.
10) Unconfirmed Event Notification.
11) Acknowledge Alarm.
12) Get Alarm Summary.
13) Who-has.
14) I-have.
15) Who-is.
16) I-am.
17) Subscribe COV.
18) Confirmed COV notification.
19) Unconfirmed COV notification.
20) Media Types.
21) Ethernet.
22) BACnet IP Annex J.
23) MSTP.
24) BACnet Broadcast Management Device (BBMD) function.
25) Routing.

2.7 DATA COLLECTION AND STORAGE (TRENDING REQUIREMENTS)

A. The NAC shall be able to collect data for any property of any object and store resident in the NAC that shall have, at a minimum, the following configurable properties:

1. Designating the log as interval or deviation.
2. For interval logs, configure the object for time of day, day of week and the sample collection interval.
3. For deviation logs, configure the object for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
4. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full or rollover the data on a first-in, first-out basis.
5. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

B. Store all log data in a relational database in the NAC that is accessible from a server (if the system is so configured) or a standard Web browser.

C. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

D. All log data shall be available to the user in ALL the following data formats:

1. HTML.
2. XML.
3. Plain text.
4. Comma or tab separated values.

E. The NAC shall archive its log data either locally (to itself) or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties:

1. Archive on time of day.
2. Archive on user-defined number of data stores in the log (buffer size).
3. Archive when log has reached its user-defined capacity of data stores.
4. Provide ability to clear logs once archived.

2.8 AUDIT LOG

A. Provide and maintain an audit log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:

1. Time and date.
2. User ID.
3. Change or activity: i.e., change setpoint, add or delete objects, commands, etc.

2.9 DATABASE BACKUP AND STORAGE

A. The NAC shall automatically backup its database on a user-defined time interval.

B. Store copies of the current database and, at the most, the recently saved database in the NAC. The age of the most recently saved database shall depend on the user-defined database save interval.

C. Store the NAC database in XML format to allow viewing and editing. Other formats are acceptable as long as XML format is supported.

2.10 GRAPHIC USER INTERFACE SOFTWARE

A. Operating System:

1. Provide computer with the most current Microsoft-based operating system with which the GUI has proven compatibility.

B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu pulldowns and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line) that displays the location and the selected object identification.

C. Point Organization: Organize points by equipment categories, location, or other means acceptable to Owner.

D. Real-Time Displays: The GUI shall support the following graphic features and functions:

1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file. Use of proprietary graphic file formats is not acceptable. In addition to, or in lieu of, a graphic background, the GUI shall support the use of scanned pictures.
2. Graphic screens shall be able to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.
3. Graphics shall support layering, and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
4. Modifying common application objects, such as schedules, calendars, and setpoints, shall be accomplished graphically.

    a. Schedule times shall be adjusted using a graphic slider without requiring any keyboard entry from the operator.
    b. Holidays shall be set by using a graphic calendar without requiring any keyboard entry from the operator.

5. Commands to start and stop binary objects shall be made by selecting the object and the appropriate command from a pop-up menu. No text entry shall be required.
6. Adjustments to analog objects, such as setpoints, shall be made by selecting the object and using a graphic slider to adjust the value. No text entry shall be required.

E. System Configuration: At a minimum, the GUI shall include the necessary software and components to enable the operator to perform the following tasks with proper password access:

1. Create, delete or modify control strategies.
2. Add/delete objects.
3. Tune control loops by adjusting control loop parameters.
4. Enable or disable control strategies.
5. Generate hard copy records or control strategies on a printer.
6. Select alarm points and define the alarm state.
7. Select points to be trended and initiate the recording of values automatically.
8. View any trend as a graph.

F. On-Line Help: Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available using hypertext. All system documentation and help files shall be in HTML format.

G. Security: Each operator shall be required to log on to that system with a user name and password to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall be able to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operator's access for viewing and/or changing each system application, full screen editor, and object. Each operator shall be automatically logged off the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. Store all system security data in an encrypted format.

H. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. Annunciate the failure of any device to the operator.

I. Alarm Console:

1. The system shall have a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and to acknowledge the alarm.
2. When the alarm console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator are not acceptable. The use of the alarm console can be enabled or disabled by the system administrator.

2.11 WEB BROWSER CLIENTS

A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Firefox™, or Chrome. Systems requiring additional software to enable a standard Web browser to reside on the client machine, or manufacturer-specific browsers, are not acceptable.

B. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphic User Interface. Systems that require different views or that require different means of interacting with objects, such as schedules or logs, are not permitted.

C. The Web browser client shall provide:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, display a blank web page. Implement security using Java authentication and encryption techniques to prevent unauthorized access.
2. Graphic screens developed for the GUI shall be the same screens used for the Web browser client. The web browser interface shall support all animated graphic objects supported by the GUI.
3. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

4. Store all graphic screens in the Network Area Controller (NAC) without requiring any graphics storage on the client machine.
5. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

    a. Modify common application objects, such as schedules, calendars, and setpoints, graphically.

        1) Schedule times shall be adjustable using a graphic slider, without requiring any keyboard entry from the operator.
        2) Holidays shall be set using a graphic calendar, without requiring any keyboard entry from the operator.

    b. Commands to start and stop binary objects shall be made by right-clicking the selected object and selecting the appropriate command from a pop-up menu. No text entry shall be required.
    c. View logs and charts.
    d. View and acknowledge alarms.
    e. Setup and execute SQL queries on log and archive information

7. The system shall be able to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just his/her defined home page. From the home page, links to other views or pages in the system shall be possible, if allowed by the system administrator.
8. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on intranet sites by specifying the Uniform Resource Locator (URL) for the desired link.

2.12 SERVER FUNCTIONS AND HARDWARE

A. Provide a central server located at Administration Building. The server shall support all NACs connected to the customer's network whether local or remote.

B. Local connections shall be via an Ethernet LAN. Remote connections can be via ISDN, ADSL, T1, or dial-up connection.

C. It shall be possible to provide access to all NACs via a single connection to the server. In this configuration, each NAC can be accessed from a remote GUI or from a standard WBI by connecting to the server.

D. The server shall provide the following functions:

1. Global Data Access: The server shall provide complete access to distributed data defined anywhere in the system.
2. Distributed Control: The server shall provide the ability to execute global control strategies based on control and data objects in any NAC in the network, local or remote.

3. The server shall include a master clock service for its subsystems and provide time synchronization for all NACs.
4. The server shall accept time synchronization messages from trusted precision atomic clock Internet sites and update its master clock based on this data.
5. The server shall provide scheduling for all Network Area Controllers and their underlying field control devices.
6. The server shall provide demand limiting that operates across all NACs. The server must be capable of running multiple demand programs for sites with multiple meters and/or multiple sources of energy. Each demand program shall be able to support separate demand shed lists.
7. The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to NACs.
8. Each NAC supported by the server shall be able to automatically archive its log data, alarm data and database to the server. Archiving options shall be user-defined, including archive time and archive frequency.
9. The server shall provide central alarm management for all NACs supported by the server. Alarm management shall include:

    a. Routing alarms to display, printer, e-mail, and pagers.
    b. Viewing and acknowledging alarms.
    c. Querying alarm logs based on user-defined parameters.

10. The server shall provide central management of log data for all NACs supported by the server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:

    a. Viewing and printing log data.
    b. Exporting log data to other software applications.
    c. Querying log data based on user-defined parameters.

11. Reports shall be generated automatically or manually, and directed to LCD displays, printers, or disk files. The system shall allow the user to easily obtain the following types of reports:

    a. List all points in network.
    b. List all points in alarm.
    c. List all off-line points.
    d. List all points in override status.
    e. List all disabled points.
    f. List all points that are locked out.
    g. List all items defined in a "follow-up" file.
    h. List all weekly and holiday schedules.
    i. List all limits and deadbands.

E. Server Hardware Requirements:

1. Provide a High-Mid Range CPU as defined by www.cpubenchmark.net (minimum processing speed of 2.9 GHz with 8.0 GB RAM and a 1-terabyte minimum hard drive). It shall include one parallel port, one asynchronous serial port and four USB ports. Include a 21" minimum flat panel color monitor, 8ms response time.
2. The server operating system shall be the latest version of Microsoft Windows and Microsoft internet browser.
3. Connect to the FMCS network via an Ethernet network interface card, 1 Gbps.
4. Provide a color laser printer with a minimum 600 x 600-dpi resolution and 12 ppm print speed.
5. For dedicated alarm printing, provide a continuous feed printer using roll or fan-fed microperforated paper. The printer shall have a parallel port interface.

2.13 GRAPHIC USER INTERFACE COMPUTER HARDWARE (LAPTOP COMPUTER)

A. Provide a High-Mid Range CPU as defined by www.cpubenchmark.net with 8 GB RAM and 750-gigabyte minimum hard drive. Laptop computer shall be equipped with minimum 15" screen.

B. The workstation operating system shall be the latest version of Microsoft Windows and Microsoft internet browser.

C. Connect to the FMCS network via a 10/100 Mbps Ethernet network interface card.

D. Provide a color laser system printer with a minimum 600 x 600-dpi resolution and 12 ppm print speed.

2.14 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. A UPS shall be provided for each of the following:

1. FMCS workstations and servers.
2. Network area controllers.

B. Provide a 120-volt 60 Hz line-interactive uninterruptible power supply with backup battery capacity for two (2) minutes at 100% load. UPS shall have hot swappable batteries, automatic battery self-test and start-on-battery capabilities. Batteries shall be valve regulated, sealed lead acid type. UPS shall have sine wave shape output waveform. UPS shall be UL 1778 list and comply with FCC Part 15, Class A.

C. Manufacturers:

1. Eaton Powerware
2. APC

2.15 SYSTEM PROGRAMMING

A. The GUI software shall perform system programming and graphic display engineering. Access to the GUI software shall be through password access as assigned by the system administrator.

B. Provide a library of control, application, and graphic objects to enable creation of all applications and user interface screens. Applications shall be created by selecting the control objects from the library, dragging or pasting them on the screen, and linking them together using a built-in graphic connection tool. Completed applications may be stored in the library for future use. GUI screens shall be created in the same fashion. Data for the user displays shall be obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Provide all software tools or processes to create applications and user interface displays.

C. Programming Methods:

1. Provide the capability to copy objects from the supplied libraries or from a user-defined library to the user's application. Link objects with a graphic linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; e.g., internal, external, hardware, etc.
2. Configuration of each object shall be done through the object's property sheet using fill-in-the-blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration is not acceptable.
3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
4. All programming shall be done in real time. Systems requiring the uploading, editing, and downloading of database objects are not allowed.
5. The system shall support object duplication in a customer's database. An application, once configured, can be copied and pasted for easy reuse and duplication. All links, other than to the hardware, shall be maintained during duplication.

2.16 DDE DEVICE INTEGRATION

A. The NAC shall support the integration of device data via Dynamic Data Exchange (DDE) over the Ethernet network. The NAC shall act as a DDE client to another software application that functions as a DDE server.

B. Provide the required objects in the library included with the Graphic User Interface programming software to support the integration of these devices into the FMCS. Objects provided shall include, at a minimum:

1. DDE Generic AI Object.
2. DDE Generic AO Object.
3. DDE Generic BO Object.
4. DDE Generic BI Object.

2.17 MODBUS SYSTEM INTEGRATION

A. The NAC shall support integration of device data from Modbus RTU, ASCII, and TCP control system devices. Connect to the Modbus system via an RS-232, RS485, or Ethernet IP as required by the device.

B. Provide the required objects in the library included with the GUI programming software to support the integration of the Modbus system data into the FMCS. Objects provided shall include, at a minimum:

1. Read/Write Modbus AI Registers.
2. Read/Write Modbus AO Registers.
3. Read/Write Modbus BI Registers.
4. Read/Write Modbus BO Registers.

C. The NAC shall perform all scheduling, alarming, logging and global supervisory control functions of the Modbus system devices.

D. The FMCS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment using Modbus shall provide documentation of the system's Modbus interface and shall provide factory support at no charge during system commissioning.

2.18 OPC SYSTEM INTEGRATION

A. The Network Area Controller shall act as an OPC client and shall support the integration of device data from OPC servers. The connection to the OPC server shall be Ethernet IP. The OPC client shall support third-party OPC servers compatible with the Data Access 1.0 and 2.0 specifications.

B. Provide the required objects in the library included with the GUI programming software to support the integration of the OPC system data into the FMCS. Objects provided shall include:

1. Read/Write OPC AI Object.
2. Read/Write OPC AO Object.
3. Read/Write OPC BI Object.
4. Read/Write OPC BO Object.
5. Read/Write OPC Date/Time Input Object.
6. Read/Write OPC Date/Time Output Object.
7. Read/Write OPC String Input Object.

8. Read/Write OPC String Output Object.

C. The NAC shall perform all scheduling, alarming, logging and global supervisory control functions of the OPC system devices.

D. The FMCS supplier shall provide an OPC client communications driver. The vendor that provided the equipment using OPC shall provide documentation of the system's OPC server interface and shall provide free factory support during system commissioning.

2.19 SOFTWARE

A. IDC/IBCs shall operate totally standalone and independent of a central computer for all specified control applications.

B. Software shall include a complete operating system (OS), communications handler, point processing, energy management application packages as specified herein, standard control algorithms and specific control sequences (IDC/IBC) and an Owner/user custom control calculation package complete with interpreter.

C. OS software shall be PROM resident, operate in real time, provide prioritized task scheduling, control time programs, monitor and manage communications, and scan inputs and outputs.

D. Each IDC/IBC panel shall include the following energy management routines:

1. Time of day scheduling.
2. Optimum start/stop.
3. Peak demand limiting.
4. Economizer control.
5. PID control.
6. Supply air reset.
7. Outdoor air reset.

E. Input/output point processing software shall include:

1. Update of all connected input and output points at least once per second.
2. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32-bit floating point format. Retain both the maximum and minimum values sensed for each analog input in memory. It shall be possible to input subsets of standard sensor ranges to the A/D converter and assign gains to match the full-scale 32-bit conversion to achieve high accuracy readout.
3. A reasonability check on all analog inputs against previous values and discarding of values falling outside preprogrammed reasonability limits.
4. Assignment of proper engineering units and status conditions to all inputs and outputs.

5. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and alarm) to an input or to assign a set of floating limits (alarm a reset schedule or FMCS control point) to the input. Assign each alarm a unique differential to prevent a point from oscillating in and out of alarm. Make alarm comparisons of each scan cycle.
6. Adjustment of timing from two seconds to two minutes in one-second increments to eliminate nuisance alarms on startup.

F. Command Control software shall manage the receipt of commands from the server and from control programs.

1. Provide command delay to prevent simultaneous energizing of loads. Delay must be programmable from 0 to 30 seconds.
2. Assign each command a command and residual priority to manage conflicts created by multiple programs having access to the same command point. Allow only outputs with a higher command priority to execute. Whenever a command is allowed to execute, its assigned residual priority shall replace the existing residual priority.
3. A "fixed mode" option (override) shall allow inputs to and outputs from control programs to set to a fixed state or value. When in the "fixed mode", assign inputs and outputs high residual command priority to prevent override by application programs.

G. Alarm lockout software shall prevent nuisance alarms. On initial start-up of mechanical equipment, assign a "timed lockout" period to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period shall be programmable for each point from 0 to 90 minutes in one-minute increments.

H. A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when a true alarm depends on the condition of an associated point. Hard lockout points and lockout initiators shall be operator programmable.

I. Runtime shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Runtime counts shall reside in non-volatile memory and have DCP resident runtime limits assignable through the operator's terminal.

J. A transition counter shall count the number of times a device is cycled on or off. Counter shall be non-volatile and capable of counting 600,000 cycles. Limits shall be assignable to counts to provide maintenance alarm printouts.

K. Custom IDC/IBC programs shall meet the control strategies called for in the sequence of operation of these specifications. Each IDC/IBC shall have resident in its memory and available to the programs a full library of IDC/IBC algorithms, intrinsic control operators, arithmetic, logic, and relational operators. Provide the following features:

1. Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning). Use Adaptive Control where the controlled flow rate is variable (such as TAB units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response to output corrections and adjust the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that, on system shutdown and restart, the learning process starts from where it left off. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.
2. All IDC/IBC setpoints, gains and time constants associated with IDC/IBC programs shall be available to the operator for display and modification via the operator workstation.
3. The execution interval of each IDC/IBC loop shall be adjustable from 2 to 120 seconds in one-second increments.
4. IDC/IBC control programs shall assign initialization values to all outputs so controlled devices assume a failsafe position on start-up.

L. Provide time and event programming (TEP) capability to initiate a controlled sequence of events for execution at a specific time or upon the occurrence of an event. Minimum program features required are:

1. Analog points commandable to a specific value.
2. Digital points commandable to a specific state; e.g. on or off; fast, slow or off.
3. Initiator to be a specific day and time or a specific event; e.g. an alarm.
4. Manual initiation via operator's command.
5. Commands must honor command delays (to prevent current surges), and assigned minimum ON and OFF times.
6. Commands must honor command and residual priority structures allowing higher priority commands (like smoke control) to override lower priority commands (like time of day scheduling) and residual priority.
7. Ability to chain TEPs.
8. Ability to enable and disable TEPs individually.
9. Ability to enable/disable TEP initiators.

M. Store Energy Management application programs and associated data files in non-volatile or 72-hour battery backed RAM memory. Individual programs shall be accessible from the operator workstation for enabling/disabling and program parameter modification and shall include:

1. Time Programs:
    a. Provide an independent start and stop program time for each system identified in the points list.
    b. It shall be possible to assign two independent start and stop times/days to any equipment connected to a controller.

2. Exception Day Scheduling:

    a. Provide an Exception Day program for holiday and other planned exceptions to time programs. Exception schedules shall be DSC resident and operator programmable up to one year in advance.
    b. The program shall allow definition of up to 32 exception time spans. Define each span by calendar start day and calendar stop day.

3. An IDC/IBC resident temporary scheduler shall allow operators to modify present time program control of equipment. Minimum feature set required is:

    a. Ability to alter time schedules as much as six days in advance.
    b. Ability to alter either start time, stop time or both for each day.
    c. Temporary schedule shall be in effect for all days specified.
    d. Automatically delete the temporary schedule and restore program to normal schedule after execution.
    e. Ability to assign schedule changes as permanent as well as temporary.

N. The IDC/IBC shall have built-in, non-descriptive, self-test procedure for checking the indication lights, digital display, and memory. It shall display advisories for maintenance, performance, and/or software problems.

O. All electronics shall be:

1. Standard locally stocked modular boards.
2. Plug-in type.
3. Furnish all ROM programs unlocked.

2.20 VARIABLE FREQUENCY DRIVES

A. The following variable frequency drives shall be furnished and installed by the TCC:

1. All project VFDs
2. Air handling units

B. Power connection between VFD and motor shall be by EC. Coordinate feeder and raceway installation with EE.

2.21 CONTROL DAMPERS

A. Rectangular Control Dampers - Standard Construction:

1. Shall be licensed to bear the AMCA Certified Rating Seal.
2. Test leakage and pressure drop per AMCA 500.
3. Frame: Hat-shaped channel, minimum 12 gauge extruded aluminum, and minimum 4" deep. Caulk or weld seams to prevent leakage.
4. Blades: Minimum 12 gauge extruded aluminum airfoil design, minimum 6" wide, and overlapping blades and blade seals (overlapping blade seals only is unacceptable).

5. Shaft: Non-cylindrical, solid aluminum or zinc plated steel with opening in blade to match profile of shaft. Shaft shall be securely fastened to the blade and of sufficient length to mount direct-coupled actuator. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.
6. Bearings: Acetal (Delrin/Celcon) inner bearing fixed to an aluminum shaft, rotating within a polycarbonate outer bearing inserted in the frame. Provide thrust bearings for vertical damper applications.
7. Blade Seals: Extruded silicone gaskets secured in an integral slot within the blade.
8. Side Seals: Stainless steel compression type or extruded silicone gasket secured in an integral slot within the frame.
9. Linkage: Shall be concealed in the frame, constructed of aluminum or corrosion-resistant zinc plated steel, and securely fastened to shaft. Blades linked for opposed operation, unless noted otherwise on the drawings. Blades shall close evenly. Use one direct-coupled actuator per damper section. Jack-shafting is not acceptable.
10. Size Limits: 48" maximum horizontal blade length, 24 square foot maximum area per damper. Total cross-sectional area of dampers in ducts shall be at least as large as the duct without the use of blank-off sections.
11. Maximum Leakage: Class 1A at 1" w.c. pressure differential for a 24" x 24" damper.
12. Maximum Pressure Drop for Opposed Blade Damper: 0.15" for 8,000 cfm through a 24" x 24" damper (2000 fpm).
13. Maximum Pressure Drop for Parallel Blade Damper: 0.08" for 8,000 cfm through a 24" x 24" damper (2000 fpm).

B. Round Galvanized Steel Control Dampers:

1. Test leakage and pressure drop per AMCA 500.
2. Frame: Minimum 20 gauge galvanized steel, 10" long.
3. Bearings: Provide thrust bearings for vertical damper applications.
4. Blades: Two-layer galvanized steel, equivalent 14 gauge thickness with neoprene or polyethylene foam seal enclosed in two-piece blade construction up to 24", 10 gauge steel over 24".
5. Linkage: Stainless steel, minimum 1/2" diameter shaft through 24", 3/4" shaft over 24" size. Stainless steel bearings. Shaft shall be securely keyed to blades and of sufficient length to mount direct-coupled actuator. Install damper with the shaft horizontal to the floor. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.
6. Maximum Leakage: 8 cfm maximum at 1" w.c. pressure differential for a 24" x 24" damper.
7. Maximum Pressure Drop: 0.10" for 6,280 cfm through a 24" damper (2,000 fpm).

## 2.22 DAMPER ACTUATORS

A. Damper Actuators - Electronic:

1. Actuator shall be UL 873 or 60730 listed and provided with NEMA housing for applicable environment, electronic overload protection to prevent actuator damage due to over-rotation. Mount actuator by means of a V-bolt dual nut clamp with a V-shaped toothed cradle, directly couple and mount to the valve bonnet stem, or ISO-style direct-coupled mounting pad. Actuators shall be capable of being mechanically and electrically paralleled to increase torque, if required.
2. Actuators shall be warranted for a period of five (5) years from the date of production, with the first two (2) years unconditional.
3. Proportional actuator position shall be proportional to analog or pulse width modulating signal from electronic control system.
4. Fail-Safe Dampers: Where shown on the drawings or sequences, fail-safe mechanism shall operate the damper to the fail position following power interruption.

    a. Mechanical/Spring: Mechanical spring return mechanism to drive controlled drive to an end position (open or close) on loss of power.
    b. Electronic: Electronic fail-safe shall incorporate an active balancing circuit to maintain equal charging rates among the capacitors. The power fail position shall be proportionally adjustable between 0 to 100% in 10 percent increments with a 10 second operational delay.
5. Feedback: Where shown on drawings or sequences, provide analog feedback signal for positive position indication.
6. Damper End Switches: Where shown on the drawings or sequences, provide end switches to prove damper reaches open/closed position.

## 2.23 CONTROL INSTRUMENTATION

A. Temperature Measuring Devices:

1. Electric Thermostats:

    a. Single Temperature - Line Voltage Electric: Integral manual ON/OFF/AUTO selector switch, minimum dead band of 5°F, concealed temperature adjustment, locking cover, rated for load, single or double pole as required.
    b. Single Temperature - Low Voltage Electric: Integral manual ON/OFF/AUTO selector switch, minimum dead band of 5°F, anticipator circuits, concealed temperature adjustment, locking cover, 24 V control transformer (if not included with unit under control), single or double pole as required.

2. Low Limit Switch:

    a. Provide one foot of sensing element for each one square foot of coil area, maximum element length 25 feet, of the vapor tension type, so that any point along the entire length of measuring element can trigger the switch.
    b. Provide 3" minimum radius capillary support clips at each turn.

c. Furnish each thermostat with one single pole, single throw normally-opened switch and one single pole, single throw normally-closed auxiliary switch.
d. Setpoint range shall be 15°F to 55°F with a permanent stop at 35°F.
e. Differential shall be fixed at approximately 5°F and supplied with manual reset.

B. Temperature Sensors:

1. Room Temperature Sensor:

a. Sensor Only: Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, no setpoint adjustment or override button.
b. Sensor with Setpoint Adjustment: Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, with exposed single setpoint adjustment (no numeric temperature scale - provide with a single warmer/cooler or red/blue visual scale), no override button.
c. Sensor with Override: Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, occupied/unoccupied override button with LED, no setpoint adjustment.
d. Sensor with Setpoint Adjustment and Override: Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, with exposed single setpoint adjustment (no numeric temperature scale - provide with a warmer/cooler or red/blue visual scale), occupied/unoccupied override button with LED.

2. Duct Temperature Sensor:

a. RTD type averaging sensor. 1000 ohm platinum RTD; accuracy: minimum +/- 1.2°F; range -40°F-220°F.
b. Sensing element shall have a minimum of 1 foot of sensor length for each 2 square feet of duct or coil area. Sensor shall be arranged evenly across the duct or coil such that no point in the duct or coil is more than 1 foot away from the sensor.
c. Probe type thermistors are acceptable in VAV box duct applications downstream of reheat coils.

C. Pressure Measuring Devices

1. Pressure Transmitters/Transducer:

a. Air-to-Air:

1) Provide transducer having the following minimum performance for measuring duct static pressure for VFD control or measuring differential pressure across filter banks:

a) Accuracy: ±1.0% FS
b) Non-Linearity, BFSL: ±0.96% FS
c) Hysteresis: 0.10% full scale
d) Non-Repeatability: 0.05% full scale
e) Thermal Effects (compensated range): 0°F to +150°F
f) Maximum Line Pressure: 10 PSI
g) Zero/Span Shift: 0.033%FS/°F
h) Long Term Stability: 0.5%FS/1year

2) Provide transducer with the following minimum performance for measuring differential pressure across piezometer fan inlet airflow measuring stations:

a) Unit shall come factory equipped with static tube attached.
b) Unit shall include: (1) LCD shall display differential pressure on face of sensor enclosure over the entire operational range, and (2) IPCC-rated polycarbonate enclosure with short circuit proof outputs and reverse polarity protected inputs.
c) Accuracy at 72°F: ±0.25% FS
d) Stability: ±0.25% full scale per year
e) Temperature Error: (1) Zero: ±0.025% full scale per °C, (2) Span: Maximum ±0.03% full scale per °C
f) Environmental Operating Range: 32°F to 140°F.
g) Overpressure: Proof: (1) 2 psi, (2) Burst: 3 psi
h) Humidity: 0% to 95% RH non-condensing.

D. Flow Measuring Devices:

1. Airflow Measuring Stations:

a. Duct Mounted Airflow Measuring Stations (AFMS) - Thermal Dispersion:

1) Provide airflow/temperature measurement devices where indicated on the plans.
2) Each AFMS shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

a) Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
b) Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.
c) Devices using chip-in-glass or diode-case chip thermistors are not acceptable.

d) Devices using less than two thermistors in each sensor assembly are not acceptable.
e) Devices using platinum wire RTDs are not acceptable.
f) Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.
g) Pitot tubes and arrays are not acceptable.
h) Vortex shedding devices are not acceptable.

3) All Sensor Probes:

a) Each sensor assembly shall independently determine the velocity and temperature at its measurement point.
b) Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
c) Airflow measuring station assembly accuracy shall be ± 2% of Reading over the entire operating airflow range. Temperature accuracy shall be ± 0.15° F between -20° F and 160° F.
d) The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
e) Each sensor probe shall have an integral, UL listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.
f) The number of probes shall be as recommended by the manufacturer to achieve the specified accuracy.

4) Duct and Plenum Probes:

a) Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.
b) Probe assembly mounting brackets shall be constructed of 304 stainless steel.
c) The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

5) Sensor Density:

| Area (sq.ft.) | Total # of Sensors Required |
|---|---|
| Less than 2 | 4 |
| 2 to less than 4 | 6 |
| 4 to less than 8 | 8 |
| 8 to less than 16 | 12 |
| ≥ 16 | 16 |

6) Transmitters:

a) The transmitter shall have an integral 16-character alphanumeric LCD display capable of simultaneously displaying individual airflow and temperature.
b) The transmitter shall be capable of field configuration and diagnostics using an on-board interface and LCD display.
c) The operating temperature range for the transmitter shall be -20° F to 120° F.
d) The transmitter shall be capable of communicating with other devices using one of the following interface options:
e) Option 1: Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)
f) Option 2: RS-485: Field selectable BACnet-ARCNET, BACnet-MS/TP, Modbus-RTU or Johnson Controls N2-Bus. BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.
g) Option 3: 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, Modbus-TCP and TCP/IP. Provide dynamic link libraries and VBA functions to interface Ethernet devices to Microsoft Excel for remote monitoring of airflow and temperature using a Windows 2000 or Windows XP based PC.
h) Option 4: LonWorks Free Topology

b. Fan Inlet Airflow Measuring Stations (AFMS) - Thermal Dispersion:

1) Sensor assemblies shall be mounted on 304 stainless steel housings.
2) Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.
3) Mounting feet shall be constructed of 304 stainless steel and securely riveted in place to prevent loosening over time due to vibration.
4) The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.
5) Transmitters

a) The transmitter shall have an integral 16-character alphanumeric LCD display capable of simultaneously displaying individual airflow and temperature.
b) The transmitter shall be capable of field configuration and diagnostics using an on-board interface and LCD display.
c) The operating temperature range for the transmitter shall be -20° F to 120° F.
d) The transmitter shall be capable of communicating with other devices using one of the following interface options:

e) Option 1: Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)
f) Option 2: RS-485: Field selectable BACnet-ARCNET, BACnet-MS/TP, Modbus-RTU or Johnson Controls N2-Bus. BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.
g) Option 3: 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, Modbus-TCP and TCP/IP. Provide dynamic link libraries and VBA functions to interface Ethernet devices to Microsoft Excel for remote monitoring of airflow and temperature using a Windows 2000 or Windows XP based PC.
h) Option 4: LonWorks Free Topology

6) The AFMS shall be UL listed as an entire assembly.

c. Mounting of fan inlet static pressure sensing elements shall be in accordance with manufacturer's published installation instructions to ensure accuracy of readings.

E. Current Measuring Devices:

1. Current Switches for Constant Speed Motors:

a. Digital device rated for amperage load of motor or device with split core design, adjustable high and low trip points, 600 VAC rms isolation, induced power from the monitored load, LED indicator lamps for output status and sensor power. The device shall sense overloading, belt-loss, and power failure with a single signal.

2. Current Switches for Motors Controlled by VFD:

a. Digital device rated for amperage load of motor or device with split core design, factory programmed to detect motor undercurrent conditions on variable or constant volume loads, self-calibrating, positive status indication, LED indicator lamps, 600 VAC rms isolation, induced power from the monitored load with NO output. The current sensor shall store the motor current operating parameters in non-volatile memory and have a pushbutton reset to clear the memory if the operating parameters change or the sensor is moved to another load. The device shall sense overloading, belt-loss, and power failure with a single signal. The sensor shall be mounted on the load side of variable frequency drives.

F. Occupancy Sensors:

1. Use auxiliary contacts on sensor provided and installed by the Electrical Contractor. Refer to electrical drawings for sensor location and specifications. Coordinate with Electrical Contractor.

2. Ceiling mounted, dual technology: sonic and passive infrared, 360° coverage pattern, zero crossing circuitry, adjustable sensitivity and time delay (initial setting: Time delay - 5 minutes unless noted otherwise below, integral isolated relay with normally open and normally closed outputs, LED indicator, five-year warranty, UL listed. TCC shall submit manufacturer supplied sensor layout drawing for shop drawing review. Provide full room coverage as recommended by manufacturer.
3. Space Occupancy Initial Setting Schedule
4. Initial Time
5. Space Delay Setting
6. Reception 20 minutes

G. Carbon Monoxide Sensors:

1. Solid-state gas sensor/transmitter, NEMA 1 gasketed enclosure, normal operating temperature 0-120°F, normal relative humidity operation 5-95%, ± 5% accuracy, and detection range of 0-200 ppm.
2. Provide 4-20 mA output from the sensor to the FMCS system.
3. Provide local alarm whenever carbon monoxide level exceeds 100 ppm.
4. It shall be compatible with BACnet network interface and shall input these values to the network area controller.
5. Install in accordance with OSHA requirements.
6. Unit shall be factory calibrated and shall be re-calibrated after installation per manufacturer's recommendations.

H. Carbon Dioxide Sensors:

1. Microprocessor based non-dispersive infrared sensor with range of 0 to 2,000 ppm CO2 with ± 100 ppm accuracy, maximum drift (compensated) of ± 5% full scale in five years, VOC software and hardware sensing, duct mounting where applicable, 0-10V dc or 4-20 mA output directly proportional to ppm, adjustable alarm limit, membrane filter, and terminal block. The diffusion gas chamber in the sensor shall incorporate a reflective light pipe or wave guide surrounded by a gas permeable membrane that prevents particulate contamination of the sensor. Unit shall have selectable IAQ mode with output signal and sum of CO2 and VOC levels.

I. Miscellaneous Devices:

1. Control Relays:

a. Form "C" contacts rated for the application with "push-to-test" contact transfer feature and an integral LED to indicate coil energization.
b. Mount all relays and power supplies in a NEMA 1 enclosure beside the FMCS panel or controlled device and clearly label their functions.

2. Thermostat and Sensor Enclosures:

a. Clear plastic guard with lock. Wire guard with tamperproof screws. Setpoint shall be adjustable with cover in place. Fasten to wall separately from thermostat. Provide guards in all corridors, gymnasiums, locker rooms, toilet rooms, assembly halls and as noted on the drawings.

3. Drain Pan Condensate Overflow Switch: Float with integral magnet overflow switch conforming to UL508. No standby power required.

J. Outdoor Weather Station:

1. Outdoor rated ventilated plastic enclosure, off-white color, radiation shield including the following parameters.
2. Measured Parameters:

a. Temperature Sensor: Thermistor sensing element or resistance temperature device (RTD).

1) Operating Range: -40°F to 140°F
2) Accuracy: ± 0.54°F at 68°F

3. ±±Calculated Parameters:

a. Dew Point Temperature in °F
b. Wet Bulb Temperature in °F
c. Enthalpy. Enthalpy sensor shall output a 4-20 ma signal input to the controller upon a varying enthalpy (total heat) to enable economizer modes of operation when outside air enthalpy is suitable for free cooling.

2.24 CONDUIT AND BOXES

A. Conduit and Boxes: Refer to Electrical Section 26 05 33 for materials, sizing, and other requirements

B. Conduit and Box Identification (Color and Labeling):

1. Refer to the Temperature Control Contractor notes located on the mechanical cover sheet for raceway and box color requirements.
2. Refer to Electrical Section 26 05 53 for raceway and box labeling requirements.

2.25 WIRE AND CABLE

A. Wire and Cable: Refer to Electrical Section 26 05 13 for wire and cable materials.

1. Wire and Cable Color: Refer to the Temperature Control Contractor notes located on the mechanical cover sheet for wire and cable color requirements.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Verify that systems are ready to receive work. Beginning of installation means installer accepts existing conditions.

B. Install system and materials in accordance with manufacturer's instructions.

C. Drawings of the TCS and FMCS network are diagrammatic only. Any apparatus not shown but required to meet the intent of the project documents shall be furnished and installed without additional cost.

D. Install all operators, sensors, and control devices where accessible for service, adjustment, calibration, and repair. Do not install devices where blocked by piping or ductwork. Devices with manual reset or limit adjustments shall be installed below 6'-0" if practical to allow inspection without using a ladder.

E. Verify locations of wall-mounted devices (such as thermostats, temperature and humidity sensors, and other exposed sensors) with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Maximum height above finished floor shall not exceed ADA mounting requirements.

F. Provide valves over 3/4" size with position indicators and pilot positioners where sequenced with other controls.

G. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room.

H. After completion of installation, test and adjust control equipment.

I. Check calibration of instruments. Recalibrate or replace.

J. Furnish and install conduit, wire, and cable per the National Electric Code, unless noted otherwise in this section.

K. All controls associated with the proper operation of air handling units, pumps, or other mechanical equipment served by emergency power shall be connected to the emergency power system. Control components shall be powered from the optional standby branch of emergency power. In no instance shall panel be connected to the life safety branch of the emergency power system. Panels may be connected to a common 20 amp, 120 volt circuit provided the total load on the circuit does not exceed 16 amps. Circuit conductors shall be sized per the table below. All power connections to the control panels shall be performed by a licensed electrician at the cost of this Contractor. Submit circuit information (total amperage on circuit, conductors length, and panel) for control panels to the Architect/Engineer for approval.

| Circuit Load (Amps) | Circuit Max Length | Feeder Size |
|---|---|---|
| ≤ 5 | ≤ 200ft | 2#12 & 1#12 ground in 3/4" conduit. |
| ≤ 10 | ≤ 100ft | 2#12 & 1#12 ground in 3/4" conduit. |
| ≤ 16 | ≤ 75ft | 2#12 & 1#12 ground in 3/4" conduit. |
| ≤ 200 | ≤ 325ft | 2#10 & 1#10 ground in 3/4" conduit. |
| ≤ 100 | ≤ 160ft | 2#10 & 1#10 ground in 3/4" conduit. |
| ≤ 75 | ≤ 100ft | 2#10 & 1#10 ground in 3/4" conduit. |

L. All hardware, software, equipment, accessories, wiring (power and sensor), piping, relays, sensors, power supplies, transformers, and instrumentation required for a complete and operational FMCS system, but not shown on the electrical drawings, are the responsibility of the TCC.

M. Remodeling:

1. All room devices as indicated on the drawings shall be removed by this Contractor. The Contractor shall also prepare the wall for finishes. Preparing the wall shall include patching old anchor holes (after the anchoring device has been removed) and sanding the wall to remove old paint outlines remaining from original devices. The wall shall be painted to match the existing wall prior to the installation of the new room device. If wall covering requires patching, the Contractor shall furnish new wall covering to match existing. If new wall covering is not available to match existing, the Contractor shall furnish a white acrylic or Plexiglas plate, 1/4" thick and sized to cover the void.

N. Labels For Control Devices:

1. Provide labels indicating service of all control devices in panels and other locations.
2. Labels may be made with permanent marking pen in the control panels if clearly legible.
3. Use engraved labels for items outside panel such as outside air thermostats.
4. Labels are not required for room thermostats, damper actuators and other items where their function is obvious.

O. VFDs:

1. This project includes several variable frequency drives to control the flow of fans and/or pumps based on a control variable.
2. Verify output signal required, 4-20 mA or 0-10V dc, with the EC.
3. If VFD has a bypass feature, auxiliary contacts on the drive may not be used for motor status. A separate relay must be used to indicate motor rotation in either hand or auto positions.

4. If a separate current transmitter or switch is indicated for status, install this device between the VFD and the motor. In this case, the drive status may be connected to the auxiliary contacts in the VFD.
5. Some devices, such as low limits and fire alarm shutdown relays, must be hardwired to the fan motor. Make connections such that fan will shut down whether in hand or auto position if the unit has a bypass feature.

P. Airflow Stations:

1. The transmitter shall be installed at a location that is protected from weather, water, and vibration.
2. Mount transmitter where they can easily be read (36" to 66" above floor). Do not fasten transmitters directly to ductwork or compromise duct insulation.
3. The manufacturer's authorized representative shall visit the project site during construction prior to station installations to confirm all submitted sizes, mounting requirements and locations. Size adjustments shall be made at no additional cost. The representative shall meet on site with the TCC to support and train them on proper installation procedures and calibration.
4. Install labels at each sensor and transmitter identifying its service.

3.2 GRAPHIC DISPLAY

A. Create a customized graphic for each piece of equipment indicated on the itemized points list.

B. Components shall be arranged on graphic as installed in the field.

C. Include each graphic point listed in the itemized points list using real time data.

D. Provide a graphic representation of the following:

1. Where there are multiple buildings, color code the campus map by the systems serving that building. The building graphic shall be linked to the graphic for that building's systems.
2. Where there are multiple floors, provide color codes/designations for the areas served by each AHU and TAB by floor.
3. Where multiple AHUs serve one floor, color code the areas served by each AHU. The area shall be linked to the graphic for that area's AHU.
4. Provide an overall floor plan of each floor of the building color coded by zone linked to the TAB for that zone. The zone shall be linked to the graphic for that zone's TAB graphic.
5. Show the location of each thermostat on the floor plan.
6. Provide separate graphics showing the chilled and heating water system flow diagram. Show temperatures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.
7. Provide a graphic showing the steam system flow diagram. Show pressures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.

E. The FMCS shall include full graphic operator interface to display the following graphics as a minimum:

1. Home page to include a minimum of six critical points: Outside Air Temperature, Outside Air Relative Humidity, Enthalpy, KWH, KW, etc.
2. Graphic floor plans accurately depicting rooms, walls, hallways, and showing accurate locations of space sensors and major mechanical equipment.
3. Detailed graphics for each mechanical system including AHUs, ERUs, EFs, chillers, and boilers, as a minimum.
4. Access corresponding system drawings, technical literature, and sequences of operations directly from each system graphic.

F. The FMCS shall include individual graphical buttons to access the following data stored in PDF format:

1. Project control as-built documentation including all TCS drawings, diagrams and sequences of operation.
2. TCS Bill of Material for each system, e.g. AHU, RTU, FCU, boiler, etc.
3. Technical literature specification data sheets for all components listed in the TCS Bill of Material.

3.3 CONDUIT AND BOXES INSTALLATION

A. Conduit and Box Installation: Refer to Electrical Section 26 05 33 for execution and installation.

B. Conduit and Box Identification (color and labeling) installation. Refer to Electrical Section 26 05 53 for raceway and box identification installation.

C. Outlet Box Schedule: Thermostat/temperature sensor:

1. Dry Interior Locations: Provide 4" square galvanized steel with raised cover to fit flush with finished wall line. When located in concrete block walls, provide square edge title cover of sufficient depth to extend out to face of block or masonry boxes.
2. Other Conditions: Refer to Electrical Section 26 05 33 for requirements.

3.4 WIRE AND CABLE INSTALLATION

A. Wire and Cable Installation: Refer to Electrical Section 26 05 13 for execution and installation.

B. Field Quality Control:

1. Inspect wire and cable for physical damage and proper connection.
2. Torque test conductor connections and terminations to manufacturer's recommended values.
3. Perform continuity test on all conductors.
4. Protection of cable from foreign materials:

a. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.

b. Overspray of paint on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

C. Installation Schedule:

1. Conduit terminations to all devices installed in applications with rotating equipment, expansion/contraction or vibration shall be made with flexible metallic conduit, unless noted otherwise. Final terminations to exterior devices installed in damp or wet locations shall be made with liquidtight flexible metallic conduit. Terminations in hazardous areas, as defined in the National Electrical Code, shall be made with flexible conduit rated for the environment.

3.5 COMMISSIONING

A. Upon completion of the installation, this Contractor shall load all system software and start up the system. This Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to ensure that the system is functioning in full accordance with these specifications.

B. This Contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the FMCS system operation.

C. This Contractor shall prove that the controls network is functioning correctly and within acceptable bandwidth criteria and shall test the system with an approved protocol analysis tool. Provide a log and statistics summary showing that each channel is within acceptable parameters. Each channel shall be shown to have at least 25% spare capacity for future expansion.

D. Upon completion of the performance tests described above, repeat these tests, point by point, as described in the validation log above in the presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

E. System Acceptance: Satisfactory completion is when this Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.6 PREPARATION FOR BALANCING

A. Verify that all dampers are in the position indicated by the controller (e.g., open, closed or modulating).

B. Check the calibration and setpoints of all controllers.

C. Check the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.

D. Check that all sequences operate as specified. Verify that no simultaneous heating and cooling occurs, unless specified. Observe that heating cannot begin at TAB reheat terminals until the unit is at the minimum cfm.

E. Verify the operation of all interlock systems.

3.7 TEST AND BALANCE COORDINATION

A. The Contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

B. The Contractor shall provide a minimum of four (4) hours training for the Balancing Contractor in the use of these tools.

C. In addition, the Contractor shall provide a qualified technician to assist in the test and balance process until the first 20 terminal units are balanced.

D. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.

3.8 DEMONSTRATION AND ACCEPTANCE

A. At completion of installation, provide two days minimum instruction for operators. Demonstrate operation of all controls and systems. Describe the normal operation of all equipment.

3.9 TRAINING

A. On-Site:

1. After completion of commissioning, the manufacturer shall provide 8 hours of training on consecutive days for 4 Owner's representatives. The training course shall enable the Owner's representatives to perform Day-to-Day Operations as defined herein. A factory-trained instructor with experience in presenting the training material and the system programmer for this project shall perform the training.

B. Day-to-Day Operations - Training Description:

1. Proficiently operate the system.
2. Understand control system architecture and configuration.
3. Understand FMCS systems components.
4. Understand system operation, including FMCS system control and optimizing routines (algorithms).
5. Operate the workstation and peripherals.
6. Log-on and off the system.
7. Access graphics, point reports, and logs.
8. Adjust and change system setpoints, time schedules, and holiday schedules.
9. Recognize malfunctions of the system by observation of the printed copy and graphic visual signals.
10. Understand system drawings and Operation and Maintenance manual.
11. Understand the job layout and location of control components.
12. Access data from FMCS controllers and ASCs.
13. Operate portable operator's terminals.

C. System Management - Training Description:

1. Maintain software and prepare backups.
2. Interface with job-specific, third-party operator software.
3. Add new users and understand password security procedures.

D. Provide course outline and materials in accordance with the "SUBMITTALS" article in Part 1 of this section. The instructor(s) shall provide one copy of training material per student.

3.10 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Averaging sensors and low limits shall be installed at the top of the assembly with the element on a slight downward incline away from the sensor making a serpentine pattern over the cross-sectional area with elements spaced not over 12" apart and within 6" of the top and bottom of the area.

F. All pipe-mounted temperature sensors shall be installed in immersion wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

G. Install outdoor air temperature sensors on exterior of north wall, complete with sun shield at designated location approved by Architect/Engineer. TCC shall prime and paint the device enclosure. Color selection by Architect.

H. Install all wall-mounted CO2 sensors between 3 feet and 6 feet above the floor.

END OF SECTION

SECTION 23 31 00 - DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Galvanized Ductwork

B. Ductwork Reinforcement

C. Ductwork Sealants

D. Rectangular Ductwork

E. Round and Flat Oval Ductwork

F. Exposed Ductwork (Rectangular, Round, or Oval)

G. Flexible Duct

H. Leakage Testing

I. Ductwork Penetrations

J. Duct Cleaning

K. Painting

1.2 REFERENCES: Conform to all applicable requirements of the following publications:

A. ADC Flexible Duct Performance and Installation Standards, 3rd Edition 1996.

B. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. ASHRAE - Handbook 2012 Systems and Equipment; Chapter 19 - Duct Construction.

D. ASHRAE - Handbook 2013 Fundamentals; Chapter 21 - Duct Design.

E. ASHRAE 170 (latest published edition) - Ventilation of Health Care Facilities.

F. ASTM A90 - Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.

G. ASTM A167- Stainless & Heat-Resisting Chromium-Nickel Steel Plate, Sheet, & Strip.

H. ASTM A653 - Steel Sheet, Zinc-Coated (Galvanized) or zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

I. ASTM A924 - Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.

J. ASTM B209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

K. ASTM E90-02 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.

L. ASTM E413-87 - Classification for Rating Sound Insulation.

M. AWS D9.1M/D9.1 - Sheet Metal Welding Code.

N. CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers Version 1.1.

O. NADCA ACR 2002 - Assessment, Cleaning, and Restoration of HVAC Systems.

P. NADCA Standard 05 1997 - Requirements for the Installation of Service Openings in HVAC Systems.

Q. NFPA 90A - Installation of Air-Conditioning and Ventilating Systems.

R. NFPA 90B - Installation of Warm Air Heating and Air- Conditioning Systems.

S. NFPA 96 - Ventilation Control and Fire Protection of Commercial Cooking Equipment.

T. SCAQMD Rule 1168 - South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications.

U. SMACNA - Air Duct Leakage Test Manual.

V. SMACNA - HVAC Duct Construction Standards.

W. SMACNA - Phenolic Duct Construction Standard 022.

X. SMACNA - Round Industrial Duct Construction Standards - 1999 Edition.

Y. UL 181 - Factory-Made Air Ducts and Air Connectors.

Z. UL 181A - Closure Systems for Use with Rigid Air Ducts and Air Connectors

AA. UL 181B - Closure Systems for Use with Flexible Air Ducts and Air Connectors.

BB. UL 1978 - Standard for Grease Ducts.

CC. UL 2221 - Standard for Tests of Fire Resistive Grease Duct Enclosure Assemblies.

DD. CMC California Mechanical Code

EE. CBC California Building Code

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00.

B. Submit duct fabrication standards in compliance with SMACNA and these specifications. Clearly indicate metal gauges, reinforcement, and joining methods intended for use for each pressure classification. Furnish details of all common duct fittings and joint connections to be used on this project.

C. Duct Layout Drawings: Submit detailed duct layout drawings at 1/4" minimum scale complete with the following information:

1. Actual duct routing, ductwork fittings, actual sheet metal dimensions including insulation liner and wrap, duct hanger and support types, ductwork accessories, etc. with lengths and weights noted.
2. Differentiate ducts that are wrapped. Include insulation thickness, type of insulation, and acoustical lagging.
3. Room names and numbers, ceiling types, and ceiling heights.
4. Indicate location of all beams, bar joists, etc. along with bottom of steel elevations for each member.
5. Verify clearances and interferences with other trades prior to preparing drawings. IMEG will provide electronic copies of ventilation drawings for contractor's use if the contractor signs and returns the "Electronic File Transfer" waiver. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for this submittal. Refer also to Section 23 05 00.

D. Duct Leakage Test Summary Report: Upon completion of the pressure test described in Part 3, the Contractor shall submit an air duct leakage test summary report as outlined in the SMACNA HVAC Duct Leakage Test Manual.

1.4 DEFINITIONS

A. Duct Sizes shown on drawings are inside clear dimensions. Maintain clear dimensions inside any lining.

B. Transitions are generally not shown in single-line ductwork. Where sizes change at a divided flow fitting, the larger size shall continue through the fitting.

C. Exterior Duct: Ductwork located outside the conditioned envelope including exposed ductwork above the roof, outside exterior walls, in attics above insulated ceilings, inside parking garages, and crawl spaces.

D. Interior Duct: Ductwork located within the conditioned envelope including return air plenums and indirectly conditioned spaces.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required duct systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

B. Duct drawings shall be at 1/4" minimum scale complete with the following information:

1. Actual duct routing, ductwork fittings, actual sheet metal dimensions including insulation liner and wrap, duct hanger and support types, ductwork accessories, etc. with lengths and weights noted.
2. Differentiate ducts that are lined or wrapped. Include insulation thickness, type of insulation, and acoustical lagging.
3. Location and size of all duct access doors.
4. Room names and numbers, ceiling types, and ceiling heights.
5. Indicate location of all beams, bar joists, etc. along with bottom of steel elevations for each member.
6. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings. Architectural plans will need to be obtained from the Architect.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS AND SUPPORTS

A. Rectangular Duct - Single Wall:

1. General Requirements:

a. All ductwork gauges and reinforcements shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space consuming reinforcement.
b. Transitions shall not exceed the angles in Figure 4-7.

2. Exceptions and modifications to the 2005 HVAC Duct Construction Standards are:

a. All ducts shall be cross-broken or beaded.
b. Snap lock seams are not permitted.
c. Turning vanes shall be used in all 90° mitered elbows, unless clearly noted otherwise on the drawings. Vanes shall be as follows:

1) Type 1:

a) Description: Single wall type with 22-gauge (0.029") or heavier vanes, 3-1/4" blade spacing, and 4" to 4-1/2" radius. Vanes hemmed if recommended by runner manufacturer. Runners shall have extra-long locking tabs. C-value independently tested at below 0.26. EZ Rail II by Sheet Metal Connectors or equal.
b) Usage: Limited to 3,000 fpm and vane lengths 36" and under.

2) Turning vanes shall operate quietly. Repair or replace vanes that rattle or flutter.
3) Runners must be installed at a 45° angle. Elbows with different size inlet and outlet must be radius type.
4) Omitting every other vane is prohibited.

d. Where smooth radius rectangular elbows are shown, they shall be constructed per SMACNA Figure 4-2. Type RE1 shall be constructed with a centerline duct radius R/W of 1.0. Where shown on drawings, Type RE3 elbows with 3 vanes shall be used with centerline duct radius R/W of 0.6 (SMACNA r/W=0.1). RE1 or RE3 elbows may be used where mitered elbows are shown if space permits. Mitered elbows (with or without turning vanes) may not be substituted for radius elbows. Do not make branch takeoffs within 4 duct diameters on the side of the duct downstream from the inside radius of radius elbows.
e. Rectangular branch and tee connections in ducts over 1" pressure class shall be 45° entry type per Figs. 4-5 and 4-6. Rectangular straight taps are not acceptable above 1" pressure class.
f. Bellmouth fittings shown on return duct inlets shall expand at a 60-degree total angle horizontally and vertically (space permitting) and have length of at least 25% of the smallest duct dimension.
g. Round taps off rectangular unlined ducts shall be flanged conical or bellmouth type (equal to Buckley Bellmouth or Sheet Metal Connectors E-Z Tap), or 45° rectangular with transition to round (equal to Sheet Metal Connectors Inc. High Efficiency Takeoff). Straight taps are acceptable if pressure class is 1" or less, round duct is 12" diameter or less, and the tap is not located between fans and TAB devices.
h. Duct offsets shall be constructed as shown on drawings. Additional offsets required in the field shall be formed of mitered elbows without turning vanes for offsets up to 30° maximum angle in accordance with SMACNA offset Type 2. Offsets of greater than 30° angle shall be formed of radius elbows with centerline radius R/W=1.0 or greater. SMACNA Type 1 offsets are not permitted.
i. All lined duct shall utilize dovetail joints where round or conical taps occur. The dovetail joints shall extend past the liner before being folded over.
j. Cushion heads are acceptable only downstream of TAB devices in ducts up to ± 2" pressure class, and must be less than 6" in length.
k. Slide-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

1) Apply sealant to all inside corners. Holes at corners are not acceptable.
2) Manufacturers:

a) Ductmate Industries - 25/35/45
b) WDCI

c) Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

B. Round and Flat Oval Spiral Seam Ductwork - Single Wall:

1. Conform to applicable portions of Rectangular Duct Section. Round or flat oval ductwork may be substituted for rectangular ductwork where approved by the Architect/Engineer. The spiral seam ductwork shall meet the standards set forth in this specification. The ductwork shall meet or exceed the specified cross-sectional area and insulation requirements. The substitution shall be coordinated with all other trades prior to installation.

2. Flat oval duct in negative pressure applications shall have flat sides reinforced as required for rectangular ducts of the same gauge with dimensions equal to the flat span of the oval duct.
3. 90° elbows shall be smooth radius or have a minimum of five sections with mitered joints and R/D of at least 1.5.
4. Duct and fittings shall meet the required minimum gauges listed in chapter 3 of the SMACNA requirements for the specified pressure class. Ribbed and lightweight duct are not permitted.
5. Ductwork shall be suitable for velocities up to 5,000 fpm.
6. Divided flow fittings may be made as separate fittings or factory installed taps with sound, airtight, continuous welds at intersection of fitting body and tap.
7. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.
8. Ducts with minor axis less than 22" shall be spiral seam type. Larger ducts may be rolled, longitudinal welded seam type. SMACNA seams RL-2 and RL-3 are not permitted.
9. Reinforce flat oval ducts with external angles. Internal tie rods are permitted only as indicated for rectangular ductwork.
10. Transverse Joint Connections:

    a. Crimped joints are not permitted.
    b. Ducts and fittings 36" in diameter and smaller shall have slip joint connections. Size fitting ends to slip inside mating duct sections with minimum 2-inch insertion length and a stop bead. Use inside slip couplings for duct-to-duct joints, and outside slip couplings for fitting-to-fitting joints.
    c. Ducts and fittings larger than 36" shall have flanged connections.
    d. Secure all joints with at least 3 sheet metal screws before sealing.
    e. Manufacturers, Slide-on Flanges:

        1) Ductmate Industries - SpiralMate
        2) Accuflange
        3) Sheet Metal Connectors are acceptable.

C. Hangers and Supports General Requirements:

1. Hanger and support materials shall be as defined within Materials and Application Specific section below.
2. Strap Hangers: Strap hanger shall be a minimum of 1 inch, 18 gauge attached to the bottom of ducts at 8'-0" OC and as required by CMC/UMC and SMACNA guidelines.
3. Cable Hangers:

   a. Aircraft cable and slip cable hangers are acceptable for ducts up to 18" diameter. Protective sleeve tubing shall be used on the cable when supporting duct with exterior insulation. Corner saddles are required when supporting rectangular ductwork.
   b. Manufacturers; Supports:

      1) Ductmate
      2) Duro Dyne
      3) Architect/Engineer approved

   c. Aircraft cable with 2-point support in standard horseshoe arrangement. Protective sleeve tubing shall be used on the cable when supporting duct with exterior insulation. 8'-0" OC and as required by CMC/UMC and SMACNA guidelines.

4. Integral Corner Connector Hanger: Integral hanger and corner assembly for use with TDC/TDF style duct flanges. Die stamped offset hanger connects to the flanged corner assembly. For use with aircraft cable or 1/4" or 3/8" diameter threaded rods. Tested to hold up to 1,400 lbs.. Install per manufacturer's ratings and instructions.

2.2 MATERIAL AND APPLICATION SPECIFIC

A. Galvanized Steel:

1. General Requirements:

   a. Duct and reinforcement materials shall conform to ASTM A653 and A924.
   b. Interior Ductwork and reinforcements: G60 galvanized (0.60 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise.
   c. Exterior Ductwork: G90 galvanized (0.90 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise. G60 is not acceptable for exterior use.
   d. Ductwork reinforcement shall be of galvanized steel.

2. Duct Hangers and Support Material:

   a. Ductwork hangers and supports shall be of galvanized or painted steel.
   b. All fasteners shall be galvanized or cadmium plated.

B. Duct Hangers and Support Material:

1. Ductwork hangers and supports shall be of galvanized or painted steel.
2. All fasteners shall be galvanized or cadmium plated.

C. Exposed Ductwork (Rectangular, Round, and Flat Oval):

1. The following applies to all ductwork exposed in finished areas in addition to requirements noted above:

   a. Provide extra shipping protection. Use Cardboard or other protective means to prevent dents and deformed ends.
   b. Provide cardboard or other means of protection during field fabrication. Protect from scratches. Provide stiffeners to retain shape during fabrication.
   c. Remove all identification stickers and thoroughly clean exterior of all ducts.
   d. Locate fitting seams on least visible side of duct.
   e. Provide exterior finish suitable for field painting without further oil removal.
   f. Provide ramp-type internal joint couplings. Provide bead of sealant around the inside of the duct about 1/2" from the end of the duct.
   g. Manufacturers, Slide-on Flanges:

      1) Ductmate Industries
      2) Accuflange
      3) Sheet Metal Connectors

   h. The system shall be free of visible dents and scratches when viewed from normal occupancy.
   i. All insulation shall be internal, except at reheat coils.

2. In addition to the paragraphs above, this section applies to all ductwork specified or shown as "Architecturally Exposed":

   a. All spiral ductwork fittings shall be carbon arc welded.
   b. Grind all welds to remove irregularities.
   c. Conical taps shall be one piece. Taps for grilles and takeoffs shall be factory installed with a continuous weld and ground smooth.
   d. Welds shall be ground smooth and painted.
   e. All architecturally exposed ducts shall be round or flat oval except where not possible (grilles, reheat coils, etc.).

3. Alternate manufacturers, including shop fabricated duct, must be reviewed before installation. The following information is required:

   a. Metal gauge of duct and fittings.
   b. Fitting type and construction.
   c. Type and size of reinforcement.

4. Hangers for Exposed Ductwork:

   a. Round Ducts:

1) Threaded rod with duct fixing bracket and metal strap. Provide single threaded rod centered on the duct. Strap hanger shall be a minimum of 1 inch, 18 gauge galvanized steel wrapping the circumference of the duct. 8'-0" OC and as required by CMC/UMC and SMACNA guidelines.
2) Aircraft cable with 2-point support in standard horseshoe arrangement. 8'-0" OC and as required by CMC/UMC and SMACNA guidelines.

b. Rectangular Ducts:

1) Aircraft cable with 2-point support in standard horseshoe arrangement. Corner saddles are required when supporting rectangular ductwork. 8'-0" OC and as required by CMC/UMC and SMACNA guidelines.

c. Strut-channel and all-thread rod is not acceptable for exposed ductwork.
d. All fasteners shall be galvanized or cadmium plated.

2.3 DUCTWORK REINFORCEMENT

A. All reinforcement shall be external to the duct except that tie rods may be used with the following limitations.

1. Ducts must be over 18" wide.
2. Duct dimensions must be increased 2" in one dimension (h or w) for each row of tie rods installed.
3. Tie rods must not exceed 1/2" diameter.
4. Manufacturer of tie rod system must certify pressure classifications of various arrangements, and this must be in the shop drawings.

2.4 DUCTWORK SEALANTS

A. One-part joint sealers shall be water-based mastic systems that meet the following requirements: maximum 48-hour cure time, service temperature of -20°F to +175°F, resistant to mold, mildew and water, flame spread rating below 25 and smoke-developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes. Mastic used to seal flexible ductwork shall be marked UL 181B-M. Joint sealers for use on exterior weather exposed ductwork shall be rated for -30°F to +175°F and 2000-hour minimum UV resistance per ASTM G-53.

B. Two-part joint sealers shall consist of a minimum 3" wide mineral-gypsum compound impregnated fiber tape and a liquid sealant. Sealant system shall meet the following requirements: maximum 48-hour cure time, service temperature of 0°F to 200°F, resistant to mold, mildew, and water, flame spread rating below 25 and smoke developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes. Joint sealers for use on exterior weather exposed ductwork shall be rated for -30°F to +175°F and 2000-hour minimum UV resistance per ASTM G-53.

C. Pressure sensitive tape used for sealing ductwork shall be minimum 2.5-inch wide, listed and marked UL 181A-P, having minimum 60 oz/inch peel adhesion to steel, and service temperature range from -20°F to +250°F.

D. Adhesives and Sealants: All sealers, adhesives, and sealants shall comply with the low emitting material limits of the following standards:

1. CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions VOC from Indoor Sources Using Environmental Chambers Version 1.1.
2. South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications. All adhesives and sealants wet-applied on site shall comply with the applicable chemical content requirements of SCAQMD Rule 1168.
3. South Coast Air Quality Management District Rule SCAQMD 1113 - Wet Applied Paints and Coatings. All paints and coatings wet-applied on site must meet the applicable VOC limits of SCAQMD Rule 1113.

E. Where pressure sensitive tape is called for on drawings and specifications for sealing flexible ductwork, tape shall be minimum 2.5-inch wide, UL 181 B-FX listed, and marked tape having minimum 60 oz/inch peel adhesion to steel and service temperature range from -20°F to +250°F.

1. Manufacturers, Pressure-Sensitive Tape:

a. Venture Tape 1581A
b. Scotch Foil Tape 3326
c. Polyken 339

2.5 FLEXIBLE DUCT

A. Flexible duct shall be listed and labeled as UL 181 Class 1 Air Duct Material, and shall comply with NFPA 90A and 90B, and meet GSA, FHA and other U.S. Government agency standards. Flexible duct shall bear the ADC Seal of Certification.

B. Flame Spread/Smoke Developed: Not over 25/50.

C. Stretch all flexible duct to prevent sags and reduce air friction. Shorten and reinstall all sagging or loose flexible duct. Avoid sharp elbows. Elbows shall maintain 1.5 diameter centerline turning radius.

D. Install per the SMACNA Flexible Duct Manual. Secure inner layer with draw band. Wrap with pressure sensitive tape for protection prior to installing draw band. Pressure sensitive tape alone is not acceptable.

E. Acoustic:

1. Flexible duct shall be acoustic rated in accordance with ASTM E477 and ADC Test Code FD 72-RI by ETL. Insertion loss values noted below are for flow velocities less than 2,500 fpm. Submittals shall include insertion losses ratings per sizes and lengths listed below regardless of sizes shown on the drawings.

2. Flexible have corrosion-resistant wire helix, bonded to a nylon fabric core inner liner that prevents air from contacting the insulation, covered with minimum 1-1/2", 3/4 lb/cf density fiberglass insulation blanket, sheathed in a vapor barrier of metalized polyester film laminated to glass mesh. Usage: All areas unless noted otherwise.
3. Inner liner shall be airtight and suitable for 6" WC static pressure through 16" diameter. Outer jacket shall act as a vapor barrier only with permeance not over 0.1 perm per ASTM E96, Procedure A. "R" value shall not be less than 4.0 ft2*ºF*hr/Btuh. Temperature range of at least 0-180ºF. Maximum velocity of 4,000 fpm. "R" value shall not be less than 4.0 ft2*°F*hr/Btuh. Ducts in unconditioned spaces and ventilated attics: "R" value shall not be less than 6.0 ft2*°F*hr/Btuh.
4. Minimum Acoustic Insertion Losses per octave band:

    a. Straight Duct:

| Dia | Length | 63hz | 125hz | 250hz | 500hz | 1000hz | 2000hz | 4000hz |
|---|---|---|---|---|---|---|---|---|
| 6" ø | 6 ft | 4.0 | 13 | 15 | 15 | 16 | 17 | 16 |
| 6" ø | 3 ft | 2.3 | 4.9 | 5.3 | 5.3 | 5.5 | 5.8 | 5.4 |
| 8" ø | 6 ft | 5.7 | 14 | 13 | 15 | 16 | 18 | 16 |
| 8" ø | 3 ft | 2.9 | 5.0 | 4.9 | 5.7 | 5.6 | 5.8 | 5.6 |
| 12" ø | 6 ft | 5.5 | 13 | 12 | 15 | 15 | 18 | 13 |
| 12" ø | 3 ft | 2.8 | 4.8 | 4.7 | 5.3 | 5.3 | 5.8 | 4.9 |

    b. 90deg Elbow:

| Dia | Length | 63hz | 125hz | 250hz | 500hz | 1000hz | 2000hz | 4000hz |
|---|---|---|---|---|---|---|---|---|
| 6" ø | 6 ft | 10 | 15 | 16 | 17 | 18 | 17 | 18 |
| 6" ø | 3 ft | 3.8 | 5.4 | 5.5 | 5.7 | 5.9 | 5.8 | 5.9 |
| 8" ø | 6 ft | 10 | 15 | 16 | 17 | 16 | 18 | 18 |
| 8" ø | 3 ft | 2.4 | 5.3 | 5.6 | 5.8 | 5.6 | 5.9 | 6.0 |
| 12" ø | 6 ft | 11 | 14 | 15 | 16 | 15 | 16 | 15 |
| 12" ø | 3 ft | 4.4 | 5.1 | 5.3 | 5.5 | 5.4 | 5.6 | 5.3 |

5. Usage:

    a. Take-offs from supply ducts to inlets of terminal air boxes. Do not exceed 36" in length.
    b. Connections to air inlets and outlets. Do not exceed 5'-0" in length.
    c. Acceptable Manufacturers:

        1) Flexmaster USA - Type 6
        2) Thermaflex M-Ke

F. Radius Forming Elbows:

1. Flexible plastic radius forming elbow for use with flexible ducts to create 90deg elbow. One size for 6" to 16" diameter ducts. UL listed for return plenum spaces.

2. Usage: All supply air terminals with flexible ductwork connection.
3. Installation: Attach to flex duct and secure draw bands without crushing flex duct to form smooth radius elbow. Suspend radius forming elbow to structure. Install per manufacturer's instructions.
4. Acceptable Manufacturers:

    a. Hart & Cooley - Smartflow
    b. Thermaflex - Flexflow
    c. Titus - Flexright

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide openings in ducts for thermometers and controllers.

B. Locate ducts with space around equipment for normal operation and maintenance.

C. Do not install ducts or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the electrical equipment. Unless intended to serve these rooms, do not install any ductwork or equipment in electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms.

D. Provide temporary closures of metal or taped polyethylene on open ducts to prevent dust from entering ductwork.

E. Supply ductwork shall be free of construction debris, and shall comply with Level "C" of the SMACNA Duct Cleanliness for New Construction Guidelines.

F. Repair all duct insulation and liner tears.

G. Install manual volume dampers in branch supply ducts so all outlets can be adjusted. Do not install dampers at air terminal device or in outlets, unless specifically shown.

H. Insulate terminal air box reheat coils. Seal insulation tight to form a tight vapor barrier.

I. Install flexible duct in accordance with the ADC Flexible Duct Performance and Installation Standards.

J. Flexible duct shall NOT be joined to flat-oval connections. Provide sheet metal oval-to-round transitions where required, to include, but not limited to, all connections to air inlets, air outlets, and terminal air boxes.

K. Install all exterior ductwork per SMACNA Fig. 6-3. Where drawings do not indicate otherwise, ductwork seams and joints shall be sealed watertight and pitched to shed water.

L. Support all duct systems in accordance with the SMACNA HVAC Duct Construction Standards: Metal and Flexible and the SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems, where applicable. Refer to Section 23 05 50 for seismic requirements.

M. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by California Building Codes.

N. Adhesives, sealants, tapes, vapor retarders, films, and other supplementary materials added to ducts, plenums, housing panels, silencers, etc. shall have flame spread/smoke developed ratings of under 25/50 per ASTM E84, NFPA 255, or UL 723.

O. All duct support shall extend directly to building structure. Do not support ductwork from pipe hangers unless coordinated with piping contractor prior to installation. Do not allow lighting or ceiling supports to be hung from ductwork or ductwork supports.

3.2 DUCTWORK APPLICATION SCHEDULE

A. Shape: Round and Flat Oval Spiral Seam Ductwork - Single Wall

1. Material: Galvanized Steel
2. Pressure Class: +6"+1.5kPa
3. Seal Class: A
4. Insulation: 1-1/2"40 mm thick Type A (R=4.5)
5. Additional Requirements: None

B. General:

1. Seal Class is per SMACNA HVAC Air Duct Leakage Test Manual
2. Insulation:

    a. Refer to Section 23 07 13 for insulation types.
    b. Type A insulation (Flexible Fiberglass Wrap) R-values noted are based on installed values (25% compression).

3. Note 1: Apply aluminum based adhesive sealant tape at non-flanged joints on ducts serving dedicated outside air supply (DOAS) and exhaust system in addition to Class A sealant.
4. Note 2: Apply aluminum based adhesive sealant tape on TAB boxes (all seams and joints of the box and duct connections) serving dedicated outside air supply (DOAS) system.

C. Constant Volume from Fan to Outlet:

1. Shape:

    a. Rectangular Duct - Single Wall
    b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel

3. Pressure Class: +2"
4. Seal Class: A
5. Insulation: See drawings

6. Additional Requirements: None

D. Return Duct:

1. Shape:

a. Rectangular Duct - Single Wall
b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: -2"
4. Seal Class: A
5. Insulation: See drawings
6. Additional Requirements: None

E. General Exhaust Duct:

1. Shape:

a. Rectangular Duct - Single Wall
b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: -1"
4. Seal Class: A
5. Insulation: None
6. Additional Requirements: None

F. AHU Exhaust Air Duct:

1. Shape:

a. Rectangular Duct - Single Wall
b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: +2"
4. Seal Class: A
5. ASHRAE 90.1-2019and IECC-2021

a. Insulation: 1" thick Type C (R=3.6)

6. Additional Requirements: None.

G. Relief Air Louver to Backdraft Damper:

1. Shape:

a. Rectangular Duct - Single Wall
b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: +2"
4. Seal Class: A
5. Insulation: See drawings

H. Transfer Ducts:

1. Shape:

a. Rectangular Duct - Single Wall
b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: -1/2"
4. Insulation: 1" thick Type C (R=3.6)

I. Ductwork Accessories (Fabric Flex Connectors, Equipment Flanges, etc.):

1. Insulation:

a. ASHRAE 90.1-2019: 1-1/2" thick Type A (R=4.5)

3.3 DUCTWORK SEALING

A. General Requirements:

1. Openings, such as rotating shafts, shall be sealed with bushings or similar.
2. Pressure sensitive tape shall not be used as the primary sealant unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification.
3. All connections shall be sealed including, but not limited to, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required. Spiral lock seams need not be sealed.
4. Mastic-based duct sealants shall be applied to joints and seams in minimum 3 inch wide by 20 mil thick bands using brush, putty knife, trowel, or spray, unless manufacturer's data sheet specifies other application methods or requirements.

B. All ducts systems, regardless of pressure class, shall be Seal Class A as defined by Section 5-1 of SMACNA HVAC Air Duct Leakage Test Manual per the Energy Code, unless specifically noted otherwise. Seal Class A shall include sealing of all transverse joints, longitudinal seams, and duct wall penetrations with welds, gaskets, mastics, or fabric-embedded mastic system. Joints are inclusive of, but not limited to, girth joints, branch and sub-branch intersections, duct collar tap-ins, fitting subsections, louver and air terminal connections to ducts, access door and access panel frames and jambs, duct, plenum, and casing abutments to building structures.

3.4 TESTING

A. Interior Duct - Less than 3" WG (positive or negative):

1. Leak testing of these pressure classes is not normally required for interior ductwork (inside the building envelope). However, leak tests will be required if, in the opinion of the Architect/Engineer, the leakage appears excessive. All exterior ductwork shall be tested. If duct has outside wrap, testing shall be done before it is applied.
2. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.
3. Seal ducts to bring the air leakage into compliance.
4. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

B. Exterior Duct - 1/2" WG and Above (positive or negative):

1. All exterior ductwork (outside the building envelope) shall be completely pressure tested. If duct has outside wrap, testing shall be done before it is applied.
2. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.
3. Seal ducts to bring the air leakage into compliance.
4. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

C. Test Procedure:

1. Testing shall be as listed in the latest edition of the SMACNA HVAC Duct Leakage Manual, with the following additional requirements:

    a. The required leakage class for Seal Class A, rectangular ducts, shall be 4; round shall be 2.
    b. Test pressure shall be the specified duct pressure class. Testing at reduced pressures and converting the results mathematically is not acceptable. This is required to test the structural integrity of the duct system.
    c. If any leak causes discernible noise at a distance of 3 feet, that leak shall be eliminated, regardless of whether that section of duct passed the leakage test.
    d. All joints shall be felt by hand, and all discernible leaks shall be sealed.
    e. Totaling leakage from several tested sections and comparing them to the allowable leakage for the entire system is not acceptable. Each section must pass the test individually.
    f. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing. Failure to notify the Architect/Engineer of pressure testing may require the contractor to repeat the duct pressure test after proper notification.
    g. Upon completion of the pressure test, the contractor shall submit an air duct leakage test summary report as outlined in the SMACNA HVAC Duct Leakage Test Manual.

h. All access doors, taps to terminal air boxes, and other accessories and penetrations must be installed prior to testing. Including terminal air boxes in the test is not required.
i. Positive pressure leakage testing is acceptable for negative pressure ductwork.

3.5 DUCTWORK PENETRATIONS

A. All duct penetrations of firewalls shall have fire or fire/smoke dampers where required by code.

B. Dampers shall be compatible with fire rating of wall assembly. Verify actual rating of any wall being penetrated with Architect/Engineer.

C. Seal all duct penetrations of walls that are not fire rated by caulking or packing with fiberglass. Install trim strip to cover vacant space and raw construction edges of all openings in finished rooms. Install escutcheon ring at all round duct openings in finished rooms. Trim strips and rings shall be same material and finish as exposed duct.

3.6 PAINTING

A. Paint interior of ducts black within twice the largest duct dimension of inlets and outlets where interior of duct is visible.

B. Paint bottom of ducts black within twice the largest duct dimension where a duct is routed above an unducted perforated grille and the duct is visible.

END OF SECTION

SECTION 23 33 00 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Manual Volume Dampers.

B. Control/Fire/Smoke Dampers.

C. Backdraft Dampers.

D. Fabric Connectors.

E. Drip Pans.

F. Duct Access Doors.

G. Duct Test Holes.

H. Remote Volume Control Devices.

I. Temperature Control Dampers.

1.2 REFERENCES

A. AMCA Guide for Commissioning and Periodic Performance Testing of Fire, Smoke and Other Life Safety Related Dampers.

B. ASTM E477-06a - Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

C. ASTM E2336-04 - Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems.

D. CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers Version 1.1.

E. NFPA 72 - National Fire Alarm and Signaling Code

F. NFPA 80 - Standard for Fire Doors and Other Opening Protectives.

G. NFPA 90A - Installation of Air-Conditioning and Ventilating Systems.

H. NFPA 92 - Standard for Smoke Control Systems.

I. NFPA 105 - Standard for Smoke Door Assemblies and Other Opening Protectives.

J. SCAQMD Rule 1168 - South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications.

K. SMACNA - HVAC Duct Construction Standards (latest edition).

L. UL 33 - Heat Responsive Links for Fire-Protection Service.

M. UL 555 - Fire Dampers and Ceiling Dampers.

N. UL 555C - Ceiling Dampers.

O. UL 555S - Leakage Rated Dampers for Use in Smoke Control Systems.

P. UL 2043 – Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit manufacturer's installation instructions.

C. Include UL ratings, California State Fire Marshal approval and NFPA 90A, dynamic ratings, leakage, pressure drop and maximum pressure data.

PART 2 - PRODUCTS

2.1 MANUAL VOLUME DAMPERS

A. Fabricate in accordance with SMACNA Duct Construction Standards, and as indicated.

B. Fabricate single blade dampers for duct sizes to 9-1/2 x 30 inches.

C. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12" x 72". Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

D. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide molded synthetic or oil-impregnated nylon or sintered bronze bearings.

E. Provide locking quadrant regulators on single and multi-blade dampers.

F. On insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

G. If blades are in open position and extend into the main duct, mount damper so blades are parallel to airflow.

2.2 FIRE/SMOKE DAMPERS (FSD)

A. General:

1. Furnish and install fire/smoke dampers in ducts, where shown on the drawings, at the point where they pass through a fire/smoke partition and in all other locations required by the local Fire Department, the National Fire Protection Association Pamphlet No. 90A, UL 2043, and all other applicable codes.
2. Fire Resistance Rating: Assemblies shall be 1-1/2 hour rated under UL Standard 555 unless noted otherwise on drawings.
3. Airflow Rating: Dynamic rated at 2,000 fpm and 4" WC.
4. Temperature Rating: Assemblies shall be UL 555S listed for use in smoke control system with a 250°F temperature rating.
5. Leakage Rating: Class II. Shall not leak over 20 cfm per square foot at 4" WC.
6. FSD dampers shall be furnished complete with factory-mounted actuators, and the damper/operator assemblies shall meet all requirements listed below.
7. Where dampers are located in aluminum or stainless steel duct, provide stainless steel dampers.
8. The complete assembly must be factory assembled, cycled and tested prior to shipment.
9. All operators shall be located with easy access for servicing.
10. Contractor to field verify actuator installation and clearance requirements prior to ordering. Actuator should not be taller than duct height. Rotate or turn over the actuator if this is the case.

B. Construction:

1. Frame: 5 inches x minimum 16 gauge roll formed, galvanized steel hat-shaped channel, reinforced at corners.
2. Sleeve: Dampers shall be installed in sleeves of sufficient thickness to comply with UL555 Standard for Safety Fire Dampers listing of the damper. Where UL555 permits sleeve thickness to be the same as that of the duct gauge, such thickness shall not be less than that specified in NFPA 90A for breakaway style sleeves. If a breakaway style duct/sleeve connection is not used, the sleeve shall be a minimum of 16 gauge for dampers up to 36" wide by 24" high and 14 gauge for dampers exceeding 36" wide by 24" high. Damper sleeve shall not extend more than 6" beyond the firewall or partition unless damper is equipped with an actuator or factory installed access door. Sleeve may extend up to 16" beyond the firewall or partition on sides equipped with the actuator or factory installed access door.
3. Blades: Opposed blade; airfoil-shaped, single piece, minimum 14 gauge double skin. Galvanized steel. Maximum 6" damper blades.
4. Seals: Blade seal shall be silicone fiberglass material to maintain smoke leakage rating to minimum of 450°F and galvanized steel for flame seal to 1,900°F. Seal to be mechanically attached to blade edge. Jam seal shall be stainless steel, flexible metal compression type.
5. Bearings: Self-lubricating stainless-steel sleeve, in extruded hole in frame.
6. Axle: Minimum 1/2" plated steel, hex shaped, mechanically attached to blade.

C. Fusible Link: Fire dampers shall be held open by a fusible link rated at 165°F unless otherwise called for on the drawings or by local codes.

D. Temperature Release Device: FSD shall contain a single 165°F heat sensor capable of remote override of fire-induced closure to permit reopenable operation in a dynamic smoke management system. Controlled closing and locking of damper in 7 to 15 seconds to allow duct pressure to equalize. Wiring by Electrical Contractor.

E. Electric Actuator: Externally mounted, electric direct coupled. Actuator shall be 120V. Wiring by Electrical Contractor. Overload protections shall be either microprocessor or electronic-based motor controller providing burnout protection if stalled before full rotation is reached. The actuator shall electronically cut off at full open to eliminate noise generation. Actuator shall be mounted by means of a V-bolt dual nut clamp with a V-shaped toothed cradle. Aluminum clamps or setscrews are not acceptable. "Stall type" actuators are NOT acceptable. Actuator shall carry a manufacturer™™s 5 year warranty. Fail to closed position. Integral auxiliary switches shall be provided on all actuators as required.

F. Remote Position Indication: Blade position indicator switches - Two position indicator switches linked directly to damper blade in order to allow remote indication of damper blade position at the FMCS workstation and firefighter smoke control panel and remote indicator panel mounted on ceiling below respective fire smoke damper.

G. Remote Inspection Panel: A momentary test switch with open and closed position indication lights shall be mounted ceiling mounted for code-required periodic testing. A remote BACnet testing system may be employed. Connect to factory-supplied position indicating devices. Wiring by Mechanical Contractor.

H. Remote Control for Firefighter Smoke Control Panel: The damper shall be capable of being remotely controlled and reset for pressurization and smoke evacuation at the firefighter smoke control panel. The fire-releasing device shall be a UL 33 listed HS10.

I. Access Door: Locate access door in ductwork for visual inspection and on the latch side to replace link easily. Each access door shall have a label with letters at least 1/2" high reading "FIRE/SMOKE DAMPER".

J. Supplemental California Requirements: Furnish and install California State Fire Marshal approved combination smoke/fire dampers where shown on plans. The fire-releasing device must also be listed by the CSFM for use with the damper assembly. Melting fusible links are not acceptable. The dampers shall be provided in sleeves with pre-mounted motor actuators The motors must be Belimo FSLF120, FSNF120 or FSAF120A/230, and both damper and motor are to have a minimum 5-year warranty. Dampers shall be rated for at least 20,000 complete cycles. Actuators shall draw no more than 27VA running or 10 VA holding for 70"/lb torque. Actuator operating time shall be 15 seconds or less to drive open or spring closed from 32°F. Actuator must reopen damper fully even if power failed for less than 2 seconds. The motors must be mounted on a bracket that allows for use of slip joint connections or "Duct-mate" type connections without modification. Provide Belimo Air Controls FSNF 120 actuator. All smoke/fire dampers shall be tested by the Contractor in the presence of the field inspector and the State Fire Marshal. This test shall be performed prior to the installation of the ceilings.

2.3 BACKDRAFT DAMPERS

A. Gravity backdraft dampers, size 18 inches x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturer's standard construction.

B. Fabricate multi-blade, parallel action gravity balanced backdraft dampers of extruded aluminum, with blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90° stop, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

C. Models:

1. Ruskin CBD4
2. Greenheck EM.

2.4 FABRIC CONNECTORS

A. Fabric connectors shall be installed between all fans or fan units and metal ducts or casings to prevent transfer of fan or motor vibration.

B. The fabric connectors shall be completely flexible material which shall be in folds and not drawn tight.

C. Fabric connectors shall be of glass fabric double coated with neoprene, with UL approval. Weight = 30 oz. per square yard minimum. Fabric shall not be affected by mildew and shall be absolutely waterproof, airtight and resistant to acids, alkalis, grease and gasoline, and shall be noncombustible.

D. Fabric connections shall not exceed 6" in length on ductwork that has a positive pressure. On ductwork that has a negative pressure, the length shall not exceed 2" in length.

E. All corners shall be folded, sealed with mastic and stapled on 1" centers.

F. Fabric connectors shall not be painted.

G. Unless otherwise shown on the drawings, the fabric connection at the inlet to centrifugal fans shall be at least one duct diameter from the fan to prevent inlet turbulence.

H. Materials:

1. Durodyne MFN-4-100
2. Vent Fabrics, Inc.
3. "Ventglas"
4. Proflex PFC3NGA

I. Fabric connectors exposed to sunlight and weather shall be as described above, except the coating shall be hypalon in lieu of neoprene.

J. Materials:

1. Durodyne "Duralon MFD-4-100"
2. Vent Fabrics, Inc.
3. "Ventlon"
4. Proflex PFC3HGA

2.5 DRIP PANS

A. Install drip pans under all rooftop exhaust fans, intake hoods, exhaust hoods and other roof penetrations that do not have ductwork below them to intercept dripping water.

B. Drip pans shall be 22 gauge minimum cross-broken or reinforced sheet metal with 2" welded upturned lips.

C. Pans shall extend 6" in all directions beyond the opening and shall have the top of the lip located 25% of the maximum throat dimension below the opening.

D. Insulate interior of drip pan with 1" thick elastomeric foam insulation. Adhere foam to drip pan with standard foam adhesive.

2.6 DUCT ACCESS DOORS

A. Fabricate per Fig. 7-2 and 7-3 of the SMACNA HVAC Duct Construction Standards and as indicated.

B. Review locations prior to fabrication. Install access doors at fire dampers, smoke dampers, motorized dampers, fan bearings, filters, automatic controls, humidifiers, louvers, duct coils and other equipment requiring service inside the duct.

C. Construction shall be suitable for the pressure class of the duct. Fabricate rigid, airtight, and close-fitting doors of materials identical to adjacent ductwork with sealing gaskets butt or piano hinges, and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.

D. Access doors with sheet metal screw fasteners are not acceptable.

E. Minimum size for access doors shall be 24" x 16" or full duct size, whichever is less.

F. Provide duct access door in all horizontal return ductwork at 20 foot intervals per NFPA 90A.

G. Fire Damper, Fire/Smoke Damper Access Provide quantity of access doors such that two hands can fit inside ductwork to manually reset fire dampers. For ducts larger than 12x12 , provide one access door. For ducts 12" x 12" and smaller, provide one access door on bottom and one on side. For ducts 12" x 12" and smaller, provide duct access sleeve.

2.7 DUCT ACCESS SLEEVE

A. Material: Galvanized G-90 ASTM A527 Access Section. 26 gauge galvanized 12" long constructed with Pittsburgh lock seam. Access section shall be suitable for ductwork pressure class and manufactured to maintain 100 percent of ductwork free area with a clamping type draw latch.

B. Leakage: Maximum of 1/2 CFM @ 2" W.G..

C. Flange Connection: 18 gauge galvanized. Clamps: 20 gauge galvanized with zinc coated draw latch.

D. Gasket: Neoprene gasket 3/16" x 1-1/4", gasket profile forms to the inside of the clamp and seals the outer edges of the access section 18 gauge flanges. Seal seams in accordance with SMACNA HVAC Duct Construction Standard “” Metal and Flexible.

E. Insulation: Contractor shall insulate in field per Duct Insulation Schedule. Include removable wrap around flanges. Manufacturer shall provide duct liner in systems as defined in Duct Insulation Schedule.

F. Locations: Install duct access sleeve in the following locations:

1. Fire Dampers, Fire Smoke Dampers and Smoke Dampers: Provide duct access sleeve at dampers 12" x 12" and 12" diameter and smaller not more than 4" away from the fire damper sleeve.

G. Manufacturers:

1. Langdon, Inc. Sure Clamp

2.8 DUCT TEST HOLES

A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

2.9 REMOTE VOLUME CONTROL DEVICES - MANUAL

A. Remote volume control balancing damper shall be supplied with either miter gears or right angle worm gears. Provide all damper shafts, gearboxes, couplings, U-joints, bearings, shafts, offsets, adapters, and adjustable concealed covers as required.

B. When distances, angles, or offsets prevent installing solid rods, the mechanical cable control system may be utilized. Provide all damper shafts, rack and pinion gear operator, cables and sleeves, and adjustable ceiling mounting cups.

C. Manufacturers:

1. Young Regulator Company
2. Metropolitan Air Technology

2.10 CONTROL DAMPERS AND DAMPER ACTUATORS

A. Control dampers and damper actuators shall be furnished by the Temperature Control Contractor (Section 23 09 00) and shall be installed by this Contractor.

B. Coordinate exact sizes, locations, and installation requirements with the Temperature Control Contractor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install accessories in accordance with manufacturer's instructions.
2. Where duct access doors are located above inaccessible ceilings, provide ceiling access doors. Coordinate location with the Architect/Engineer.
3. Coordinate and install access doors provided by others.
4. Provide access doors for all equipment requiring maintenance or adjustment above an inaccessible ceiling. Minimum size shall be 24" x 24".
5. Provide duct test holes where indicated and as required for testing and balancing purposes.

B. Manual Volume Damper:

1. Provide manual volume dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts where indicated on drawings and as required for air balancing. Use splitter dampers only where indicated.
2. Provide ceiling access doors for manual volume dampers. When manual volume dampers are located above an inaccessible ceiling and an access door cannot be installed, provide a remote-controlled volume control device for operation of the damper. Coordinate location with the Architect/Engineer.

C. Drain Pan:

1. Drain pans shall be installed per ASHRAE 62.1.

    a. All drain pans shall be field tested under normal operating conditions to ensure proper drainage.
    b. Field testing of drain pans is not required if units with factory installed drain pans have been certified (attested in writing) by the manufacturer for proper operation when installed as recommended.

D. Control Dampers and Damper Actuators:

1. Install control dampers and damper actuators in accordance with manufacturer's instructions and in coordination with the Temperature Control Contractor.
2. Seal around damper frame inside ductwork with duct sealant to prevent bypass around damper.
3. Provide duct access door at each control damper.

END OF SECTION

SECTION 23 34 23 - POWER VENTILATORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Rooftop Exhaust Fan - Vertical Discharge - Belt Driven.

B. Propeller Fan.

C. In-Line Cabinet Fan.

1.2 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300.

C. Fabrication: Conform to AMCA 99.

D. Fan Energy Index (FEI): Fans shall meet or exceed the minimum FEI scheduled at the specified airflow, pressure, and air density (duty point). In no case shall the FEI at the specified duty point fall below 1.0.

1.3 REFERENCES

A. AMCA 99 - Standards Handbook.

B. AMCA 208 - Calculation of the Fan Energy Index (FEI).

C. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

D. AMCA 230 - AMCA 230 - Laboratory Methods of Testing Air Circulating Fans for Rating and Certification.

E. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

F. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.

G. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

H. ANSI/AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

I. SMACNA - HVAC Duct Construction Standards (latest edition).

1.4 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include data on all fans and accessories. Submit sound power levels for both fan inlet and outlet at rated capacity. Submit motor ratings and electrical characteristics, plus motor and electrical accessories. Submit multi-speed fan curves including minimum and maximum fan speed with specified operating points clearly plotted. Submit the Fan Energy Index (FEI) at the selected duty point (ceiling and HVLS fans are exempt from FEI submittal requirements).

B. Submit manufacturer's installation instructions.

C. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

1.5 EXTRA STOCK

A. Provide one (1) extra belt set for each fan unit.

PART 2 - PRODUCTS

2.1 ROOFTOP EXHAUST FAN - VERTICAL DISCHARGE - BELT DRIVEN

A. Fan Wheel: Centrifugal type, aluminum hub and wheel with backwards inclined blades, statically and dynamically balanced.

B. Housing: Removable, spun aluminum dome or rectangular top, with square, one piece, aluminum base and curb cap with Venturi inlet cone.

C. Fan Shaft: Turned, ground and polished steel; keyed to wheel hub.

D. V-belt drive with adjustable pitch drive sheave and adjustable motor mountings for belt tensioning.

E. Motor mounted outside of airstream and ventilated with outside air. Motor not less than 1/3 HP.

F. Aluminum or brass bird screen. Plastic mesh will not be allowed.

G. Mill aluminum finish.

H. Dampers: Furnish normally closed, electric motorized damper. Provide step-down transformer if required. Install and wire damper to open when fan runs. Damper shall be aluminum with brass bushings, blade seals and blade tie rods. Leakage shall not exceed 4 cfm/sq.ft @1" SP (or shall be AMCA Class 1 certified).

I. Motor (as scheduled on drawings):

1. Induction: Furnish permanently lubricated sealed ball type motor and drive shaft bearings. Motor and wheel supported by vibration isolators.

a. Disconnect provided by Electrical Contractor, wired in the field.

J. Speed Controller: For single phase induction motor fans, furnish solid-state dial speed controller. Mount and wire inside fan unless shown otherwise on the drawings. Provide permanent marking at balanced point.

K. Bearings:

1. Permanently lubricated, permanently sealed, self-aligning ball bearings.
2. Furnish permanently lubricated sealed ball type motor and drive shaft bearings sized for 200,000 hours life at specified operating conditions. Drives sized for 150% of rated motor horsepower. Drive assembly and wheel supported by vibration isolators.

L. Manufacturers:

1. Cook
2. Greenheck

2.2 PROPELLER FAN

A. Propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.

B. Galvanized steel sheet, all welded, and integral Venturi orifice ring with baked-enamel finish coat applied after assembly.

C. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

D. Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

E. Cast-aluminum blades fastened to cast-aluminum hub; factory set pitch angle of blades.

F. Provide galvanized steel motor-side/back guard complying with OSHA specifications, removable for maintenance.

G. Belt-Driven Drive Assembly:

1. Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
2. Motor Sheaves: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select sheave so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, non-sparking, and anti-static; matched sets for multiple belt drives.
4. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

H. Dampers:

1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.

I. Motor (as scheduled on drawings):

1. Electronically Commutated Motor (ECM): Motor shall be variable speed, constant torque, brushless DC motor for direct-drive applications. Electronics shall be encapsulated for moisture protection and shall include integral surge protection. Motor shall be pre-wired for specific voltage and phase. Motor frame shall be NEMA 48; All EC motors shall be a minimum of 85% efficient at all speeds. Provide motor with onboard motor control module. Motor speed shall be limited to provide electronic overcurrent protection. Provide non-fused, with thermal overload protection, factory mounted and wired disconnect switch mounted inside fan housing. Starter shall provide soft start to reduce inrush current and shall be controllable from 20% to 100% of full rated speed. Operational mode shall be as follows:

a. ECM set for constant pressure.

J. Speed Controller: For single phase induction motor fans, furnish solid-state dial speed controller. Mount and wire inside fan unless shown otherwise on the drawings. Provide permanent marking at balanced point.

K. Bearings:

1. Shaft Bearings: Permanently lubricated, $L_{10}$ of 100,000 hours, permanently sealed, self-aligning ball bearings. Drive assembly and wheel supported by vibration isolators.

L. Provide with the following accessories:

1. Wall Sleeve: Galvanized steel to match fan and accessory size.
2. Weather Hood: Galvanized steel to match fan and accessory size.
3. Weather Front Guard: Galvanized steel with expanded metal screen.

M. Manufacturers:

1. Cook
2. Greenheck

2.3 IN-LINE CABINET FAN

A. Fiberglass lined, sheet metal housing, arranged for in-line installation.

B. Rubber torsion motor mounts.

C. Manual Motor Starter: NEMA ICS 2; AC general-purpose Class A manually operated non-reversing full-voltage controller for fractional horsepower induction motors, with thermal overload relay, toggle operator.

D. Built-in backdraft damper.

E. Centrifugal fan.

F. Provide variable speed controller if shown on the drawings.

G. Manufacturers:

1. Cook
2. Greenheck

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure roof exhausters with cadmium plated lag screws to roof curb.

C. If manufacturer has no recommendations, secure roof exhaust fans to curbs with 1/4" lag bolts on 8" maximum centers.

D. MC shall install and wire factory provided damper to open when the fan runs if the manufacturer does not provide an option to pre-wire the damper.

END OF SECTION

SECTION 23 37 00 - AIR INLETS AND OUTLETS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Grilles And Registers.

B. Louvers.

C. Roof Hoods.

D. Roof Curbs.

1.2 QUALITY ASSURANCE

A. Test and rate performance of air inlets and outlets per ASHRAE 70.

B. Test and rate performance of louvers per AMCA 500L-99.

C. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 REFERENCES

A. AMCA 500-L-12 - Laboratory Methods of Testing Louvers for Rating.

B. ANSI/ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Inlets and Outlets.

C. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

D. ASHRAE 170 (latest published edition) - Ventilation of Health Care Facilities.

E. SMACNA - Duct Construction Standards.

1.4 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00.

B. Submit schedule of inlets and outlets indicating type, size, location, application, and noise level.

C. Review requirements of inlets and outlets as to size, finish, and type of mounting prior to submitting product data and schedules of inlets and outlets.

D. Submit manufacturer's installation instructions.

1.5 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A.

B. Conform to ASHRAE 90.1.

PART 2 - PRODUCTS

2.1 AIR TERMINALS - GRILLES AND REGISTERS

A. Reference to a grille means an air supply, exhaust or transfer device without a damper.

B. Reference to a register means an air supply, exhaust or transfer device with a damper.

C. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule and suitable for the intended use.

D. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents shall be brought to the attention of the Architect/Engineer, in writing, prior to Bid Date. Submission of Bid indicates ceiling and air inlet and outlet types have been coordinated.

E. The capacity and size of the unit shall be as shown on the drawings.

F. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to $10^{-12}$ watts with a 10 dB room effect. .

G. Refer to the drawings for construction material, color and finish, margin style, deflection, and sizes of grilles and registers.

H. Provide with 3/4" blade spacing. Blades shall have steel friction pivots to allow for blade adjustment, plastic pivots are not acceptable.

I. Corners of steel grilles and registers shall be welded and ground smooth before painting. Aluminum grilles and registers shall have staked corners.

J. Where specified to serve registers, provide opposed blade volume dampers operable from the face of the register.

K. Screw holes for surface fasteners shall be countersunk for a neat appearance. Provide concealed fasteners for installation in lay-in ceilings and as specified on the drawings.

L. Manufacturers:

1. Titus
2. Price
3. Nailor
4. Krueger

2.2 AIR TERMINALS - SQUARE MODULAR CORE DIFFUSERS

A. Reference to a diffuser means an air supply device, ceiling mounted, that shall diffuse air uniformly throughout the conditioned space.

B. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule.

C. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents should be brought to the attention of the Architect/Engineer, in writing, prior to bid date. Submission of bid indicates ceiling and air inlet and outlet types have been coordinated.

D. The capacity and size of the unit shall be as shown on the drawings.

E. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10-12 watts with a 10 dB room effect.

F. Modular core diffusers shall consist of an outer frame assembly to facilitate mounting and shall include an integral square collar to allow connection to the square duct. Where shown on the drawings, the diffuser shall be supplied with a square to round adapter. Flat-oval inlets are not acceptable for connection to flexible ducts.

G. The diffuser core shall consist of fixed louver directional modules that may be field adjusted from the diffuser face without any type of tools or mechanical device for one-way, two-way, two-way corner ,three-way or four-way horizontal discharge airflow.

H. Each louvered module shall be removable to allow access to any damper or other component in or near the diffuser neck.

I. The core's blade spacing shall be 1 inch on center.

J. Manufacturers:

1. Titus
2. Price
3. Nailor
4. Krueger

2.3 LOUVERS - FIXED - ALUMINUM

A. Louvers shall be minimum 4" deep and constructed of extruded aluminum. Blade, jamb and sill thickness shall be minimum 0.081". Blades shall be spaced at a maximum of 5.1" apart.

B. Louvers shall be of the drainable blade design with water collected on the leading edge of the blade and diverted to the jamb.

C. Louvers shall be furnished with aluminum bird screen mounted on the inside surface.

D. Size, cfm, finish and pressure drop for louvers shall be as scheduled on the drawings.

E. AMCA Certified performance for 48" x 48" samples with intake airflow of 8,000 cfm shall not exhibit more than 0.19" pressure drop. Maximum water penetration shall be 0.01 ounces per square foot at the scheduled intake velocity based on 15 minute test duration when subjected to a water flow rate of 0.25 gal/min as described under the Water Penetration Test in AMCA 500-L-07.

F. Contractor shall provide the General Contractor with the correct sizes and locations of all louvers required in masonry walls.

G. Louvers shall be sealed around perimeter to avoid moisture penetration between the louver frame and wall.

H. Louvers shall be suitable for duct connection.

I. Manufacturers:

1. Ruskin - "ELF375DX"
2. Greenheck - ESD "403"
3. Pottorff - EFD

2.4 ROOF HOODS

A. Hoods shall be constructed of roll formed, interlocking aluminum panels. Vertical end panels are fully locked into hood.

B. Top of curb to hood inlet shall be minimum of 5".

C. Curb cap shall be of 14 gauge formed aluminum with mitered corners continuously heliarc-welded. Hood shall be of the same material and cross-broken for added strength. Underside of hood shall be coated with insulating mastics.

D. Hoods shall be furnished with aluminum bird screen.

E. Hood and throat shall be reinforced with extruded aluminum angle and have a minimum snow load rating of 30 lbs. per square foot.

F. Size, cfm, finish and pressure drop for hoods shall be as scheduled on the drawings.

G. Inlet area shall be minimum 150% of throat area for intake hoods. Outlet area shall be minimum 125% of throat area for exhaust hoods and relief vents.

H. Hoods shall be furnished with 12" high curb (above top of roof) and be of the size and type as shown on the drawings.

I. Hood shall be furnished with motorized damper unless otherwise noted on the drawings.

J. Manufacturers:

1. Cook
2. Greenheck

2.5 ROOF CURBS

A. Furnish and install, where shown on the drawings, prefabricated roof curbs for all rooftop hood openings.

B. Roof Mounting Curb: Curb shall be sized to match curb cap of the hood. Curb height as shown on drawings, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.

C. Curbs shall be unitized construction, 18 gauge galvanized steel, with continuous arc welded corner seams, insulated with 1-1/2" thick, 3 lb. density rigid fiberglass board and damper support angle.

D. Curb without cant - suitable for use with membrane type roof.

E. Manufacturers:

1. Same manufacturer as the equipment it serves or Pate, RPS, or Thy.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install items in accordance with manufacturers' instructions.
2. Check location of inlets and outlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.
3. Install diffusers to ductwork with air tight connections.
4. Flexible ducts shall NOT be joined to flat-oval connections. Provide sheet metal oval-to-round transitions where required.
5. Supply grille and register blades shall be aimed in the field to provide adequate air distribution in the space. All return grilles and registers blades shall be oriented to minimize sight distance beyond installed device.

B. Volume Damper:

1. Provide manual volume dampers on duct take-off to diffusers when there are multiple connections to a common duct. Locate volume dampers as far as possible from the air inlet or outlet.

C. Roof Hood and Louvered Penthouse:

1. If manufacturer has no recommendations, secure roof hoods and louvered penthouses to curbs with 1/4" lag bolts on 8" maximum centers.
2. Provide 20 gauge sheet metal duct blank-off behind louvers at unused portions of louver openings in exterior walls. Back with 2" rigid 3# density fiberglass board insulation with foil scrim facing the room. Seal watertight.

D. Maintaining Duct Cleanliness:

1. When grilles, registers, and diffusers are installed, Contractor shall prevent construction dust, dirt, and debris from entering ductwork as required by Section 23 05 00.

END OF SECTION

SECTION 23 40 00 - AIR CLEANING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Filters and Filter Media.

B. Side Access Filter Housings.

C. Activated Carbon Filters.

D. Filter Gauges.

1.2 QUALITY ASSURANCE

A. Filter media shall be tested under ANSI/UL 900 and labeled.

B. Provide all filters and filter banks by one manufacturer.

C. Air filters shall be State Fire Marshal approved and of a listed type. Preformed filters having combustible framing shall be tested as a complete assembly. Air filters in all occupancies shall be Class 2 or better (as shown in the State Fire Marshal listing). Air filters shall be accessible for cleaning or replacement.

1.3 REFERENCES

A. ANSI/UL 586 - Test Performance of High Efficiency Particulate, Air Filter Units.

B. ANSI/UL 867 - Standard for Electrostatic Air Cleaners.

C. ANSI/UL 900 - Test Performance of Air Filter Units.

D. ANSI/UL 2998 - Environmental Claim Validation Procedure (ECVP) for Zero Ozone Emissions from Air Cleaners.

E. ASHRAE 26 - Guideline for Field Testing of General Ventilation Devices and Systems for Removal Efficiency In-Situ by Particle Size and Resistance to Flow.

F. ASHRAE 52 - Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

G. ANSI/NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

A. Submit data on media, performance, assembly and frames.

1.5 EXTRA STOCK

A. Provide a total of three (3) sets of filters for all units.

1. Provide clean filters in all units at time of installation.
2. Provide clean filters in all units at project final completion after all interior finishes are complete.
3. Provide one additional set of replacement filters for all units. Deliver to Owner at job site.

PART 2 - PRODUCTS

2.1 MERV 8 (MEDIUM EFFICIENCY) - DISPOSABLE - TYPE D

A. Non-woven cotton fabric, pleated media, disposable type with welded wire grid support bonded to the filter media.

B. Heavy duty, paper board frame with diagonal support members bonded to inlet and exit sides of each pleat. Bond frame to media periphery to eliminate air bypass.

C. 1" thick media with at least 2.3 square feet of media per square foot of face area. Maximum 0.25" WG initial resistance at 350 fpm face velocity.

D. 25-30% efficiency and 90-92% arrestance per ASHRAE 52.1 or MERV 8 per ASHRAE 52.2.

2.2 MERV 13 (85% EFFICIENT) RIGID FILTER - DISPOSABLE - TYPE F

A. Pleated, rigid, disposable type with high density, fine fiberglass laminated to non-woven synthetic backing. Welded wire grid media support bonded to the filter media. Galvanized steel enclosing frame bonded to media periphery to eliminate air bypass.

B. Maximum 12" thick cartridges with at least 14.5 square feet of media per square foot of face area.

C. 80-85% efficiency and 98% arrestance per ASHRAE 52.1 or MERV 13 per ASHRAE 52.2. Maximum 0.60" WG initial resistance at 500 fpm face velocity.

D. Manufacturers:

1. Camfil
2. Flanders

2.3 ACTIVATED CARBON FILTERS - TYPE L

A. Assembly: Galvanized steel unit with extruded aluminum tracks to hold filter servicing trays in deep V arrangement with disposable panel pre-filter.

B. Media: 34lb/ft3 pelletized or granular activated carbon. Minimum 60% carbon tetrachloride activity; in thin bed trays, nominal frame size 24" x 24" x 12"; 1.42 ft3 of carbon per 1,000 cfm nominal airflow capacity.

C. Maximum 0.45" WG initial resistance at 500 fpm face velocity.

D. Manufacturers:

1. Camfil
2. Flanders

2.4 SIDE ACCESS FILTER HOUSING

A. 16 gauge welded galvanized steel construction with bracing and prepunched standing flanges on inlet and outlet.

B. Full size, hinged access doors on each end of housing with 16 gauge galvanized steel, reinforced, positive sealing heavy duty latches and resilient gasketing.

C. 16 gauge galvanized steel or extruded aluminum holding tracks. "U" shaped bearing channel. Replaceable woven pile seals for filters.

D. Holds nominal 24" x 24" filters without alteration.

E. Filter channel suitable for 1" or 2" thick prefilter and bag or cartridge type.

F. Manufacturers:

1. Camfil
2. American Air Filter

2.5 FILTER GAUGES

A. Accessories: Static pressure tips with integral compression fittings, 1/4" plastic tubing, 2- or 3-way vent valves, indicating fluid.

B. Differential Pressure Gauge: Diaphragm actuated, nominal 3" round dial, glass filled nylon housing, polycarbonate lens, zero adjustment, 0-2" W.G. range, 5% of full scale accuracy.

C. Accessories: Static pressure tips with integral compression fittings and 1/8" NPT plastic tubing.

D. Manufacturers:

1. Dwyer "Minihelic II" 2-5000
2. Marshalltown Instrument "Series 85C"

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturers' instructions.

B. Seal filter media to prevent passage of unfiltered air around filters with felt, rubber, or neoprene gaskets.

C. Do not operate fan systems without filters.

D. Install static pressure tips upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and calibrate. Every filter bank, including packaged units, shall have a filter gauge.

E. Install four (4) high efficiency filter test holes, two upstream and two downstream, at all high efficiency filter banks in air handling units and ductwork (85% efficiency and higher). Coordinate location of test holes with Owner.

END OF SECTION

SECTION 23 73 13 - INDOOR MODULAR AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Modular Indoor Handling Units.

1.2 QUALITY ASSURANCE

A. AHU Unit: Manufacturer specializing in design and manufacturing of the products specified in this section with a minimum of five years' experience.

B. Fabrication: Conform to AMCA 99 and AHRI 430.

C. Fan Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

D. Sound Ratings: Tested to AMCA 300.

E. Fan Energy Index (FEI): Fans shall meet or exceed the minimum FEI scheduled at the specified airflow, pressure, and air density (duty point). In no case shall the FEI at the specified duty point fall below 1.0.

F. Air Coils: Certify capacities, pressure drops, and selection procedures per AHRI 410.

G. Electrical control wiring shall be in accordance with NEC codes and ETL requirements.

H. Unit shall contain only UL listed components.

I. Conform to ASHRAE 90.1.

J. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 REFERENCES

A. AMCA 208 - Calculation of the Fan Energy Index (FEI).

B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

C. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.

D. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters

E. AMCA 99 - Standards Handbook.

F. ANSI/AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

G. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

H. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

I. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.

J. AHRI 430 - Standard for Central-Station Air-Handling Units.

K. ASHRAE/ANSI Standard 111 - Practices for Measurements, Testing, Adjusting and Balancing Heating, Ventilating, Air-Conditioning and Refrigeration Systems.

L. NFPA 70 - National Electrical Code.

M. NFPA 90A - Installation of Air-Conditioning and Ventilation Systems.

N. SMACNA - HVAC Duct Construction Standards (latest edition).

O. Standard 62-2004 - Ventilation for Acceptable Indoor Air Quality (ANSI Approved).

1.4 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Indicate ratings, fan performance, motor electrical characteristics, gauges, material finishes, assembly, unit dimensions, weight loading, required clearances, construction details, and field connection details.

1. Product Data

a. Include data on all fans and accessories. Submit motor ratings and electrical characteristics, plus motor and electrical accessories. Submit multi-speed fan curves including minimum and maximum fan speed with specified operating points clearly plotted. Submit the Fan Energy Index (FEI) at the selected duty point.

b. Select fans using external static pressure noted in the schedule. Manufacturer responsible for calculation of internal static pressure. Manufacturer shall include an allowance for clean filters in the internal static pressure. An allowance for the difference between dirty filters and clean filters is included in the external static. Submit static pressure calculations showing total pressure drops, including tabulated internal pressure drops and specified external static pressure drops

c. Submit sound power level data for both fan outlet and casing radiation at rated capacity.

d. Submit shop drawings indicating coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions

e. Submit manufacturer's data showing that coil capacities, pressure drops, and selection procedures meet or exceed specified requirements.

f. Provide a copy of data of filter media, filter performance data, filter assembly, and filter frames with unit submittal for reference only.

B. Submit manufacturer's installation instructions.

C. All base bid pricing shall be based on the drawings, schedules and this specification

1. If a manufacturer requests to deviate from the requirements described herein, the Manufacturer and/or Contractor may list voluntary add or deduct prices on the bid form. These voluntary prices will not be used in determining the low bidder.
2. All voluntary adds or deducts shall be discussed and agreed to by the Owner and Architect/Engineer prior to the award of the air handling unit bid and before the submittal process begins.

D. Any exceptions to the specifications must be clearly noted to the Architect/Engineer prior to acceptance. Contractor is responsible for all expenses due to exceptions.

E. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

F. Submit operation and maintenance data. Include instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists.

G. Piezometer Flow Coefficients: Submittals for fans shall clearly indicate the size and associated flow coefficient for each fan included in the submittal as it relates to the piezometric airflow measuring system. Provide instructions indicating how the flow coefficient can be used in calculating fan airflow using the fan manufacturer provided empirically derived formulas for calculating airflow. Include recommended differential pressure controller ΔP range (inches w.g based on scheduled maximum airflows.

1.5 EXTRA STOCK

A. Provide clean filters in all units at time of installation.

B. Provide clean filters in all units at project final completion after all interior finishes are complete.

C. Provide one additional set of replacement filters for all units. Deliver to Owner at job site.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site with protective coverings in-place. Loose shipped items must be in factory-provided protective coverings, with factory-installed shipping skids and lifting lugs.

B. Store unit in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.7 WARRANTY

A. Provide a manufacturer's 1-year parts and labor warranty against defects in material and workmanship.

1.8 GENERAL DESCRIPTION

A. Unit Location:

1. The air handling unit (AHU--1 and 9-1) re a variable air volume modular unit, located in a non-conditioned mezzanine.
2. The unit will be set on structural steel by the Contractor.

B. Building Type: The building is a steel structure

C. Unit Description:

1. The unit shall contain all the components described in these specifications and shown on the drawings and schedules.
2. Refer to air handling unit drawings and schedules for additional information

PART 2 - PRODUCTS

2.1 MODULAR INDOOR AIR HANDLING UNITS

A. Manufacturers

1. Trane - Performance Climate Changer.
2. Carrier - 39 Series (Basis of Design).

B. Housing:

1. Minimum 18 gauge G60 galvanized steel exterior panels reinforced and braced with galvanized steel framework.
2. Removable access panels for coil and fan removal.
3. Unit shall be double wall insulated constructed panel. Exterior wall shall be minimum 18 gauge galvanized steel. Interior wall shall be minimum 20 gauge solid galvanized steel. Cover all portions of the interior of the unit exposed to the airstream with steel to allow cleaning and prevent fiberglass erosion into the airstream. Foil facing on insulation shall not be acceptable as a substitute for double wall construction. If casing sections are not provided by the unit manufacturer with double wall construction, the Contractor is responsible for covering exposed insulation with galvanized sheet metal. The minimum R-value of the panel assemblies shall be 8.
4. Install a stainless steel drain pan under each cooling coil meeting requirements as outlined in ASHRAE 62.1. Extend drain pans the entire width of each coil, including piping and header if in the air stream, and from the upstream face of each coil to a distance 1/2 of the vertical coil height downstream from the downstream face. Pitch drain pans in two directions towards the outlet, with a slope of at least 1/8" per foot.

C. Units shall be draw-thru or blow-thru as noted on the drawings and shall not exceed the overall dimensions. Doors:

1. Unit doors shall be double wall and insulated with the same materials used in the surrounding unit walls.
2. Doors shall contain a continuous neoprene bulb type gasket.
3. Each door shall contain a double pane tempered, reinforced or safety glass window.
4. Each door shall have a minimum of two (2) high compression type latches, operable from both sides.
5. Provide minimum 12" x 18" hinged access doors on both sides of the fan housing.

D. Access Sections:

1. Provide access sections as shown on the drawings between unit sections. Provide access doors as shown on plans..

E. Fan: Direct Drive Single Width, Single Inlet Plenum Multi-fan Array with Airfoil Blades:

a. Fan RPM shall not exceed 110% of scheduled value with the scheduled wheel type.
b. Statically and dynamically balanced.
c. Fans shall have permanently lubricated ball bearings.
d. Provide extended lubrication lines for all bearings to an easily accessible location.
e. Factory balanced fans will be used with variable speed controls to operate at all speeds up to the design speed.
f. Fan(s) shall have internal spring isolators.
g. Piezometer Air Flow Measuring: Provide fan with factory installed piezometer ports for monitoring the pressure difference between the fan inlet and the smallest diameter of the inlet cone. Ports shall be installed by the factory to ensure proper location of the taps to match how the fans were tested. Orifices shall be factory drilled in the smallest diameter of the inlet cone venturi. Flow tubes from each venturi sensor shall extend to a termination plate mounted on the fan housing. High pressure flow probes shall be factory mounted in the low velocity fan inlet. Flow probes from the high-pressure sensor shall extend to a termination plate mounted on the fan housing. Provide piezometer on each fan in an array. Transducer for measuring differential pressure shall be provided by the Temperature Control Contractor (TCC). Include with fan submittal the empirically derived formulas developed by the fan manufacturer for each supply and return fan provided with the air handling unit, along with the recommended differential pressure transducer range.

F. Motors and Drives:

1. AC Induction Motors:

a. Motors shall have slide rails, adjusting screws, anchor bolts and bedplates.
b. Motor mounting bracket shall be adjustable to allow tightening of belts.
c. Motors shall be open drip-proof or TEFC type with grease lubricated bearings.

d. Motors shall be "variable frequency drive rated" when controlled by VFDs. Refer to Section 23 05 13.
e. Drives shall be V-belt type with adjustable pitch sheaves for units 20 HP and below. On units over 20 HP, use fixed sheaves. This Contractor shall provide replacement sheaves and belts as required to allow final air balancing.
f. No equipment shall be selected or operate above 90% of its motor nameplate rating.

2. Variable Frequency Drives: Provided and installed by unit manufacturer. Refer to Section 26 29 23 for requirements.

G. Coils:

1. Direct Expansion Coils:

a. Extended surface type with seamless copper tubes and continuous plate type aluminum fins.
b. Galvanized steel casing.
c. Suitable for 250 psig. Maximum air velocity of 500 fpm.
d. AHRI rated for direct expansion use with R-410A.
e. Size coils based on saturated suction temperature, EAT and cfm scheduled. The leaving DB and APD shall not exceed the scheduled values.
f. Maximum 144 fins per foot. No water carryover shall occur at design airflow and no anti-carryover coating shall be used.
g. All coils shall be split row or intertwined configuration.
h. Minimum 0.016" tube wall thickness.
i. Manufacturers:

1) Heatcraft
2) Coilmaster (Basis of Design)

H. Pre-Filter Section:

1. Provide side-loading particulate pre-filter section located downstream of return fan module as scheduled on drawings. Filter module shall be equipped with framing for 2" deep MERV-8 pleated media filters. Provide pre-filter module with full height hinged access door.
2. Maximum particulate pre-filter face velocity shall not exceed 230 feet/minute.
3. Reference Section 23 40 00 for filter requirements.

I. Final Filter Section:

1. Provide front-loading final filter section located downstream of supply fan module as scheduled on drawings. Filter module shall be equipped with framing for 12" deep cartridge filters with seals on all four sides where each filter is inserted in the frame to prevent air bypass. Provide final filter module with full height hinged access door.
2. Maximum final filter face velocity shall not exceed 400 feet/minute.

3. Reference Section 23 40 00 for filter requirements.

J. Mixing and Filter Section:

1. Provide with a mixing box and a separate angled filter section. Damper arrangement shall be as shown on the drawings. Furnish dampers with the unit. Dampers shall be extruded aluminum with 6" airfoil blades, compressible metal jamb seals, molded synthetic or stainless steel sleeve bearings. The damper shall not leak more than 4 cfm/sq.ft. at 1" W.C. as tested per AMCA Standard 500-D-98. Maximum damper size shall be 48" in length. Provide multiple damper sections for larger lengths. Multiple dampers shall use individual actuators. Jackshafting is not acceptable. Filters shall be as scheduled and have full size hinged access doors.
2. Provide an angle filter section for 2" thick filters. Maximum filter velocity shall not exceed specified value. Provide full size hinged access doors.
3. Reference Section 23 40 00 for filter requirements.

K. Electrical Power:

1. Provide factory-mounted, vapor-tight light fixtures in each accessible section of the unit. The fixture shall be complete with junction box, globe, aluminum globe guard, switch, and bulb. Lighting shall be wired to a single 120-volt point, terminating at a designated junction box mounted on the air-handling unit. The Mechanical Contractor is responsible to complete all wiring connection between shipping splits after assembly.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements

1. Install per manufacturer's instructions.
2. During construction provide temporary closures of metal or taped polyethylene over openings into housing ducts to prevent dust from entering ductwork.
3. Seal all contractor installed penetrations airtight. Seal all openings prior to cleaning. Seal holes with proper SMACNA closures conforming to pressure class of the housing.
4. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

B. Coil Requirements:

1. Comb all coils to repair bent fins.
2. Extend coil drain and vent connections to outside unit housing. Provide normally closed valve on drain and vent connection outside of unit housing.

3.2 MANUFACTURER'S FIELD SERVICES

A. Provide factory authorized field representative for starting unit and training operator.

B. Prepare and start systems with installing contractor observation.

END OF SECTION

SECTION 23 74 16.12 - PACKAGED ROOFTOP AIR CONDITIONING UNITS 25 TON AND BELOW

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged Rooftop Unit.

B. Unit Controls.

C. Roof Mounting Frame and Base.

D. Economizers.

E. Power Exhaust.

1.2 QUALITY ASSURANCE

A. All insulation inside the unit and in the air stream must comply with the requirement of NFPA 90A (maximum flame spread of 25 and maximum smoke developed of 50).

B. All units must be UL or ETL listed and must contain UL labeled components.

C. Fans shall be tested and rated in cabinet in accordance with AMCA Standard 210. All fan assemblies shall be dynamically balanced in cabinet at final assembly.

D. Conform to ASHRAE 90.1California Energy Code Title 24.

E. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 REFERENCES

A. AHRI 210 - Unitary Air Conditioning Equipment.

B. AHRI 240 - Air Source Unitary Heat Pump Equipment.

C. AHRI 270 - Sound Rating of Outdoor Unitary Equipment.

D. ASHRAE 37 - Methods of Testing for Rating Unitary Air Conditioning and Heat Pump Equipment.

E. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

F. NFPA 70 - National Electrical Code.

G. NFPA 90A - Installation of Air Conditioning and Ventilating System.

H. UL - Underwriters' Laboratory.

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00.

B. Indicate electrical service and duct connections on shop drawings or product data.

C. Submit manufacturer's installation instructions.

D. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

E. Submit fan curves, including minimum and maximum fan speed, with specified operating points clearly plotted.

F. Provide 8 octave maximum sound power levels at unit discharge and return connection.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect units from physical damage by storing off site until roof mounting frames are in place, ready for immediate installation of units.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, installation instructions, maintenance and repair data, and parts listing.

1.7 WARRANTY

A. Provide five (5) year manufacturer's warranty for compressors.

B. Provide five (5) year manufacturer's warranty for heat exchanger.

C. Provide five (5) year manufacturer's warranty for controls and electrical components (thermostats, VFD, etc.).

1.8 MAINTENANCE SERVICE

A. Contractor shall furnish complete service and maintenance of packaged roof top units for one year from Date of Substantial Completion.

B. Provide maintenance service with a two-month interval as maximum time period between calls. Provide 24-hour emergency service on breakdowns and malfunctions.

C. Include maintenance items as outlined in manufacturer's operating and maintenance data, including minimum of four (quarterly) filter replacements, minimum of one fan belt replacement, and controls checkout, seasonal adjustments, and recalibrations.

D. Submit copy of service call work order or report and include description of work performed to Owner and Architect/Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Trane

B. Carrier (Basis of Design)

C. Aaon

2.2 MANUFACTURED UNITS

A. Provide roof-mounted units having electric heating elements, and electric refrigeration.

B. Unit shall be self-contained, packaged, factory assembled, pre-wired and tested, consisting of cabinet and frame, supply fan, exhaust fan, electric heating elements, controls, air filters, refrigerant cooling coil and compressor, condenser coil, condenser fan, and a full refrigerant charge.

C. Unit shall be furnished with non-fused disconnect switch, short fuse protection of all internal electrical components, and all necessary motor starters, contactors, and over-current protection.

2.3 FABRICATION

A. Cabinet: Galvanized steel with baked enamel finish, access doors or removable access panels with quick fasteners locking door handle type with piano hingesAccess doors shall be provided at each section (e.g., filter section, supply fan section, etc.). All exterior access panels must be permanently labeled on the outside indicating what is behind the panel. Structural members shall be minimum 18 gauge, with access doors or removable panels of minimum 20 gauge.

B. Outside Air Intakes: The outside air intakes shall be located a minimum of 15 inches above the roof mounting curb to minimize the effect of heat pickup from the roof during the natural cooling cycle and the effects of snow on the roof during winter operation. Each air intake shall be furnished with rain eliminators.

C. Insulation: Minimum of 1/2" thick, 1.5 lb./cu.ft. density coated glass fiber insulation on surfaces where conditioned air is handled. Protect edges from erosion.

D. Air Filters: Two inch thick glass fiber disposable media in metal frames.

2.4 ROOF MOUNTING FRAME AND BASE

A. Roof Mounting Curb: Minimum 24 inches high, minimum 14 gauge galvanized steel, one-piece construction, insulated, structurally calculated, spring isolated, all welded, wood nailer. Micrometl or approved equal (Basis of Design)

2.5 FANS/MOTORS

A. Fans:

1. Supply Fans: centrifugal; SWSI plenum or vane axial fan.
2. Exhaust Fans: Propeller or SWSI plenum fan.
3. All fans shall be aluminum or composite construction with fan shaft: turned, ground and polished steel; keyed to wheel hub.
4. Fan and motor assemblies shall be resiliently mounted.
5. Direct drive motor or with V-belt drive and rubber isolated hinge mounted motor.
6. All fan bearings must be capable of being lubricated by easily accessible grease fittings.
7. All fans must be statically and dynamically balanced.

B. Motors:

1. Motors shall be "variable frequency drive rated" when controlled by VFDs.
2. No equipment shall be selected or operate above 90% of its motor nameplate rating.
3. Motor shall have 1.15 service factor.

2.6 ELECTRIC HEATING COIL

A. helical nickel-chrome resistance wire coil heating elements with refractory ceramic support bushings easily accessible with automatic reset thermal cut-out, built-in magnetic contactors, galvanized steel frame, control circuit transformer and fuse, manual reset thermal cut-out, airflow proving device, toggle switch (pilot duty), fused disconnect,.

B. Controls shall start supply fan before electric elements are energized and continue operating until air temperature reaches minimum setting, with switch for continuous fan operation.

C. Heating shall have four stages of modulating SCR control.

2.7 EVAPORATOR COIL

A. Provide copper tube with aluminum fin coil assembly.

B. Install a drain pan under each cooling coil meeting requirements as outlined in ASHRAE 62.1. The drain pans shall extend the entire width of each coil, including piping and header if in the air stream. The length shall be as necessary to limit water droplet carryover beyond the drain pan to 0.0044oz per ft2 of face area per hour under peak sensible and peak dew point design conditions, considering both latent load and coil face velocity. Pitch drain pans in two directions towards the outlet, with a slope of at least 1/8" per foot.

C. Provide capillary tubes or thermostatic expansion valves for units of 6 tons capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 tons cooling capacity and larger.

D. Provide insulation on liquid refrigerant and suction piping between compressor and evaporator coil where not protected by drain pans. Insulation shall be elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.27 maximum 'K' value at 75°F, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). Maximum 1" thick per layer where multiple layers are specified.

E. Drain Pan Condensate Overflow Switch: Float with integral magnet overflow switch conforming to UL508. Factory installed in drain pan and wired to shut the rooftop unit down with a fault alarm. No standby power required.

2.8 COMPRESSOR

A. Provide hermetic or semi-hermetic compressors (quantity as scheduled on drawings), 3600 rev/min maximum, resiliently mounted with positive lubrication, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gauge ports, and filter drier.

B. Provide capacity control by staging multiple compressors,.

C. Five minute timed off circuit shall delay compressor start.

D. For heat pump units, provide reversing valve, suction line accumulator, flow control check valve, and solid-state defrost control utilizing thermistors.

E. The use of hydrochlorofluorocarbon (HCFC) or chlorofluorocarbon (CFC) based refrigerants is prohibited.

2.9 CONDENSER

A. Condenser shall provide design capacity between the minimum and maximum ambient conditions scheduled on the drawings.

B. Condenser Coil:

1. Microchannel: All aluminum brazed fin construction. The maximum allowable working pressure of the condenser is 450 psig. Air test under water to 450 psig. Coils and frame shall include 5000+ hour salt spray resistance (ASTM B117-90).

C. Condenser Fans: Provide direct drive propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor. Fan blade shall be aluminum or composite material.

D. Condenser Motors: Fan motors shall be an ECM type motor for proportional control. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.

E. Entire fan assembly shall be statically and dynamically balanced.

F. Provide refrigerant pressure switches to cycle condenser fans.

G. Provide hail guards on all condenser coils.

H. Liquid and discharge isolation valves with staged and digital scrolls.

2.10 MIXING SECTION

A. Dampers: Provide outside, return, and relief dampers with damper operator and control package to automatically vary outside air quantity. Outside air damper shall fail to closed position. Relief dampers may be gravity balanced.

B. Gaskets: Provide tight fitting dampers with edge gaskets. Gaskets must be mechanically fastened (use of adhesive alone shall not be acceptable). Damper blades shall be gasketed with side seals to provide an air leakage rate of Class 1A at 1" w.c. pressure differential for a 24"x 24" damper.

C. Damper Actuator: 24 volt with gear train sealed in oil, with spring return on units 7.5 tons cooling capacity and larger.

2.11 ECONOMIZERS

A. Factory installed by approved rooftop unit manufacturer with fully modulating motorized outside air and return air dampers.

B. To be controlled by fixed enthalpy and fixed dry-bulb controller with minimum position setting.

C. Shall be equipped with 100% capable relief barometric damper relieving up to 100% return air and sealed to meet ASHRAE 90.1 requirements.

D. Shall be capable of introducing up to 100% outside air.

E. Shall maintain minimum airflow into the building during occupied period and provide design ventilation rate for full occupancy.

F. Dampers shall be capable of completely closing when unit is in unoccupied mode.

G. Outside air damper normally closed and return air damper normally open.

H. Provide factory installed and tested, outdoor air monitor that controls outdoor air ± 15% accuracy down to 40 cfm per ton.

I. Economizer assembly shall be California Title 24 compliant. MicroTech III controls shall display a warning, and write a warning to the BAS, if the economizer malfunctions in accordance with Title 24 specifications.

J. Provide a field installed duct/space-mounted C02 sensor. Outside air damper position shall modulate between the demand control ventilation limit (minimum position setpoint) and the ventilation limit (maximum non-economizer position setpoint) to satisfy the space requirements. Damper position shall be controlled to the greater of the two command signals, either minimum outside airflow or space IAQ (CO2).

K. Economizer Fault Detection and Diagnostics (FDD):

1. Air-cooled unitary direct-expansion units that are equipped with an economizer shall include a fault detection and diagnostics system complying with the following:

a. The following temperature sensors shall be permanently installed to monitor system operation:

1) Outside air.
2) Supply air.
3) Return air.

b. Temperature sensors shall have an accuracy of ±2°F over the range of 40°F to 80°F.
c. Refrigerant pressure sensors, where used, shall have an accuracy of ± 3 percent of full scale.
d. The unit controller shall be configured to provide system status by indicating the following:

1) Free cooling available.
2) Economizer enabled.
3) Compressor enabled.
4) Heating enabled.
5) Mixed air low limit cycle active.
6) The current value of each sensor.

e. The unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans, and the heating system can be independently tested and verified.
f. The fault detection and diagnostics system shall be configured to detect the following faults:

1) Air temperature sensor failure/fault.
2) Not economizing when the unit should be economizing.
3) Economizing when the unit should not be economizing.
4) Damper not modulating.

5) Excess outdoor air.

g. The unit shall be configured to report faults to a fault management application available for access by day-to-day operating or service personnel or annunciated locally on zone thermostats.

2.12 POWER EXHAUST

A. Factory installed by economizer supplier or compatible equivalent.

B. Controlled by economizer controls.

C. Power exhaust shall be factory wired to electrical section complete with conduit, feeders, disconnect, and overcurrent protection. Power exhaust shall be energized based on building pressure or when dampers open past the adjustable setpoint of the economizer control.

D. Must comply with Energy Code Fan Power Limitation formula.

E. Fans:

1. Exhaust Fans: Plenum
2. All fans shall be aluminum or composite construction with fan shaft: turned, ground and polished steel; keyed to wheel hub.
3. Fan and motor assemblies shall be resiliently mounted
4. Direct drive motor.
5. All fan bearings must be capable of being lubricated by easily accessible grease fittings.
6. All fans must be statically and dynamically balanced.

F. Motors:

1. Motors shall be "variable frequency drive rated" when controlled by VFDs.
2. No equipment shall be selected or operate above 90% of its motor nameplate rating.
3. Motor shall have 1.15 service factor.

2.13 ELECTRICAL

A. Provide with single point power connection to service all controls, dampers, outlet, and fans, complete with non-fused disconnect switch, short circuit protection of all internal electrical components, and all necessary motor starters, contactors, and over-current protection, transformer.

B. All units must be so constructed that when the electrical section access panel is opened, all electrical power to the unit (with the exception of the 120 volt duplex convenience outlet) is disconnected by means of a single disconnect.

C. All wiring must be labeled, numbered, and terminate in "spade clips". All terminal strips must be keyed to the wiring numbers. Each control device must be permanently labeled to indicate its function.

D. Wiring diagrams for all circuits must be permanently affixed to the inside of the electrical section access panel. The markings of terminal strips and wiring must agree with the numbering on the wiring diagrams.

E. All units shall include a transformer for controls and convenience outlet.

F. Only one power cable connection to the unit shall be necessary.

G. Motor shall include phase failure protection and prevent the motor from operation in the event of phase loss.

2.14 OPERATING CONTROLS - SINGLE ZONE UNITS

A. When variable speed drives are applied:

1. Single Zone VAV: An electronic variable frequency drive shall be provided for the supply air fan. Each drive shall be factory installed out of the airstream in a conditioned cabinet. Drives shall meet UL Standard 95-5V. The completed unit assembly shall be listed by a recognized safety agency, such as ETL. Drives are to be accessible through a hinged door assembly. Mounting arrangements that expose drives to high temperature unfiltered ambient air are not acceptable.

B. Room thermostat shall incorporate:

1. Automatic switching from heating to cooling.
2. Preferential rate control to minimize overshoot and deviation from set point.
3. Set-up for four separate temperatures per day.
4. Instant override of setpoint for continuous or timed period from one hour to 31 days.
5. Short cycle protection.
6. Programming based on weekdays, Saturday and Sunday.
7. Switch selection features including imperial or metric display, 12 or 24 hour clock, keyboard disable, remote sensor, fan on-auto.

C. Room thermostat display shall include:

1. Time of day.
2. Actual room temperature.
3. Programmed temperature.
4. Programmed time.
5. Duration of timed override.
6. Day of week.
7. System model indication: heating, cooling, auto, off, fan auto, fan on.
8. Stage (heating or cooling) operation.

D. Provide low limit sequence to close outside air dampers and stop supply fan.

E. Mixed Air Controls: Maintain selected supply air temperature and revert dampers to minimum outside air position on a call for heating and above 75°F ambient, when ambient air enthalpy exceeds return air enthalpy.

2.15 DDC TEMPERATURE CONTROLS

A. Install standalone control module providing communication between unit controls and packaged DDC temperature control system.

B. Control module shall be compatible with temperature control system specified in Section 23 09 00. Provide BACnet gateway for communication.

2.16 ACOUSTICS

A. Manufacturer shall submit calculated sound power levels.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings and illustrated by the manufacturer.

B. Verify that proper power supply is available.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Mount units on factory built roof mounting curb and provide watertight enclosure to protect ductwork and utility services. Install unit level.

C. All field wiring shall be in accordance with the National Electrical Code.

D. P-traps must be provided for all drain pans.

E. Comb all coils to repair bent fins.

F. Contractor shall coordinate unit access stair and walkway placement to ensure compliance with OSHA requirements.

3.3 MANUFACTURER'S FIELD SERVICES

A. Provide initial start-up and shutdown during first year of operation.

END OF SECTION

SECTION 23 81 26 - SPLIT SYSTEM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Split system air conditioning wall units.

1.2 REFERENCES

A. ARI 210 - Unitary Air Conditioning Equipment

B. ARI 240 - Air Source Unitary Heat Pump Equipment

C. ANSI NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

D. ANSI/ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality.

E. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

F. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

G. ASHRAE 52 - Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

H. ASTM B1003 - Standard Specification for Seamless Copper Tube for Linesets.

I. FS TT-C-490 - Cleaning Method and Pretreatment of Ferrous Surfaces for Organic Coatings.

J. UL - Underwriters' Laboratories.

1.3 SUBMITTALS

A. Indicate drain, electrical, and refrigeration rough-in connections on shop drawings or product data.

B. Submit manufacturer's installation instructions.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Accept units and components on site in factory protective containers, with factory shipping skids and lifting lugs. Inspect for damage.

B. Comply with manufacturer's installation instruction for rigging, unloading, and transporting units.

C. Protect units from weather and construction traffic by storing in dry, roofed location until units are ready for immediate installation.

1.5 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A for the installation of computer room air conditioning units.

B. Conform to ASHRAE 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.7 WARRANTY

A. Provide five (5) year manufacturer's warranty on all compressors.

PART 2 - PRODUCTS

2.1 SPLIT SYSTEM WALL AND CEILING-MOUNTED UNITS

A. Manufacturers:

1. Carrier/Toshiba (Basis of Design)
2. LG

B. Manufactured Units:

1. Provide packaged, air-cooled, factory assembled, pre-wired and pre-piped unit consisting of cabinet, fans, filters, remote condensing unit, and controls. Wall-mounted units shall be furnished with integral wall mounting bracket and mounting hardware.
2. Assemble unit for wall-mounted or ceiling installation with service access required.
3. Performance shall be as scheduled on the drawings.
4. Unit shall be rated per AHRI Standards 210/240 and listed in the AHRI directory as a matched system.
5. Provide unit with factory-supplied cleanable air filters.
6. The units shall be listed by Electrical Laboratories (ETL) in accordance with UL-1995 certification and bear the ETL label.
7. All wiring shall be in accordance with the National Electric Code (NEC).

C. Evaporator Cabinet and Frame:

1. Cabinet:

a. Refer to schedule on drawings for mounting type (wall-mounted).
b. Exposed units shall have a finished appearance with concealed refrigerant piping, condensate drain piping, and wiring connections.

D. Evaporator Fans and Motors:

1. Fans:

a. The evaporator fan shall be direct drive with a single motor having permanently lubricated bearings.
b. The fan shall be statically and dynamically balanced.
c. The indoor fan shall have at least three speeds.

2. Motor:

a. Direct driven, digitally controlled with multiple speeds. Permanently lubricated with internal overload protection.

E. Evaporator Coils (Direct Expansion):

1. Direct expansion cooling coil of seamless copper tubes expanded into aluminum fins.
2. Single refrigeration circuit with externally equalized expansion valve.
3. Coils shall be pressure tested at the factory.
4. A sloped, corrosion-resistant condensate pan with drain shall be provided under the coil.

F. Electrical Panel:

1. Service Connections, Wiring, and Disconnect Requirements: Conform to the National Electrical Code and local electrical codes.

G. Control:

1. The unit shall have a hard-wired 7-day programmable remote controller to operate the system. Provide wall mounting bracket for controller.
2. Remote controller shall have "automatic", "dry" (dehumidification), and "fan only" operating modes.
3. The remote controller shall have the following features:

a. On/Off power switch.
b. Mode Selector to operate the system in auto, cool, heat, fan, or dehumidification (dry) operation.
c. Fan Setting to provide multiple fan speeds.
d. Swing Louver for adjusting supply louver discharge.
e. On/Off Timer for automatically switching the unit off or on.

f. Temperature Adjustment allows for the increase or decrease of the desired temperature.
g. Powerful Operation to allow quick cool down or heating up in the desired space to achieve maximum desired temperature in the shortest allowable time.

4. The remote controller shall perform fault diagnostic functions that may be system related, indoor or outdoor unit related depending on the fault code.
5. Temperature range on the remote controller shall be 64°F to 90°F in cooling mode and 50°F to 86°F in heating mode.
6. The indoor unit microprocessor shall have the capability to receive and process commands via return air temperature and indoor coil temperature sensors enabled by commands from the remote controller.
7. Integration: Manufacturer shall provide a BACnet interface with the building automation system in accordance with ASHRAE/ANSI Standard 135. This may be accomplished through a system integration panel or "gateway". Integration panels shall be provided as part of the split system.

H. Outdoor Unit:

1. General:

a. The outdoor unit shall be specifically matched to the corresponding indoor unit size. The outdoor unit shall be completely factory assembled and pre-wired with all necessary electronic and refrigerant controls.

2. Cabinet:

a. The outdoor unit shall be fabricated of galvanized steel, bonderized and coated with a baked enamel finish for corrosion protection.

3. Fan:

a. The fan shall be direct drive, propeller type fan with fan guard.
b. Fan blades shall be statically and dynamically balanced.
c. The fan shall have permanently lubricated type bearings.
d. Motor shall be protected by internal thermal overload protection.
e. Airflow shall be horizontal discharge.

4. Coil:

a. The outdoor coil shall be nonferrous construction with corrugated fin tube.
b. The coil shall be protected with an internal guard.
c. Refrigerant flow from the condenser shall be controlled via a metering device.

5. Compressor:

    a. Hermetic or scroll refrigerant compressors with resilient suspension system, inverter driven, oil strainer, sight glass/moisture indicator, internal motor protection, high pressure switch, and crankcase heater.
    b. The outdoor unit shall have an accumulator and four-way reversing valve.

6. Refrigerant:

    a. Unit shall use R-410a.
    b. The use of chlorofluorocarbon (CFC)-based refrigerants is prohibited.

I. Integral Condensate Pump:

1. Packaged unit matched to evaporator unit including float switch, pump, motor assembly, check valve, and reservoir.
2. Provide alarm to indicate high level reservoir.
3. Unit shall be powered from evaporator unit with appropriate field connections available.

2.2 PIPING

A. Design Pressure: 450 psig; Maximum Design Temperature: 250°F

B. Type ACR Seamless Copper Tube Linesets; Brazed Joints:

1. 3/4" and under.
2. Tubing: Type ACR seamless copper tube linesets, ASTM B1003. Sizes indicated are nominal designation.
3. Joints: Brazed with silver solder.
4. Fittings: Wrought copper solder joint, ANSI B16.22.
5. Special Requirements: All tubing shall be cleaned, dehydrated, pressurized with dry nitrogen, plugged, and tagged by manufacturer "for refrigeration service". During brazing operations, continuously purge the interior of the pipe with nitrogen to prevent oxide formation.
6. Limitations:
    a. Only between refrigerant splitter box and indoor terminal unit.
    b. For use above ceiling only. Do not use in exposed areas.

C. Type ACR Hard Drawn Seamless Copper Tube; Brazed Joint:

1. 4" and under.
2. Tubing: Type ACR hard drawn seamless copper tube, ASTM B280. Sizes indicated are nominal designation.
3. Joints: Brazed with silver solder.
4. Fittings: Wrought copper solder joint, ANSI B16.22.
5. Special Requirements: All tubing shall be cleaned, dehydrated, pressurized with dry nitrogen, plugged and tagged by manufacturer "for refrigeration service". During brazing operations, continuously purge the interior of the pipe with nitrogen to prevent oxide formation.

D. Refrigerant linesets are permitted.

1. Provide manufacturer-packaged refrigerant linesets and accessories of sizes needed for installation. Verify lengths of piping required for installation.

2.3 INSULATION

A. EPDM (NBR/PVC Blend is not permitted) elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.25 maximum 'K' value at 75°F, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). Minimum 1/2" thick for pipe sizes less than 1-1/4" and 3/4" thick for pipe sizes 1-1/4" and above.

2.4 EXPANSION COMPENSATION

A. Assembly consisting of two flexible connectors, two copper flexible connectors, two 90° elbows, and a 180° return pipe. Unit shall be in the form of a pipe loop.

B. Connectors shall have corrugated copper hose bodies with copper braided casings.

C. Connectors shall be rated for 150 psi working pressure at 70°F.

D. Sizes 2" and smaller shall have copper sweat ends.

E. Connectors shall be suitable for 1/2" permanent misalignment.

F. Manufacturer:

1. Metraflex Type MLS

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that proper power supply is available.

3.2 INSTALLATION

A. General Installation Requirements:

1. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
2. Install units in accordance with manufacturer's instructions. Install all units level and plumb. Indoor units shall be installed using manufacturer's standard mounting hardware securely fastened to building structure.
3. Refer to Section 23 05 29 for concrete base for outdoor unit.

4. Coordinate the exact mounting location of all indoor and outdoor units with architectural and electrical work. Coordinate installation of ceiling-mounted units with ceiling grid layout. Provide additional ceiling grid reinforcement or modification as required and coordinate the work with the GC. Locate the indoor unit where it is readily accessible for maintenance and filter changes. Where outdoor units are located on the roof, locate at least 10' from the roof edge.
5. Verify locations of wall-mounted remote controllers with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Height above finished floor shall not exceed 48".
6. Maintain minimum clearances to all equipment. Maintain manufacturer's minimum maintenance, and airflow clearances, and maintain minimum spaces about electrical equipment, whichever is greater.

    a. 120V: 36" deep x 30" wide or the width of the panel whichever is wider.
    b. 208V: 42" deep x 30" wide or the width of the panel whichever is wider.
    c. 480V: 42" deep x 30" wide or the width of the panel whichever is wider.

B. Condensate Removal:

1. Install condensate piping with trap and route from drain pan to nearest drain. Discharge to nearest code-approved receptor or to a properly vented indirect waste fitting. Flush all piping before making final connections to units.

C. Comb all coils to repair bent fins.

D. Install new filters in the unit at Substantial Completion.

E. A factory-authorized service agent shall assist in commissioning the unit and inspecting the installation prior to startup. Submit startup report with O&M manuals.

3.3 REFRIGERANT PIPING

A. Install refrigerant piping from the indoor unit(s) to the condensing unit. Refrigerant pipe sizes, lengths, specialties and configurations shall be as recommended by the manufacturer. Evacuate refrigerant piping and fully charge system with refrigerant per manufacturer's requirements.

B. Provide weather-tight insulated roof curb to accommodate refrigerant piping and conduit roof penetrations.

C. Insulate all refrigerant piping. Both liquid and suction lines shall be insulated between the indoor and outdoor units.

D. Joining of Piping:

1. Brazed Joints:

a. Make up joints with brazing filler metal conforming to ANSI/AWS A5.8. Cut copper tubing ends perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt, and grease just prior to brazing. Apply flux evenly, but sparingly, to all surfaces to be joined. Brazing filler metal with a flux coating may also be used. Heat joints uniformly to proper brazing temperature so braze filler metal flows to all mated surfaces. Wipe excess braze filler metal, leaving a uniform fillet around cup of fitting.
b. Flux shall conform to ANSI/AWS A5.31.
c. Remove composition discs and all seals during brazing if not suitable for a minimum of 840°For greater than the melting temperature of the brazing filler metal, whichever is greater.

E. Insulation:

1. California Title 24 - 2022:

a. Refrigerant Suction (40°F & Below):

1) Up to 1": 1"
2) 1" and up: 1-1/2"

b. Refrigerant Suction (41°F to 60°F:

1) Up to 1-1/2": 1/2"
2) 1-1/2" and up: 1"

c. Refrigerant Low Pressure Gas (141°F to 200°F):

1) Up to 1-1/2": 1-1/2"
2) 1-1/2" and up: 2"

d. Refrigerant High Pressure Gas (201°F to 250°F):

1) Up to 4": 2-1/2"

e. Refrigerant Liquid:

1) Up to 1": 1"
2) 1" and up: 1-1/2"

END OF SECTION

SECTION 23 81 45 - VARIABLE REFRIGERANT FLOW HEAT PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Variable refrigerant flow split system heat pump with heat recovery (simultaneous heat/cool).

B. Refrigerant piping/tubing and insulation.

1.2 QUALITY ASSURANCE

A. Manufacturer: Manufacturer shall have a factory trained service contractor within 50 miles of project site.

B. Installed: Company with minimum five years documented experience performing the work of this Section.

C. Installer: Refrigerant system installer shall be certified with one of the following:

1. ASSE 6010 Medical Gas Installer Certificate
2. Commercial Refrigeration Technician Certificate

1.3 REFERENCES

A. ANSI/AHRI 210/240 - Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment.

B. ANSI/AHRI 270 - Sound Rating of Outdoor Unitary Equipment.

C. ANSI/ASHRAE 62 - Ventilation for Acceptable Indoor Air Quality.

D. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

E. MIL-H-22547B - Heat Pump, Heating and Cooling (Unitary).

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00.

B. Indicate water, drain, and electrical rough-in connections on shop drawings or product data.

C. Submit manufacturer's installation instructions.

D. Submit manufacturer's warranty information.

E. Submit installing contractor's manufacturer training certification.

F. Submit ASSE 6010 or Commercial Refrigeration Technician Certificates for all installers.

G. Submit refrigerant charge. Charge calculation should be based on installed piping lengths and equipment capacities.

H. VRF Piping Layout Drawings:

1. Submit manufacturer's detailed VRF piping layout drawings at 1/8" = 1'-0" minimum scale complete with the following information at beginning of project:

    a. Actual pipe routing, fittings, hanger and support types, accessories, etc. with lengths and refrigerant charge noted.
    b. Include insulation thickness and type of insulation.
    c. Room names and numbers, ceiling types, and ceiling heights.
    d. Indicate location of all beams, bar joists, etc., along with bottom of steel elevations, for each member.

2. Submit VRF piping and equipment layout drawings. Verify clearances and interferences with other trades prior to preparing drawings. IMEG will provide electronic copies of piping drawings for Contractor's use if the Contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for this submittal. Submittals shall be in accordance with Section 23 05 00.
3. Following installation and prior to refrigerant charge, Contractor shall verify actual installation, pipe routing, elevation changes, and piping lengths, noting variations from the original manufacturer's design and resubmit to the manufacturer. Manufacturer shall verify layout and determine the final refrigerant charge prior to operation.

I. Submit Electrical Power and Controls Diagrams:

1. Power wiring diagrams for each component.
2. Wiring diagrams and layouts for each control panel showing all termination numbers.
3. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Show all interface wiring to the control system.
4. Schematic diagrams for all field sensors and controllers.
5. A schematic diagram of each controlled system. The schematics shall have all control points labeled. The schematics shall graphically show the location of all control elements in the system.
6. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Label all terminals.
7. All installation details and any other details required to demonstrate that the system will function properly.
8. All interface requirements with other systems.

J. Sequences: Submit a complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system. **The wording of the control sequences in the submittal shall match verbatim that included in the construction documents to ensure there are no sequence deviations from that intended by the Architect/Engineer. Clearly highlight any deviations from the specified sequences on the submittals.**

K. Control System Demonstration and Acceptance: Provide a description of the proposed process, along with all reports and checklists to be used.

L. Clearly identify work by others in the submittal.

M. Quantities of items submitted may be reviewed but are the responsibility of the Contractor to verify.

N. Manufacturer's Startup Report: Submit manufacturer's startup report documenting equipment startup. StartUp report shall include Contractor's field test reports.

1.5 DELIVERY STORAGE AND HANDLING

A. Protect finished cabinets from physical damage by leaving factory packing cases in place before installation and providing temporary covers after installation.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.7 WARRANTY

A. Installing contractor shall perform tasks required by manufacturer to ensure maximum available warranty is achieved. This will include but is not limited to:

1. System design performed by manufacturer certified designer.
2. System installation performed by manufacturer certified installer.
3. Complete system commissioning paperwork and submit to manufacturer.

B. Provide minimum ten (10) year manufacturer's parts warranty (one-year basic warranty plus nine-year extended warranty) on all parts (excluding compressors) and one (1) year labor warranty.

C. Provide minimum five (5) year manufacturer's compressor parts warranty.

D. Contractor shall provide one (1) year parts and labor warranty on the associated controls system, including all devices, wiring, and programming.

1.8 DEMONSTRATION

A. Engage manufacturer or factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain individual units and complete system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. LG

B. Carrier/Toshiba (Basis of Design)

2.2 SYSTEM DESCRIPTION

A. The variable capacity, heat recovery, heat pump air conditioning system shall be a variable refrigerant flow split system. The system shall consist of multiple evaporators using PID control and inverter driven heat pump unit. The unit shall consist of direct expansion (DX), air-source heat pump air conditioning system, and variable speed driven compressor multi zone split system.

B. Air-Source Heat Pump Unit - General: The heat pump unit is designed specifically for use with the manufacturer's components:

1. Refrigerant: R410A.
2. The air-source heat pump unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant control. The refrigeration circuit of the heat pump unit shall consist of a compressor, motors, fans, condenser coil, electronic expansion valves, oil separators, service ports, liquid receivers, and accumulators.
3. All refrigerant lines shall be individually insulated between the heat pump and indoor units.
4. The connection ratio of the nominal capacity of indoor units to heat pump unit shall be 50-130%.
5. The sound pressure shall be no greater than 63 dBA at 4 feet from the heat pump unit at full load at fan height.
6. The system shall automatically restart operation after a power failure and shall not cause any settings to be lost, thus eliminating the need for re-programming.
7. The following safety devices shall be included on the heat pump unit: high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature. Oil recovery cycle shall be automatic as required to maintain oil levels at the heat pump unit.
8. The heat pump unit shall be able to operate in heating mode to -4°F -13°F dry bulb ambient temperature without additional ambient controls.

a. Heating capacity at design condition of -5°F, shall be no less than 100% of the value scheduled on the drawings.

9. The heat pump unit shall have air cooled heat exchange coils constructed from copper tubing with aluminum fins. The coils shall be capable of being divided into sections to enable the heat pump unit to match the capacity required by the indoor units and to allow individual defrosting to take place as required.
10. The heat pump unit shall have at least one inverter controlled compressor, depending on scheduled capacity. The system shall use a control sequence to ensure that indoor loads are matched to the compressor capacity control.
11. The refrigeration process of the heat pump unit will be maintained by pressure and temperature sensors controlling solenoid valves, check valves, and bypass valves. The heating or cooling mode of the heat pump unit will be controlled using a combination of 2 and 3-way valves that shall reverse the cycle of the refrigerant to change the mode of the heat pump unit.
12. Unit Cabinet: The heat pump unit model shall be completely weatherproof and corrosion resistant. The heat pump unit shall be constructed from steel plate and treated with an anti-corrosive paint. Provide hail guards on all condenser coils.
13. Fan:

    a. The heat pump unit shall consist of propeller type, direct-drive fan motors that have multiple speed operation via a DC inverter.
    b. The fans shall be a vertical discharge. The fan motors shall have inherent protection and permanently lubricated bearings.
    c. The fans shall be provided with fan guards.

14. Condenser Coil: The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
15. Compressor:

    a. The variable speed compressor shall be capable of changing the speed to follow the variations in total cooling load as determined by the suction gas pressure as measured in the heat pump unit.
    b. The inverter driven compressor in each heat pump unit shall be DC, hermetically sealed, scroll type.
    c. The capacity control range shall be a minimum of 20% to 100% of total capacity.
    d. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
    e. Oil separators shall be standard with the equipment, together with an oil balancing circuit.
    f. The compressor shall be mounted to avoid the transmission of vibration.

16. Bypass Filter Assembly: Provide bypass cartridge filter at outdoor unit. The purpose is to provide refrigerant contaminate filtration for the first 24 hours of operation. Normal operation will bypass filter to outdoor unit.

a. Replaceable Cartridge Angle Type: ANSI/AHRI 710, UL listed, brass or epoxy-coated steel shell, molded desiccant high-water capacity filter core(s); maximum working pressure of 500 psi; maximum temperature of 275°F; maximum pressure drop of 3 psi with R410a at system flow rate.

C. Indoor Units:

1. General – Each indoor unit shall have a heat exchanger that shall be constructed from copper tubing with aluminum fins. The flow of refrigerant through the heat exchanger shall be controlled by an electronic modulating expansion valve. This valve shall be controlled by internal temperature sensors and shall be capable of controlling the variable capacity of the indoor unit between at least 25% and 100%. The units shall be shipped from the factory fully charged with dehydrated air.
2. The indoor units shall be designed for installation within a conditioned space to be connected to an air-source heat pump air conditioning system.

3. Ceiling Concealed Ducted (High Static Pressure):

a. The indoor unit shall be a built-in ceiling concealed indoor unit, high static pressure (HSP), for installation into the ceiling cavity. The unit shall be constructed of a galvanized steel as scheduled. The indoor unit shall be manufactured for ducted horizontal discharge air, with ducted horizontal return air or bottom return air configuration (as scheduled or shown on the drawings). The external static pressure shall be as scheduled on the drawings.
b. Acoustic Performance: The indoor units' sound pressure shall not exceed 31 dBA at low speed 5 feet from the unit.
c. Construction:

1) The indoor unit shall be completely factory assembled and tested. The unit shall include factory wiring, piping, electronic modulating expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
2) The indoor units shall be equipped with a return air thermistor.
3) The indoor unit shall be separately powered.
4) The switch box shall be reached from the side or bottom for ease of service and maintenance.

d. Unit Cabinet:

1) The cabinet shall be in the ceiling and ducted to the supply and return openings.
2) The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
3) The cabinet shall be factory insulated for use in unconditioned indoor spaces.

e. Fan:

1) The fan shall be direct-drive type, with statically and dynamically balanced impeller with high and low fan speeds.
2) The fan motor shall be thermally protected.

f. Filter: The return air shall be filtered by means of a washable long-life filter with mildew proof resin.

g. Coils:

1) Coils shall be of the direct expansion type, constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2) The refrigerant connections shall be flare connections, and the condensate shall be coordinated with piping material specified in Section 23 21 00.
3) A condensate pump with at least 18 inches of lift shall be located below the coil in the condensate pan, with a built-in high-level safety alarm to shut down the unit.
4) A thermistor shall be located on the liquid and gas line.

2.3 PIPING

A. Design Pressure: 450 psig.

1. Maximum Design Temperature: 250°F.

B. Type ACR Seamless Copper Tube Linesets; Brazed Joints:

1. 1" and under.
2. Tubing: Type ACR seamless copper tube linesets, ASTM B1003. Sizes indicated are nominal designation.
3. Joints: Brazed with silver solder.
4. Fittings: Wrought copper solder joint, ANSI B16.22.
5. Special Requirements: All tubing shall be cleaned, dehydrated, pressurized with dry nitrogen, plugged, and tagged by manufacturer "for refrigeration service". During brazing operations, continuously purge the interior of the pipe with nitrogen to prevent oxide formation.
6. Limitations:
   a. Only sizes 1" and under.
   b. For use above ceiling only. Do not use in exposed areas.

C. Type ACR Hard Drawn Seamless Copper Tube; Brazed Joint:

1. 4" and under.
2. Tubing: Type ACR hard drawn seamless copper tube, ASTM B280. Sizes indicated are nominal designation.
3. Joints: Brazed with silver solder.
4. Fittings: Wrought copper solder joint, ANSI B16.22.

5. Special Requirements: All tubing shall be cleaned, dehydrated, pressurized with dry nitrogen, plugged and tagged by manufacturer "for refrigeration service". During brazing operations, continuously purge the interior of the pipe with nitrogen to prevent oxide formation.

D. Insulation:

1. EPDM (NBR/PVC Blend is not permitted) elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.25 maximum 'K' value at 75°F, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). If thickness required in Part 4 - Execution does not meet 25/50 flame spread/smoke developed rating, use multiple layers of a thickness that does meet 25/50 flame spread/smoke developed.

2.4 CONTROLS GENERAL

A. The unit shall have controls provided with the unit by the manufacturer to perform input functions necessary to operate the system.

B. Computerized PID control shall be used to maintain room temperature within 1°F of setpoint.

C. The unit shall be equipped with a programmable drying cycle that dehumidifies while inhibiting changes in room temperature.

D. The indoor circuit board shall be wired to enable auxiliary heating when at least one of the following occurs:

1. Coil thermistor temperature drops below a factory setpoint in heating mode.
2. Heat pump temperature drops below setpoint (adj.).
3. Based on a user adjustable schedule.

2.5 CENTRAL CONTROLLER - TYPE D

A. This controller shall be wall mounted and hard wired, either directly to the control system or via gateway. It shall be manufactured in ABS plastic with an LCD display and shall be the manufacturer's standard color. The controller shall be capable of individually controlling the following functions on at least 128 indoor units:

1. On/off
2. Operating mode
3. Setpoint
4. Fan speed
5. Louver position
6. Timer settings
7. Test run

B. The controller shall also be capable of displaying the following information individually for at least 128 indoor units:

1. On/off
2. Operating mode
3. Setpoint
4. Fan speed
5. Louver position
6. Timer settings
7. Test run
8. Fault diagnosis

C. Each central controller unit can be accessed either locally or remotely via standard internet software. The central controller will be able to indicate system alarms via volt free contacts, as well as providing control points for other devices. Additionally, the central controller shall be able to monitor individual usage of heating and cooling demands, report alarm and conditions to nominated email address, and enable remote alteration of systems setpoints to registered users. All required software costs and licensing fees shall be included for the life of the systems.

2.6 MAINTENANCE ACCESS

A. Provide all gateways and connection cabling for performing maintenance functions on system.

B. Provide all software and registration codes as required to allow access into advanced maintenance functions.

2.7 SEQUENCE

A. Install a remote mounted temperature sensor.

B. The thermostat shall stage heating or cooling as required to maintain space setpoint at 72°F (adj.).

C. Thermostat shall automatically change the indoor unit mode based on the space setpoint.

D. If space setpoint continues to drop once indoor unit has been changed to heating mode, the thermostat shall enable the space electric baseboard heat.

E. Control system shall have capability to control electric baseboard heat.

F. Central controller shall enable dedicated heat pump unit based on an adjustable occupancy schedule. Coordinate enable/disable function with AHU manufacturer.

2.8 SYSTEM INTEGRATION

A. Integration: Manufacturer shall provide a BACnet interface with the building automation system in accordance with ASHRAE/ANSI Standard 135. This may be accomplished through a system integration panel or "gateway". Integration panels shall be provided as part of the VRF system.

2.9 ROOM REFRIGERANT DETECTOR

A. Occupied space wall-mounted VRF refrigerant detector. Suitable to sense refrigerant types as specified with VRF system.

B. White plastic finished enclosure, approximate dimensions of 4.5" x 4.5" x 1.75" deep.

C. Power Supply: 24VAC, 24A.

D. Outputs: 0-10VDC.

E. Alarm: 80dB @ 12".

F. Operating Environment: 32F-122F; 0-90%RH non-condensing.

G. Sensing Parameters: Range: 0-1000ppm; minimum detection 25ppm; minimum alarm 50ppm; Repeatability +/-10ppm @ 50ppm; linearity +/-20% of reading between 50-100ppm.

H. Manufacturers:

1. SENVA (24V)

2.10 EXPANSION COMPENSATION

A. Assembly consisting of two flexible connectors, two copper flexible connectors, two 90° elbows, and a 180° return pipe. Unit shall be in the form of a pipe loop.

B. Connectors shall have corrugated copper hose bodies with copper braided casings.

C. Connectors shall be rated for 150 psi working pressure at 70°F.

D. Sizes 2" and smaller shall have copper sweat ends.

E. Connectors shall be suitable for 1/2" permanent misalignment.

F. Install in every straight run of hard drawn seamless copper tube; 30 feet long or longer. Expansion compensation is not required for flexible line sets.

G. Manufacturer:

1. Metraflex Type MLS

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

B. Install in accordance with manufacturer's instructions. Install all piping, fittings, and insulation to meet manufacturer's requirements. Install units level and plumb. Evaporator fan components shall be installed using manufacturer's standard mounting devices securely fastened to building structure. Install and connect refrigerant tubing and fittings.

C. Installing contractor shall attend manufacturer sponsored training to obtain installation certification. Submit training certificates as noted in Part 1.

D. Installer shall supply isolation ball valves for zoned refrigerant isolation. Installer shall supply isolation ball valves with Schrader connection for isolating refrigerant charge and evacuation at each connected indoor unit and heat pump unit. Isolation ball valves, with Schrader connection, are required for instances of indoor unit isolation for troubleshooting, repair, or replacement without affecting the remainder of the system. Isolation ball valves with Schrader connection are also required at heat pump unit connection to isolate unit for troubleshooting, repair, or replacement and as required to provide partial capacity heating/cooling in the instance of a failure of one of the multiple heat pump unit compressors.

E. Insulate all refrigerant pipes between the heat pump and indoor units. This includes the liquid pipe, the suction pipe, the hot gas pipe, and the high/low pressure gas pipe. All fittings, valves, and specialty refrigerant components in the piping between the indoor and heat pump units shall also be insulated. The insulation shall have a continuous vapor barrier and shall pass through hangers and supports unbroken. All exterior insulated piping shall be painted with minimum of one (1) coat of UV resistant paint. Over size hangers and supports to allow the insulation to pass through unbroken. Following are the minimum insulation thicknesses unless noted otherwise in the manufacturer's literature or required by local AHJ:

1. California Tittle 24 - 2022:

   a. Refrigerant Suction (40°F & Below):

      1) Up to 1": 1"
      2) 1" and up: 1-1/2"

   b. Refrigerant Suction (41°F to 60°F):

      1) Up to 1-1/2": 1/2"
      2) 1-1/2" and up: 1"

   c. Refrigerant Low Pressure Gas (141°F-200°F):

      1) Up to 1-1/2": 1-1/2"
      2) 1-1/2" and up: 2"

   d. Refrigerant High Pressure Gas (201°F-250°F):

      1) Up to 4": 2-1/2"

e. Refrigerant Liquid:

1) Up to 1": 1"
2) 1" and up: 1-1/2"

F. Engage manufacturer or factory-authorized service representative to perform startup service. Manufacturer shall provide on-site startup and commissioning assistance through job completion. Complete installation and startup checks according to manufacturer's written instructions.

G. Fully charge system with refrigerant based on volume per manufacturer's requirements using actual field dimensions (not original design submittal). Installing Contractor must coordinate final pipe sizes and lengths, and equipment location, with manufacturer to determine exact fill volume.

H. Field Quality Control:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing.
2. Perform the following field tests and inspections, and prepare test reports:

a. Positive Pressure Leak Test: After installation, test for leaks by charging the system per manufacturer’s airtight positive test criteria for a minimum of 24 hours. Repair leaks and retest until no leaks exist.
b. Negative Pressure Leak Test: After positive pressure leak test, evacuate the system with a vacuum pump per manufacturer’s vacuum drying test criteria. The system shall maintain vacuum without pump operation or gauge movement for a minimum of 1 hour. If the gauge rises, the system may contain moisture or have leaks. Repair leaks and retest until no leaks exist. Manufacturer shall be present to witness the negative pressure test.
c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
e. Provide field test reports to manufacturer to include with manufacturer’s startup report.

I. Coordinate installation of units with architectural and electrical work. Coordinate installation of ceiling recessed units with ceiling grid layout. Additional ceiling grid reinforcement or modification is the responsibility of the Mechanical Contractor and shall be coordinated with the General Contractor.

J. Verify locations of wall-mounted devices (such as thermostats, temperature and humidity sensors, and other exposed sensors) with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Height above finished floor shall not exceed 48".

K. Contractor is responsible for routing all condensate drains from all indoor equipment to a nearby floor drain or standpipe. If ceiling heights or space finish does not accommodate gravity drainage, Contractor is responsible for providing a condensate pump and all electrical work required.

L. Contractor is responsible for installing VRF heat pump control system. Contractor shall coordinate with the Temperature Controls Contractor to determine extent of integration with building automation system (BAS). Equipment that is required to integrate the VRF heat pump system with the BAS is the responsibility of the VRF heat pump installing contractor. Final connections between VRF heat pump system and BAS shall be by the Temperature Controls Contractor.

M. Maintain minimum clearances to all equipment. Maintain manufacturer's minimum maintenance, and airflow clearances and maintain minimum spaces about electrical equipment, whichever is greater.

1. 120V: 36" deep x 30" wide or the width of the panel whichever is wider.
2. 208V: 42" deep x 30" wide or the width of the panel whichever is wider.
3. 480V: 42" deep x 30" wide or the width of the panel whichever is wider.

3.2 JOINING OF PIPE

A. Brazed Joints:

1. Make up joints with brazing filler metal conforming to ANSI/AWS A5.8. Cut copper tubing ends perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to brazing. Apply flux evenly, but sparingly, to all surfaces to be joined. Brazing filler metal with a flux coating may also be used. Heat joints uniformly to proper brazing temperature so braze filler metal flows to all mated surfaces. Wipe excess braze filler metal, leaving a uniform fillet around cup of fitting.
2. Flux shall conform to ANSI/AWS A5.31.
3. Remove composition discs and all seals during brazing if not suitable for a minimum of 840°F (or greater than the melting temperature of the brazing filler metal, whichever is greater).

3.3 REFRIGERANT PIPING SUPPORTS AND ANCHORS

A. Horizontal Supports: Spacing of hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

1. Type ACR Hard Drawn Seamless Copper Tube (Liquid Service):

a. Maximum Spacing:

1) 3/4" and under: 5'-0"
2) 1": 6'-0"
3) 1-1/4": 6'-0"
4) 1-1/2" 6'-0"

5) 2": 8'-0"

2. Type ACR Hard Drawn Seamless Copper Tube (Vapor Service):

a. Maximum Spacing:

1) 3/4" & under: 6'-0"
2) 1": 6'-0"
3) 1-1/4": 6'-0"
4) 1-1/2": 6'-0"
5) 2": 8'-0"

3. ACR Seamless Copper Tube Linesets:

a. Hangers shall be spaced based on the piping system manufacturer's instructions or, if no system instructions are available, space hangers at 4'-0" maximum centers.

B. Vertical Supports:

1. Support and laterally brace vertical pipes at every floor level in multi-story structures, unless otherwise noted by applicable codes, but never at intervals over 10 feet.

C. Install piping support within 2 feet of equipment connections.

END OF SECTION

SECTION 26 05 00 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 26 Sections. Also refer to Division 1 - General Requirements. This section is also applicable to Interior Communications Pathways Section 27 05 28. This section is also applicable to Fire Alarm and Detection Systems Section 28 31 00.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 REFERENCES

A. NFPA 70 - National Electrical Code (NEC)

B. CEC California Electrical Code

C. OSHPD - Office of State Wide Health Planning and Development (California)

D. CCR California Code of Regulation

E. CBC California Building Code

F. CFC California Fire Code

G. CMC California Mechanical Code

H. CPC California Plumbing Code

I. California Title 24 - Building Energy Efficiency Standards

J. SCAQMD South Coast Air Quality Management District

1.3 SCOPE OF WORK

A. This Specification and the associated drawings govern furnishing, installing, testing and placing into satisfactory operation the Electrical Systems.

B. The Contractor shall furnish and install all new materials as indicated on the drawings, and/or in these specifications, and all items required to make the portion of the Electrical Work a finished and working system.

C. Separate contracts will be awarded for the following work.

D. All work will be awarded under a single General Contract. The division of work listed below is for the Contractor's convenience and lists normal breakdown of the work.

E. Separate contracts will be awarded for the following work. The division of work listed below is for the contractors' convenience and lists a normal breakdown of the work. Please refer to the Construction Manager's scope statements for complete scope of work description.

F. Description of Systems shall be as follows:

1. Electrical power system to and including luminaires, equipment, motors, devices, etc.
2. Electrical power service system from the Utility Company to and including service entrance equipment, distribution and metering.
3. Grounding system.
4. Fire alarm system.
5. Wiring of equipment furnished by others.
6. Removal work and/or relocation and reuse of existing systems and equipment.
7. Telecommunications rough-in, as shown on drawings, for installation of telecommunications equipment by others under separate contract.
8. Technology Systems as described in Division 27/28 and on the T-series documents as described in the Suggested Matrix of Scope Responsibility.
9. Furnish and install firestopping systems for penetrations of fire-rated construction associated with this Contractor's work.

G. Work Not Included:

1. Telecommunications cabling will be by Division 27, in raceways and conduits furnished and installed as part of the Electrical work.
2. Temperature control wiring for plumbing and HVAC equipment (unless otherwise indicated) will be by other Contractors.

1.4 WORK SEQUENCE

A. All work that will produce excessive noise or interference with normal building operations, as determined by the Owner, shall be scheduled with the Owner. It may be necessary to schedule such work during unoccupied hours. The Owner reserves the right to determine when restricted construction hours are required.

B. Itemize all work and list associated hours and pay scale for each item.

1.5 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL, and CONTROL CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described at any location on the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described on the contract documents on bid day. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Mechanical Contractors" refers to the Contractors listed in Division 21/22/23 of this Specification.
2. "Technology Contractors" refers to the Contractors furnishing and installing systems listed in Division 27/28 of this Specification.
3. Motor Power Wiring: The single phase or 3 phase wiring extending from the power source (transformer, panelboard, feeder circuits, etc.) through disconnect switches and motor controllers to, and including the connections to the terminals of the motor.
4. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case, the devices are usually single phase, have "Manual-Off-Auto" provisions, and are usually connected into the motor power wiring through a manual motor starter.
5. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.
6. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. When the motor power wiring exceeds 120 volts, a control transformer is usually used to give a control voltage of 120 volts.
7. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring that directly powers or controls a motor used to drive equipment such as fans, pumps, etc. This wiring will be from a 120-volt source and may continue as 120 volt, or be reduced in voltage (24 volt), in which case a control transformer shall be furnished as part of the temperature control wiring.
8. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.
9. Low Voltage Technology Wiring: The wiring associated with the technology systems, used for analog or digital signals between equipment.
10. Telecommunications/Technology Rough-in: Relates specifically to the backboxes, necessary plaster rings and other miscellaneous hardware required for the installation or mounting of telecommunications/technology information outlets.

C. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractors' responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors, etc. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals approved. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.

2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall furnish complete wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.
3. Control low (24V) and control line (120V) voltage wiring, conduit, and related switches and relays required for the automatic control and/or interlock of motors and equipment, including final connection, are to be furnished and installed under Divisions 21, 22 and 23. Materials and installation to conform to Class 1 or 2 requirements, California Electrical Code Article 725.
4. The Electrical Contractor shall establish electrical utility elevations prior to fabrication and installation. The Electrical Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

    a. Luminaires.
    b. Conduits and wireway.

D. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment furnished by the Mechanical Contractor.
2. Assumes all responsibility for miscellaneous items furnished by the Mechanical Contractor that require wiring but are not shown on the electrical drawings or specified in the Electrical Specification. If items such as relays, flow switches, or interlocks are required to make the mechanical system function correctly or are required by the manufacturer, they are the responsibility of the Mechanical Contractor.
3. Assumes all responsibility for Temperature Control wiring, if the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.
4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Electrical Contractor's Responsibility:

1. Furnishes and installs all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor in the Mechanical Drawings or Specifications.
2. Installs and wires all remote-control devices furnished by the Mechanical Contractor or Temperature Control Contractor when so noted on the Electrical Drawings.
3. Furnishes and installs motor control and temperature control wiring, when noted on the drawings.
4. Furnishes, installs, and connects all relays, etc., for automatic shutdown of certain mechanical equipment (supply fans, exhaust fans, etc.) upon actuation of the Fire Alarm System.
5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

F. General (Electrical/Technology):

1. "Electrical Contractor" as referred to herein shall be responsible for scope listed in Division 27/28 of this specification when the "Suggested Matrix of Scope Responsibility" indicated work shall be furnished and installed by the EC. Refer to the Contract Documents for this "Suggested Matrix of Scope Responsibility".
2. The purpose of these Specifications is to outline the Electrical and Technology Contractor's work responsibilities as related to Telecommunications Rough-in, conduit, cable tray, power wiring and Low Voltage Technology Wiring.
3. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals approved. Therefore, only known wiring, conduits, raceways and electrical power related to such items is shown on the Technology drawings. Other wiring, conduits, raceways, junction boxes and electrical power not shown on the Technology Drawings but required for operation of the systems is the responsibility of the Technology Contractor and included in said Contractor's bid.
4. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of Technology systems, the final installation shall not be until a coordination meeting between the Electrical Contractor and the Technology Contractor has convened to determine the exact location and requirements of the installation.
5. Where the Electrical Contractor is required to install cable tray that will contain Low Voltage Technology Wiring, installation shall not begin prior to a coordination review of the cable tray shop drawings by the Technology Contractor.

G. Technology Contractor's Responsibility:

1. Assumes all responsibility for the low voltage technology wiring of all systems, including cable support where open cable is specified.
2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being furnished and installed by the Electrical Contractor on the "Suggested Matrix of Scope Responsibility".
3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined herein).
4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of technology equipment which is required to be bonded to the telecommunications ground bar.
5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.6 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.
b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
d. Maintenance clearances and code-required dedicated space shall be included.
e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. Spaces with open/cloud ceiling architecture shall indicate the overhead utilities and locate equipment as required to maintain clearance above lights. The intent for the installation is to maintain a maximum allowable vertical clearance and an organized/clean manner in the horizontal. Notify Architect/Engineer of the maximum clearance which can be maintained. Failure to comply will result in modifications with no cost to Owner.

   a. In cloud ceiling architecture, when open cabling/wire and/or cable tray crosses gaps between ceiling clouds and/or walls, cabling is to transition to conduits to span the gaps in order to conceal cabling from below.

3. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.
2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

   a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

    a. Scale of drawings:

        1) General plans: 1/4 Inch = 1 '-0" (minimum).
        2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).
        3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).
        4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).
        5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.
3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.
4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the Architect/Engineer for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the Architect/Engineer and Owner's Representative. The Architect/Engineer will only review identified conflicts and give an opinion, but will not perform as a coordinator.
2. A plotted set of coordination drawings shall be available at the project site.
3. Coordination drawings are not shop drawings and shall not be submitted as such.
4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in the bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.
5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.
7. The Architect/Engineer reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.
8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the Architect/Engineer.
9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

    a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.
    b. Potential layout changes shall be made to avoid additional access panels.
    c. Additional access panels shall not be allowed without written approval from the Architect/Engineer at the coordination drawing stage.
    d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the Architect/Engineer and the Owner's Representative.
    e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign-off of the drawings by all contractors prior to installing any of the components.
11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.
12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.7 QUALITY ASSURANCE

A. Contractor's Responsibility Prior to Submitting Pricing/Bid Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guides, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Architect/Engineer any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.
2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor's own employees. Any work performed prior to receipt of instructions from the Architect/Engineer will be done at the Contractor's risk.

B. Qualifications:

1. Only products of reputable manufacturers as determined by the Architect/Engineer are acceptable.
2. All Contractors and subcontractors shall employ only workmen who are skilled in their trades. At all times, the number of apprentices at the job site shall be less than or equal to the number of journeymen at the job site.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the State of InsertCalifornia Codes, Laws, Ordinances and other regulations having jurisdiction.
2. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.
3. If the Contractor notes, at the time of bidding, that any parts of the drawings or specifications do not comply with the codes or regulations, Contractor shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, Contractor shall submit with the proposal a separate price to make the system comply with the codes and regulations.
4. All changes to the system made after the letting of the contract to comply with codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.
5. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.
6. If there are no local codes having jurisdiction, the current issue of the National Electrical Code shall be followed.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.
2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.
3. Pay all charges for permits or licenses.
4. Pay all fees and taxes imposed by State, Municipal, and other regulatory bodies.
5. Pay all charges arising out of required inspections by an authorized body.
6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.
7. Where applicable, all fixtures, equipment and materials shall be listed by Underwriter's Laboratories, Inc. or a nationally recognized testing organization.
8. Pay all telephone company charges related to the service or change in service.

E. Utility Company Requirements:

1. Secure from the private or public utility company all applicable requirements.
2. Comply with all utility company requirements.
3. The Owner shall make application for and pay for new electrical service equipment and installation. The Contractor shall coordinate schedule and requirements with the Owner and Utility Company.

4. The contractor is responsible for completing utility requested forms and sharing utility requested load data from the construction documents.
5. Furnish the meter socket metering compartment with CT space within the main switchboard. Verify approved manufacturers and equipment with the Utility Company.
6. The Owner shall apply and pay for any changes for removal of existing electrical service by the utility company. The Contractor shall verify approved manufacturers and equipment with the Utility Company.

F. Examination of Drawings:

1. The drawings for the electrical work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.
2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of raceways to best fit the layout of the job. Conduit entry points for electrical equipment including, but not limited to, panelboards, switchboards, switchgear and unit substations, shall be determined by the Contractor unless noted in the contract documents.
3. Scaling of the drawings will not be sufficient or accurate for determining these locations.
4. Where job conditions require reasonable changes in arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.
5. Because of the scale of the drawings, certain basic items, such as junction boxes, pull boxes, conduit fittings, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.
6. If an item is either shown on the drawings or called for in the specifications, it shall be included in this contract.
7. The Contractor shall determine quantities and quality of material and equipment required from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater and better-quality number shall govern.
8. Where used in electrical documents the word "furnish" shall mean supply for use, the word "install" shall mean connect up complete and ready for operation, and the word "provide" shall mean to supply for use and connect up complete and ready for operation.
9. Any item listed as furnished shall also be installed unless otherwise noted.
10. Any item listed as installed shall also be furnished unless otherwise noted.

G. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.
2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.
3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by IMEG.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.
7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.
8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

H. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any conduit, conductors, wireways, bus duct, fittings, etc.

1.8 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

| Referenced Specification Section | Submittal Item | Coordination Drawing |
|---|---|---|
| 26 05 03 | Through Penetration Firestopping | |
| 26 05 13 | Wire and Cable | |
| 26 05 26 | Grounding and Bonding | |
| 26 05 33 | Conduit and Boxes | +> 1.5" |
| 26 05 48 | Seismic Requirements for Equipment and Supports | |
| 26 05 53 | Electrical Identification | |
| 26 05 73 | Power System Study | |
| 26 09 13 | Power Monitoring and Control System | |
| 26 09 33 | Lighting Control System | |
| 26 20 00 | Service Entrance | |
| 26 22 00 | Dry Type Transformers | Yes |
| 26 24 13 | Switchboards | Yes |
| 26 24 16 | Panelboards | Yes |
| 26 24 19 | Motor Control | Yes |
| 26 27 16 | Cabinets and Enclosures | Yes |
| 26 27 26 | Wiring Devices | Ceiling mount |

| Referenced Specification Section | Submittal Item | Coordination Drawing |
|---|---|---|
| 26 28 13 | Fuses | |
| 26 28 16 | Disconnect Switches | Yes |
| 26 28 21 | Contactors | Yes |
| 26 29 23 | Variable Frequency Drives | Yes |
| 26 32 13 | Packaged Engine Generator Systems | Yes |
| 26 36 00 | Transfer Switch | Yes |
| 26 43 00 | Surge Protection Devices | |
| 26 51 19 | LED Lighting | Yes |
| 28 31 00 | Fire Alarm and Detection Systems | Yes |

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

   a. Date
   b. Project title and number
   c. Contractor's name and address
   d. Division of work (e.g., electrical, plumbing, heating, ventilating, etc.)
   e. Description of items submitted and relevant specification number
   f. Notations of deviations from the contract documents
   g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

   a. Date
   b. Project title and number
   c. Architect/Engineer
   d. Contractor and subcontractors' names and addresses
   e. Supplier and manufacturer's names and addresses
   f. Division of work (e.g., electrical, plumbing, heating, ventilating, etc.)
   g. Description of item submitted (using project nomenclature) and relevant specification number
   h. Notations of deviations from the contract documents
   i. Other pertinent data
   j. Provide space for Contractor's review stamps

3. Composition:

   a. Submittals shall be submitted using specification sections and the project nomenclature for each item.

b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).
c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.
5. Contractor's Approval Stamp:

a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.
b. Unstamped submittals will be rejected.
c. The Contractor's review shall include, but not be limited to, verification of the following:

1) Only approved manufacturers are used.
2) Addenda items have been incorporated.
3) Catalog numbers and options match those specified.
4) Performance data matches that specified.
5) Electrical characteristics and loads match those specified.
6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
7) Dimensions and service clearances are suitable for the intended location.
8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.
e. The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.

6. Submittal Identification and Markings:

a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.
b. The Contractor shall clearly indicate the size, finish, material, etc.
c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.
d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.
8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.
9. Reproduction of contract documents alone is not acceptable for submittals.
10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.
11. Submittals not required by the contract documents may be returned without review.
12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.
13. Submittals shall be reviewed and approved by the Architect/Engineer before releasing any equipment for manufacture or shipment.
14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.
15. Schedule shall allow for adequate time to perform orderly and proper review of submittals, including time for consultants and Owner if required, and resubmittals by Contractor if necessary, and to cause no delay in Work or in activities of Owner or other contractors.

    a. Allow at least two weeks for Architect's/Engineer's review and processing of each submittal, excluding mailing.

16. Architect/Engineer reserves the right to withhold action on a submittal which, in the Architect/Engineer's opinion, requires coordination with other submittals until related submittals are received. The Architect/Engineer will notify the Contractor, in writing, when they exercise this right.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. Submittal file name: 26 XX XX.description.YYYYMMDD
    b. Transmittal file name: 26 XX XX.description.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.

1.9 SCHEDULE OF VALUES

A. The requirements herein are in addition to the provisions of Division 1.

B. Format:

1. Use AIA Document Continuation Sheets G703 or another similar form approved by the Owner and Architect/Engineer.
2. Submit in Excel format.
3. Support values given with substantiating data.

C. Preparation:

1. Itemize work required by each specification section and list all providers. All work provided by subcontractors and major suppliers shall be listed on the Schedule of Values. List each subcontractor and supplier by company name.
2. Break down all costs into:

    a. Material: Delivered cost of product with taxes paid.
    b. Labor: Labor cost, excluding overhead and profit.

3. Itemize the cost for each of the following:

    a. Overhead and profit.
    b. Bonds.
    c. Insurance.
    d. General Requirements: Itemize all requirements.

4. For each line item having an installed cost of more than $5,000, break down costs to list major products or operations under each item. At a minimum, provide material and labor cost line items for the following:

    a. Each piece of equipment requiring shop drawings. Use the equipment nomenclature (SB-1, PANEL P-1, etc.) on the Schedule of Values.
    b. Each type of small unitary equipment (e.g., FDS, FCS, CS, etc.). Multiple units of the same type can be listed together provided quantities are also listed so unit costs can be determined.

c. Each conduit system (medium voltage, normal, emergency, low voltage systems, etc.). In addition, for larger projects breakdown the material and labor for each conduit system based on geography (building, floor, and/or wing).
d. Fire alarm broken down into material and labor for the following:

1) Engineering
2) Controllers, devices, sensors, etc.
3) Conduit
4) Wiring
5) Programming
6) Commissioning

e. Site utilities (5' beyond building)
f. Seismic design
g. Testing
h. Commissioning
i. Record drawings
j. Punchlist and closeout

D. Update Schedule of Values when:

1. Indicated by Architect/Engineer.
2. Change of subcontractor or supplier occurs.
3. Change of product or equipment occurs.

1.10 CHANGE ORDERS

A. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders shall be broken down by sheet or associated individual line item indicated in the change associated narrative, whichever provides the most detailed breakdown. Change orders with inadequate breakdown will be rejected.

B. Itemized pricing with unit cost shall be provided from all distributors and associated subcontractors.

C. Change order work shall not proceed until authorized.

1.11 PRODUCT DELIVERY, STORAGE, HANDLING and MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage.

B. Keep all materials clean, dry and free from damaging environments.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Electrical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate the work with other trades.

1.12 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

B. The following network connected equipment shall be equipped with restricted access protocols:

1. Adjustable trip overcurrent protection devices
2. Power monitoring and control
3. Electrical controls
4. Lighting control system
5. Variable frequency drives
6. Package engine generator and remote annunciator
7. Transfer switch and remote annunciator
8. Fire alarm and automatic detection

1.13 WARRANTY

A. Provide one-year warranty for all fixtures, equipment, materials, and workmanship.

B. The warranty period for all work in this specification Division shall commence on the date of Substantial Completion or successful system performance whichever occurs later. The warranty may also commence if a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization of the Owner. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner.

C. Warranty requirements extend to correction, without cost to the Owner, of all work found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage due to defects or nonconformance with contract documents excluding repairs required as a result of improper maintenance or operation, or of normal wear as determined by the Architect/Engineer.

1.14 INSURANCE

A. This Contractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.15 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the manufacturer for which a catalog number is given is the basis for job design and establishes the quality.

B. Equivalent equipment manufactured by the other listed manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meet all requirements of the drawings and specifications and fits in the allocated space. When using other listed manufacturers, the Contractor shall assume responsibility for any and all modifications necessary (including, but not limited to structural supports, electrical connections and rough-in, and regulatory agency approval, etc.) and coordinate such with other contractors. The Architect/Engineer shall make the final determination of whether a product is equivalent.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer via addendum. The Contractor assumes all costs incurred as a result of using the offered material, article or equipment, on the Contractors part or on the part of other Contractors whose work is affected.

D. Voluntary add or deduct prices for alternate materials may be listed on the bid form. These items will not be used in determining the low bidder. This Contractor assumes all costs incurred as a result of using the offered material or equipment on the Contractors part or on the part of other Contractors whose work is affected.

E. All material substitutions requested after the final addendum must be listed as voluntary changes on the bid form.

1.16 PROJECT COMMISSIONING

A. The Contractor shall work with the Commissioning Agent (CxA) as described in Section 26 08 00 and provide all services as described in the Commissioning Plan.

PART 2 - PRODUCTS

2.1 GENERAL

A. All items of material having a similar function (e.g., safety switches, panelboards, switchboards, contactors, motor starters, dry type transformers) shall be of the same manufacturer unless specifically stated otherwise on drawings or elsewhere in specifications.

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or the employees and subconsultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found by calling 811.
2. The Contractor shall do all excavating, filling, backfilling, compacting, and restoration in connection with the work.

B. Excavation:

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.
2. If excavations are carried in error below indicated levels, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by the Architect/Engineer shall be placed in such excess excavations under the foundation. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Contractor's expense.
3. Trim bottom and sides of excavations to grades required for foundations.
4. Protect excavations against frost and freezing.
5. Take care in excavating not to damage surrounding structures, equipment or buried pipe. Do not undermine footing or foundation.
6. Perform all trenching in a manner to prevent cave-ins and risk to workmen.
7. Where original surface is pavement or concrete, the surface shall be saw cut to provide clean edges and assist in the surface restoration.
8. If satisfactory bearing soil is not found at the indicated levels, immediately notify the Architect/Engineer or their representative, and do no further work until the Architect/Engineer or their representative gives further instructions.

9. Excavation shall be performed in all ground conditions, including rock, if encountered. Bidders shall visit the premises and determine the soil conditions by actual observations, borings, or other means. The cost of all such inspections, borings, etc., shall be borne by the bidder.
10. If a trench is excavated in rock, a compacted bed with a depth of 3" (minimum) of sand and gravel shall be used to support the conduit unless masonry cradles or encasements are used.
11. Mechanical excavation of the trench to line and grade of the conduit or to the bottom level of masonry cradles or encasements is permitted, unless otherwise indicated on the electrical drawings.
12. Mechanical excavation of the trench to line and grade where direct burial cables are to be installed is permitted provided the excavation is made to a depth to permit installation of the cable on a fine sand bed at least 3 inches deep.

C. Underground Obstructions:

1. Known underground piping, conduit, feeders, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Review all Bid Documents for all trades on the project to determine obstructions indicated. Take great care in making installations near underground obstructions.
2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by the Architect/Engineer.

D. Fill and Backfilling:

1. No rubbish or waste material is permitted for fill or backfill.
2. Provide all necessary sand and/or CA6 for backfilling.
3. Native soil materials may be used as backfill if approved by the Geotechnical Engineer.
4. Dispose of the excess excavated earth as directed.
5. Backfill materials (native soil material, sand, and/or CA6) shall be suitable for required compaction, clean and free of perishable materials, frozen earth, debris, earth with a high void content, and stones greater than 4 inches in diameter. Water is not permitted to rise in unbackfilled trenches.
6. Backfill all trenches and excavations immediately after installing of conduit, or removing forms, unless other protection is directed.
7. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Spread fill and backfill materials in 6" uniform horizontal layers with each layer compacted separately to required density.
8. For conduits that are not concrete encased, lay all conduits on a compacted bed of sand at least 3" deep. Backfill around conduits with sand, in 6" layers and compact each layer.
9. Conduits that are concrete encased or in a ductbank, conduit spacers, and cradles shall be installed on a bed of compacted CA-6 gravel. Refer to conduit section for backfilling and ductbank requirements.
10. Backfill with native soil material (if approved) or sand up to grade for all conduits under slabs or paved areas. All other conduits shall have sand backfill to 6" above the top of the conduit.

11. Place all backfill above the sand in uniform layers not exceeding 6" deep. Place then carefully and uniformly tamp each layer to eliminate lateral or vertical displacement.
12. Where the fill and backfill will ultimately be under a building, floor or paving, each layer of fill shall be compacted to 95% of the maximum density as determined by AASHTO Designation T-99 or ASTM Designation D-698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content as determined by AASHTO T-99 or ASTM D-698 test.
13. After backfilling of trenches, no superficial loads shall be placed on the exposed surface of the backfill until a period of 48 hours has elapsed.

E. Surface Restoration:

1. Where trenches are cut through graded, planted or landscaped areas, the areas shall be restored to the original condition. Replace all planting and landscaping features removed or damaged to its original condition. At least 6" of topsoil shall be applied where disturbed areas are to be seeded or sodded. All lawn areas shall be sodded unless seeding is called out in the drawings or specifications.
2. Concrete or asphalt type pavement, seal coat, rock, gravel or earth surfaces removed or damaged shall be replaced with comparable materials and restored to original condition. Broken edges shall be saw cut and repaired as directed by Architect/Engineer.

3.3 ARCHITECT/ENGINEER OBSERVATION OF WORK

A. The contractor shall provide seven (7) calendar days' notice to the Architect/Engineer prior to:

1. Placing fill over underground and underslab utilities.
2. Covering exterior walls, interior partitions and chases.
3. Installing hard or suspended ceilings and soffits.

B. The Architect/Engineer will review the installation and provide a written report noting deficiencies requiring correction. The contractor's schedule shall account for these reviews and show them as line items in the approved schedule.

C. Above-Ceiling Final Observation:

1. All work above the ceilings must be complete prior to the Architect/Engineer's review. This includes, but is not limited to:

a. All junction boxes are closed and identified in accordance with Section 26 05 53 Electrical Identification.
b. Luminaires, including ceiling-mounted exit and emergency lights, are installed and operational.
c. Luminaire whips are supported above the ceiling.
d. Conduit identification is installed in accordance with Section 26 05 53 Electrical Identification.
e. Luminaires are suspended independently of the ceiling system when required by these contract documents.

f. All wall penetrations have been sealed.

2. To prevent the Above-Ceiling Final Observation from occurring too early, the Contractor shall review the status of the work and certify, in writing, that the work is ready for the Above-Ceiling Final Observation.
3. It is understood that if the Architect/Engineer finds the ceilings have been installed prior to this review and prior to seven days elapsing, the Architect/Engineer may not recommend further payments to the contractor until full access has been provided.

3.4 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 1.

B. IDPH Pre-Occupancy Requirements:

1. Each Contractor must submit all forms and certifications required by IDPH relating to their work at 85% completion of the project or when directed by the Owner/Architect/Engineer.

C. Final Jobsite Observation:

1. To prevent the Final Jobsite Observation from occurring too early, the Contractor shall review the completion status of the project and certify that the job is ready for the final jobsite observation.
2. Attached to the end of this section is a typical list of items that represent the degree of job completeness expected prior to requesting a review. The Contractor shall sign the attached certification and return it to the Architect/Engineer so that the final observation can be scheduled.
3. It is understood that if the Architect/Engineer finds the job not ready for the final observation and additional trips and observations are required to bring the project to completion, the cost of the additional time and expenses incurred by the Architect/Engineer will be deducted from the Contractor's final payment.
4. Contractor shall notify Architect/Engineer 48 hours prior to installation of ceilings or lay-in ceiling tiles.

D. The following must be submitted before Architect/Engineer recommends final payment:

1. Operation and maintenance manuals with copies of approved shop drawings.
2. Record documents including marked-up drawings and specifications.
3. A report documenting the instructions given to the Owner's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of this Contractor and shall be signed by the Owner's representatives.
4. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and submit receipt to Architect/Engineer.
5. Inspection and testing report by the fire alarm system manufacturer.
6. Start-up reports on all equipment requiring a factory installation or start-up.

E. Circuit Directories:

1. Provide custom typed circuit directory for each branch circuit panelboard. Provide updated custom typed circuit directory for each existing branch circuit panelboard with new or revised circuits per the scope of work. Label shall include equipment name or final approved room name, room number, and load type for each circuit (examples: SUMP SP-1 or ROOM 101 RECEPT). Revise directory to reflect circuit changes required to balance phase loads. Printed copies of the bid document panel schedules are not acceptable as circuit directories.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.
2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. O&M file name: O&M.div26.contractor.YYYYMMDD
    b. Transmittal file name: O&Mtransmittal.div26.contractor.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.
6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.
7. All text shall be searchable.

8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.
2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.
3. Copies of all final approved shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.
4. Copies of all factory inspections and/or equipment startup reports.
5. Copies of warranties.
6. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
7. Dimensional drawings of equipment.
8. Detailed parts lists with lists of suppliers.
9. Operating procedures for each system.
10. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
11. Repair procedures for major components.
12. Replacement parts and service material requirements for each system and the frequency of service required.
13. Instruction books, cards, and manuals furnished with the equipment.
14. Include record drawings of the one-line diagrams for each major system. The graphic for each piece of equipment shown on the one-line diagram shall be an active link to its associated Operation & Maintenance data.
15. Copies of all panel schedules in electronic Microsoft Excel spreadsheet (.xlsx) file. Each panelboard shall be a separate tab in the workbook.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. Contractor shall make a DVD video recording of instructions to the Owner while explaining the system so additional personnel may view the instructions at a later date. The video recording shall be the property of the Owner.

D. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

E. The instructions shall include:

1. Maintenance of equipment.
2. Start-up procedures for all major equipment.
3. Description of emergency system operation.

F. Notify the Architect/Engineer of the time and place for the verbal instructions to be given to the Owner's representative so a representative can be present if desired.

G. Minimum hours of instruction time for each item and/or system shall be as indicated in each individual specification section.

H. Operating Instructions:

1. Contractor is responsible for all instructions to the Owner's representatives for the electrical and specialized systems.
2. If the Contractor does not have staff that can adequately provide the required instructions, the Contractor shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 RECORD DOCUMENTS

A. The following paragraphs supplement Division 1 requirements.

B. Maintain at the job site a separate and complete set of electrical drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

C. Mark drawings and specifications to indicate approved substitutions; Change Orders, and actual equipment and materials used. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable. Should this Contractor fail to complete Record Documents as required by this contract, this Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer's hourly rates in effect at the time of work.

D. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

E. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

F. Record actual routing of conduits exceeding 2 inches.

3.8 PAINTING

A. Paint all equipment that is marred or damaged prior to the Owner's acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available. All equipment shall have a finished coat of paint applied unless specifically allowed to be provided with a prime coat only.

B. Equipment in finished areas that will be painted to match the room decor will be painted by others. Should this Contractor install equipment in a finished area after the area has been painted, the Contractor shall have the equipment and all its supports, hangers, etc., painted to match the room decor. Painting shall be performed as described in project specifications.

C. Equipment cabinets, casings, covers, metal jackets, etc., located in equipment rooms or concealed spaces, shall be furnished in standard finish, free from scratches, abrasions, chippings, etc.

D. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with baked enamel finish coat free from scratches, abrasions, chipping, etc. If color option is specified or is standard to the unit, verify with the Architect the color preference before ordering.

E. Paint all equipment in unfinished areas such as boiler room, mechanical spaces, and storage rooms. Equipment furnished with a suitable factory finish need not be painted; provided the factory applied finish is not marred or spattered. If so, equipment shall be refinished with the same paint as was factory applied.

F. All electrical conduit and equipment, fittings, hangers, structural supports, etc., in unfinished areas, such as equipment and storage room area, shall be painted two (2) coats of oil paint of colors selected by the Architect.

G. Do NOT paint electric conduits in crawl spaces, tunnels, or spaces above suspended ceilings except that where conduit is in a damp location give exposed threads at joints two coats of sealer after joint is made up.

H. After surfaces have been thoroughly cleaned and are free of oil, dirt or other foreign matter, paint all raceway and equipment with the following:

1. Bare Metal Surfaces - Apply one coat of metal primer suitable for the metal being painted. Finish with two coats of Alkyd base enamel paint.
2. Plastic Surfaces - Paint plastic surfaces with two coats of semi-gloss acrylic latex paint.

3.9 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Clean all foreign paint, grease, oil, dirt, labels, stickers, etc. from all equipment.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.10 SPECIAL REQUIREMENTS

A. Coordinate the installation of all equipment, controls, devices, etc., with other trades to maintain clear access area for servicing.

B. Install all equipment to maximize access to parts needing service or maintenance. Review the final location, placement, and orientation of equipment with the Owner's representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with the Owner's representative will result in removal and reinstallation of the equipment at the Contractor's expense.

D. Raceway and Cable Routing Restrictions: Raceways and cable are restricted from being routed in the following locations, unless serving the space or permitted by the authority having jurisdiction.

1. Elevator machine rooms and hoistways.
2. Exit enclosures.
3. Other areas restricted by code.
4. Technology, data, server rooms.
5. Fire pump and sprinkler rooms.
6. Normal power in emergency power equipment rooms: Limited to feeders and branch circuits serving the emergency power equipment located in the room.
7. Emergency power in normal power equipment rooms: Limited to feeders and branch circuits serving the normal power equipment located in the room.

E. Adhesives and Sealants: All sealers, adhesives, and sealants shall comply with the low emitting material limits of the following standards:

1. CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions VOC from Indoor Sources Using Environmental Chambers Version 1.1.
2. South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications. All adhesives and sealants wet-applied on site shall comply with the applicable chemical content requirements of SCAQMD Rule 1168.
3. South Coast Air Quality Management District Rule SCAQMD 1113 - Wet Applied Paints and Coatings. All paints and coatings wet-applied on site must meet the applicable VOC limits of SCAQMD Rule 1113.

3.11 INDOOR AIR QUALITY (IAQ) MAINTENANCE FOR OCCUPIED FACILITIES UNDER CONSTRUCTION

A. Within the Limits of Construction:

1. The Electrical Contractor shall coordinate all work with the contractor responsible for IAQ.

2. The means, methods and materials used by the Electrical Contractor shall be coordinated with the contractor responsible for IAQ and shall comply with the IAQ requirements set forth in Division 1 and Division 21/22/23 of these specifications.

B. Outside the Limits of Construction:

1. IAQ shall be the responsibility of the electrical contractor for work that is required outside the limits of construction.
2. The Electrical Contractor is responsible for the IAQ set forth in Division 1 and Division 21/22/23 of these specifications.
3. The Electrical Contractor shall review and coordinate all IAQ plans and procedures with the owner's IAQ representative.

C. Contractors shall make all reasonable efforts to prevent construction activities from affecting the air quality of the occupied areas of the building or outdoor areas near the building. These measures shall include, but not be limited to:

1. General Contractor shall erect and maintain dust barriers throughout the construction work. These barriers shall be reasonably airtight and shall prevent entry into the construction zone by unauthorized persons. Reasonably airtight means construction equivalent to full-height temporary or permanent walls with joints taped or sealed, and shafts and other penetrations sealed as well as possible. Fire resistant polyethylene is acceptable; if flame spread/smoke developed ratings are demonstrated to conform to the applicable building codes and licensing acts.
2. The Contractor shall continuously maintain the construction zone under a negative pressure of at least 0.01" w.g. minimum relative to all adjacent areas of the building.
    a. Exhaust fans used for this purpose shall filter air and discharge it outdoors or to the least populated area adjacent to the construction work using negative air machines designed specifically for this purpose. All filtration for air recirculated back into the building shall be HEPA (99.97% DOP efficiency) for work adjacent to healthcare or elderly facilities. If no work is adjacent to these areas, 95% filtration is acceptable. Filtering air discharged to outdoors shall be accomplished with 30% filters.
    b. If air is discharged outdoors, maintain all required distances to doors, windows, air intakes, etc.
    c. If high levels of Volatile Organic Compounds (VOC's) or odors are released, activated carbon or equivalent filtration shall also be employed. Exhaust shall not discharge near doors, air intakes, pedestrians, gathering areas, or operable windows.
    d. Adjusting existing air handling equipment to assist in pressure control is acceptable, if approved by the Owner and the authority having jurisdiction.
    e. Seal return, exhaust, and supply air openings in or near the construction zone that serve existing air handling systems, and rebalance the systems for proper operation. If this is impractical, add filters at the intakes of sufficient cross sectional area to minimize the pressure drop and avoid the need for rebalancing.

f. Maintain pressure control one hour before and after all construction periods, and 24 hours per day in healthcare or elderly facilities.

3. All contractors shall endeavor to minimize the amount of contaminants generated during construction. Methods to be employed shall include, but not be limited to:

   a. Minimizing the amount of dust generated.
   b. Reducing solvent fumes and VOC emissions.
   c. Maintain good housekeeping practices, including sweeping and periodic dust and debris removal. There should be no visible haze in the air.

4. Request that the Owner designate an IAQ representative.
5. Review and receive approval from the Owner's IAQ representative for all IAQ-related construction activities and negative pressure containment plans.
6. Inform the IAQ representative of all conditions that could adversely impact IAQ, including operations that will produce higher than normal dust production or odors.
7. Schedule activities that may cause IAQ conditions that are not acceptable to the Owner's IAQ representative during unoccupied periods.
8. Request copies of and follow all Owner's IAQ and infection control policies.
9. Unless no other access is possible, the entrance to construction site shall not be through the existing facility.
10. To minimize growth of infectious organisms, do not permit damp areas in or near the construction area to remain for over 24 hours.
11. In addition to the criteria above, provide measures as recommended in the SMACNA "IAQ Guidelines for Occupied Buildings under Construction".

3.12 SYSTEM STARTING AND ADJUSTING

A. The electrical systems shall be complete and operating. System startup, testing, adjusting, and balancing to obtain satisfactory system performance is the responsibility of the Contractor. This includes all calibration and adjustment of electrical controls, balancing of loads, troubleshooting and verification of software, and final adjustments that may be needed.

B. Complete all manufacturer-recommended startup procedures and checklists to verify proper equipment operation and does not pose a danger to personnel or property.

C. All operating conditions and control sequences shall be tested during the start-up period. Testing all interlocks, safety shut-downs, controls, and alarms.

D. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.13 FIELD QUALITY CONTROL

A. General:

1. Conduct all tests required during and after construction. Submit test results in NETA format, or equivalent form, that shows the test equipment used, calibration date, tester's name, ambient test conditions, humidity, conductor length, and results corrected to 40°C.
2. Supply necessary instruments, meters, etc., for the tests. Supply competent technicians with training in the proper testing techniques.
3. All cables and wires shall be tested for shorts and grounds following installation and connection to devices. Replace shorted or grounded wires and cables.
4. Any wiring device, electrical apparatus or luminaire, if grounded or shorted on any integral "live" part, shall have all defective parts or materials replaced.
5. Test cable insulation of service and panel feeder conductors for proper insulation values. Tests shall include the cable, all splices, and all terminations. Each conductor shall be tested and shall test free of short circuits and grounds and have an insulation value not less than Electrical Code Standards. Take readings between conductors, and between conductors and ground.
6. If the results obtained in the tests are not satisfactory, make adjustments, replacements, and changes as needed. Then repeat the tests, and make additional tests, as the Architect/Engineer or authority having jurisdiction deems necessary.

B. Ground Resistance:

1. Conduct service ground resistance tests using an approved manufactured ground resistance meter. Submit to the Architect/Engineer a proposed test procedure including type of equipment to be used. (The conventional ohmmeter is not an acceptable device.)
2. Make ground resistance measurements during normal dry weather and not less than 48 hours after a rain. Ground resistance values shall be verified by the Architect/Engineer at the time the readings are taken.
3. If the ground resistance value obtained is more than the value set forth in Section 26 05 26, the following shall be done to obtain the value given:

    a. Verify that all connections in the service ground system are secure.

b. Increase the depth to which ground rods are driven by adding section lengths to the rods and retest. If the resistance is still excessive increase the depth by adding an additional rod section and retest.
c. If the resistance is still excessive, furnish and install additional ground rods, spaced not less than 20 feet from other ground rods unless otherwise noted on plans, and connect into the ground electrode system. Retest.
d. Review results with the Architect/Engineer.

4. Before final payment is made to the Contractor submit a written report to the Architect/Engineer including the following:

a. Date of test.
b. Number of hours since the last rain.
c. Soil condition at the time of the test in the ground electrode location. That is: dry, wet, moist, sand, clay, etc.
d. Diagram of the test set-up showing distances between test equipment, ground electrode, auxiliary electrodes, etc.
e. Make, model, and calibration date of test equipment.
f. Tabulation of measurements taken and calculations made.

C. Ground-Fault Equipment Performance Testing:

1. Test: Perform ground-fault performance testing when system is installed. The test process shall use primary current injection per manufacturer instruction and procedures. Perform test for the following:

a. Service disconnects
b. Solid state molded case circuit breakers and solid-state insulated case circuit breakers equipped with ground fault protection.
c. Fusible switches with ground fault relay protection.
d. Outside branch circuits and feeders.
e. Code required.

2. Report: Provide copy of test result report with Operation and Maintenance manuals. Provide report to Authority Having Jurisdiction when requested.

D. Arc Energy Reduction Equipment Performance Testing:

1. Test: Perform arc energy protection performance testing when system is installed. The test process shall use primary current injection or approved method per manufacturer instructions and procedures. Perform test for the following:

a. All arc energy reduction systems installed.

2. Report: Provide copy of test result report with Operation and Maintenance manuals. Provide report to Authority Having Jurisdiction when requested.

E. Other Equipment:

1. Give other equipment furnished and installed by the Contractor all standard tests normally made to assure that the equipment is electrically sound, all connections properly made, phase rotation correct, fuses and thermal elements suitable for protection against overloads, voltage complies with equipment nameplate rating, and full load amperes are within equipment rating.

F. If any test results are not satisfactory, make adjustments, replacements and changes as needed and repeat the tests and make additional tests as the Architect/Engineer or authority having jurisdiction deem necessary.

G. Contractor shall thermographic study all electrical gear, switchboard, panelboards, etc. at the end of construction to identify any unusual conditions/heating within the equipment. Coordinate with Owner/Architect/Engineer to have an Owner/Architect/Engineer representative present during testing.

H. Report shall include color printouts, in binder, of pictures taken to use as a baseline reading after building is occupied.

I. Upon completion of the project, the Contractor shall provide amperage readings for all panelboards and switchboards and turn the results over to the Owner for "benchmark" amperages.

3.14 UTILITY REBATE

A. Submit utility rebate forms, where offered at project location, with rebate items completed. Rebate may include lighting, lighting controls, variable speed drives, heat pumps, package terminal A/C, air conditioners, chillers, water heaters, programmable thermostats, and motors.

B. Contractor must submit notification of any value engineering or product substitution that will affect the utility rebate amount prior to approval.

READINESS CERTIFICATION PRIOR TO FINAL JOBSITE OBSERVATION

To prevent the final job observation from occurring too early, we require that the Contractor review the completion status of the project and, by copy of this document, certify that the job is indeed ready for the final job observation. The following is a typical list of items that represent the degree of job completeness expected prior to your requesting a final job observation.

1. Penetrations of fire-rated construction fire sealed in accordance with specifications.
2. Electrical panels have typed circuit identification.
3. Smoke and fire/smoke dampers are wired and have been tested.
4. Per Section 26 05 00, cable insulation test results have been submitted.
5. Per Section 26 05 00, ground resistance test results have been submitted.
6. Operation and Maintenance manuals have been submitted as per Section 26 05 00.
7. Bound copies of approved shop drawings have been submitted as per Section 26 05 00.
8. Report of instruction of Owner's representative has been submitted as per Section 26 05 00.
9. Fire alarm inspection and testing report has been submitted as per Sections 26 05 00 and 28 31 00.
10. Start-up reports from factory representative have been submitted as per Section 26 05 00.

Accepted by:

Prime Contractor _____

By _____ Date _____

Upon Contractor certification that the project is complete and ready for a final job observation, we require the Contractor to sign this agreement and return it to the Architect/Engineer so that the final observation can be scheduled.

It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineers for additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

END OF SECTION

SECTION 26 05 03 - THROUGH PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Through-Penetration Firestopping.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this Section.

B. Installer: Individuals performing work shall be certified by the manufacturer of the system selected for installation.

1.3 REFERENCES

A. UL 263 - Fire Tests of Building Construction and Materials

B. UL 723 - Surface Burning Characteristics of Building Materials

C. ANSI/UL 1479 - Fire Tests of Through Penetration Firestops

D. UL 2079 - Tests for Fire Resistance of Building Joint Systems

E. UL Fire Resistance Directory Through Penetration Firestop Systems (XHEZ)

F. Intertek / Warnock Hersey - Directory of Listed Products

G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials

H. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Firestops

I. The Building Officials and Code Administrators National Building Code

J. 1997 Uniform Building Code

K. 2021 International Building Code

L. NFPA 5000 - Building Construction Safety Code

M. CBC California Building Code

1.4 SUBMITTALS

A. Submit under provisions of Section 26 05 00.

B. Submit Firestopping Installers Certification for all installers on the project.

C. Through-Penetration Firestop System Schedule: Indicate locations of each through-penetration firestop system, along with the following information:

1. Types of penetrating items.
2. Types of constructions penetrated, including fire-resistance ratings and, where applicable, thicknesses of construction penetrated.
3. Through-penetration firestop systems for each location identified by firestop design designation of qualified testing and inspecting agency.
4. F ratings for each firestop system.

D. Maintain a notebook on the job site at all times that contains copies of approved submittals for all through penetration firestopping to be installed. Notebook shall be made available to the Authority Having Jurisdiction at their request and turned over to the Owner at the end of construction as part of the O&M Manuals.

E. Submit VOC rating of firestopping material in g/L (less water) with documentation that it meets the limits set forth in SCAQMD Rule 1168.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store, protect and handle products on site. Accept material on site in factory containers and packing. Inspect for damage. Protect from deterioration or damage due to moisture, temperature changes, contaminants, or other causes. Follow manufacturer's instructions for storage.

B. Install material prior to expiration of product shelf life.

1.6 PERFORMANCE REQUIREMENTS

A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

1. Fire-resistance-rated walls including fire partitions, fire barriers, and smoke barriers.
2. Fire-resistance-rated horizontal assemblies including floors, floor/ceiling assemblies, and ceiling membranes of roof/ceiling assemblies.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per UL 1479:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.

C. For through-penetration firestop systems exposed to light, traffic, moisture, or physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

E. For through-penetration firestop systems in air plenums, provide products with flame-spread and smoke-developed indexes of less than 25 and 50, respectively, as determined per ASTM E 84.

F. Adhesives and Sealants: All sealers, adhesives, and sealants shall comply with the low emitting material limits of the following standards:

1. CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions VOC from Indoor Sources Using Environmental Chambers Version 1.1.
2. South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications. All adhesives and sealants wet-applied on site shall comply with the applicable chemical content requirements of SCAQMD Rule 1168.
3. South Coast Air Quality Management District Rule SCAQMD 1113 - Wet Applied Paints and Coatings. All paints and coatings wet-applied on site must meet the applicable VOC limits of SCAQMD Rule 1113.

1.7 MEETINGS

A. Pre-installation meeting: A pre-installation meeting shall be scheduled and shall include the Construction Manager, General Contractor, all Subcontractors associated with the installation of systems penetrating fire barriers, Firestopping Manufacturer's Representative, and the Owner.

1. Review foreseeable methods related to firestopping work.
2. Tour representative areas where firestopping is to be installed; inspect and discuss each type of condition and each type of substrate that will be encountered, and preparation to be performed by other trades.

1.8 WARRANTY

A. Provide one year warranty on parts and labor.

B. Warranty shall cover repair or replacement of firestop systems which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability, or appear to deteriorate in any manner not clearly specified by the manufacturer as an inherent quality of the material.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the through-penetration firestop systems indicated for each application that are produced by one of the following manufacturers. All firestopping systems installed shall be provided by a single manufacturer.

1. 3M; Fire Protection Products Division
2. Hilti, Inc.
3. RectorSeal Corporation, Metacaulk
4. Tremco; Sealant/Weatherproofing Division
5. Johns-Manville
6. Spec Seal Firestop Products

2.2 THROUGH PENETRATION FIRESTOP SYSTEMS

A. Provide materials and systems classified by or listed by Intertek / Warnock Hersey to provide firestopping equal to time rating of construction being penetrated.

B. All firestopping materials shall be free of asbestos, lead, PCB's, and other materials that would require hazardous waste removal.

C. Firestopping shall be flexible to allow for normal penetrating item movement due to expansion and contraction.

D. Provide firestopping systems capable of supporting floor loads where systems are exposed to possible floor loading or traffic.

E. Provide firestopping systems allowing continuous insulation for all insulated pipes.

F. Provide firestopping systems classified by UL or listed by Intertek / Warnock Hersey for penetrations through all fire rated construction. Firestopping systems shall be selected from the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory Category XHEZ based on substrate construction and penetrating item size and material and shall fall within the range of numbers listed:

1. Combustible Framed Floors and Chase Walls - 1 or 2 Hour Rated:

a. F Rating = Floor/Wall Rating

| Penetrating Item | UL System No. |
|---|---|
| No Penetrating Item | FC 0000-0999* |
| Metallic Pipe or Conduit | FC 1000-1999 |
| Non-Metallic Pipe or Conduit | FC 2000-2999 |
| Electrical Cables | FC 3000-3999 |
| Insulated Pipes | FC 5000-5999 |
| Multiple Penetrations | FC 8000-8999 |

| Penetrating Item | UL System No. |
|---|---|

*Alternate method of firestopping is patching opening to match original rated construction.

2. Non-Combustible Framed Walls - 1 or 2 Hour Rated:

   a. F Rating = Wall Rating

| Penetrating Item | UL System No. |
|---|---|
| No Penetrating Item | WL 0000-0999* |
| Metallic Pipe or Conduit | WL 1000-1999 |
| Non-Metallic Pipe or Conduit | WL 2000-2999 |
| Electrical Cables | WL 3000-3999 |
| Multiple Penetrations | WL 8000-8999 |

*Alternate method of firestopping is patching opening to match original rated construction.

3. Concrete or Masonry Floors and Walls - 1 or 2 Hour Rated:

   a. F Rating = Wall/Floor Rating

| Penetrating Item | UL System No. |
|---|---|
| No Penetrating Item | CAJ 0000-0999* |
| Metallic Pipe or Conduit | CAJ 1000-1999 |
| Non-Metallic Pipe or Conduit | CAJ 2000-2999 |
| Electrical Cables | CAJ 3000-3999 |
| Multiple Penetrations | CAJ 8000-8999 |

*Alternate method of firestopping is patching opening to match original rated construction.

G. Any opening in walls or floors not covered by the listed series of numbers shall be coordinated with the firestopping manufacturer.

H. Any openings in floors or walls not described in the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory, or outlined in manufacturer's information shall be sealed in a manner agreed upon by the Firestopping Manufacturer, Owner, and the Authority Having Jurisdiction.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Ensure all surfaces that contact seal materials are free of dirt, dust, grease, oil, rust, or loose materials. Clean and repair surfaces as required. Remove laitance and form-release agents from concrete.

B. Ensure substrate and penetrating items have been permanently installed prior to installing firestopping systems. Ensure penetrating items have been properly spaced and have proper clearance prior to installing firestopping systems.

C. Surfaces to which sealing materials are to be installed must meet the selected UL or Intertek / Warnock Hersey system substrate criteria.

D. Prime substrates where recommended in writing by through-penetration firestop system manufacturer. Confine primer to area of bond.

3.2 INSTALLATION

A. In existing construction, provide firestopping of openings prior to and after installation of penetrating items. Remove any existing coatings on surfaces prior to firestopping installation. Temporary firestopping shall consist of packing openings with fire resistant mineral wool for the full thickness of substrate, or an alternate method approved by the Authority Having Jurisdiction. All openings shall be temporarily firestopped immediately upon their installation and shall remain so until the permanent UL or listed by Intertek / Warnock Hersey listed firestopping system is installed.

B. Install penetration seal materials in accordance with printed instructions of the UL or Intertek / Warnock Hersey Fire Resistance Directory and with the manufacturer's printed application instructions.

C. Install dams as required to properly contain firestopping materials within openings and as required to achieve required fire resistance rating. Remove combustible damming after appropriate curing.

3.3 CLEANING AND PROTECTING

A. Clean excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not cause damage.

B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

3.4 IDENTIFICATION

A. Provide and install labels adjacent to each firestopping location. Label shall be provided by the firestop system supplier and contain the following information in a contrasting color:

1. The words "Warning - Through Penetration Firestop System - Do Not Disturb. Notify Building Management of Any Damage."
2. Firestop System Supplier; UL or listed by Intertek / Warnock Hersey system number; date installed; contractor name and phone number; manufacturer's representative name, address, and phone number.

3.5 INSPECTION

A. All penetrations shall be inspected by the manufacturer's representative to ensure proper installation.

B. Access to firestop systems shall be maintained for examination by the Authority Having Jurisdiction at their request.

C. Proceed with enclosing through-penetration firestop system with other construction only after inspection reports are issued and firestop installations comply with requirements.

D. The contractor shall allow for visual destructive review of 5% of installed firestop systems (minimum of one) to prove compliance with specifications and manufacturer's instructions and details. Destructive system removal shall be performed by the contractor and witnessed by the Architect/Engineer and manufacturer's factory representative. The Architect/Engineer shall have sole discretion of which firestop system installations will be reviewed. The contractor is responsible for all costs associated with this requirement including labor and material for removing and replacing the installed firestop system. If any firestop system is found to not be installed per manufacturer's specific instructions and details, all firestop systems are subject to destructive review and replacement at the Architect/Engineer's discretion and the contractor's expense.

END OF SECTION

SECTION 26 05 13 - WIRE AND CABLE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Building wire

B. Cabling for remote control, signal, and power limited circuits

1.2 RELATED WORK

A. Section 26 05 53 - Electrical Identification: Refer to electrical identification for color and identification labeling requirements.

1.3 REFERENCES

A. ASTM B800-05 - Standard Specification for 8000 Series Aluminum Alloy Wire Electrical Purposes-Annealed and Intermediate Tempered.

B. ASTM B801-07 - Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation

C. NEMA WC 70 - Power Cables Rated 2,000V or Less for the Distribution of Electrical Energy

D. NFPA 70 - National Electrical Code (NEC)

E. CEC California Electrical Code

F. UL 44 - Thermoset-Insulated Wires and Cables

G. UL 83 - Thermoplastic-Insulated Wires and Cables

H. UL 854 - Service-Entrance Cables

I. UL 1581 - Standard for Electrical Wires, Cables, and Flexible Cords

J. UL 2196 - Fire Resistive, Fire Resistant and Circuit Integrity Cables

1.4 SUBMITTALS

A. Submit shop drawings and product data under the provisions of Section 26 05 00.

B. Submit manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 BUILDING WIRE

A. Feeders and Branch Circuits 8 AWG and larger: Copper, stranded conductor, 600-volt insulation, THHN/THWN or XHHW-2.

B. Feeders and Branch Circuits 8 AWG and larger in Underground Conduit: Copper, stranded conductor, 600-volt insulation, THWN or XHHW-2.

C. Feeders and Branch Circuits 10 AWG and Smaller: Copper, solid or stranded conductor, 600-volt insulation, THHN/THWN, unless otherwise noted on the drawings.

D. Motor Feeder from Variable Frequency Drives: Copper conductor, 600-volt XHHW-2 insulation, stranded conductor, unless otherwise noted on the drawings. Three conductor stranded copper, 600-volt XHHW-2 insulation, with copper ground and overall helical copper tape shield. Shield shall be terminated at both ends of cable with an approved termination.

E. Control Circuits: Copper, stranded conductor 600-volt insulation, THHN/THWN.

F. Aluminum conductors are not to be used.

G. Each 120 and 277-volt branch circuit shall have a dedicated neutral conductor. Neutral conductors shall be considered current-carrying conductors for wire derating.

2.2 CABLING FOR REMOTE CONTROL, SIGNAL, AND POWER LIMITED CIRCUITS

A. Wire for the following specialized systems shall be as designated on the drawings, or elsewhere in these specifications. If not designated on the drawings or specifications, the system manufacturer's recommendations shall be followed.

1. Fire alarm
2. Low voltage switching and lighting control
3. Electronic control

B. Control Cable for Class 1 Remote Control and Signal Circuits: Copper conductor, 600-volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a PVC jacket.

C. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300-volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a PVC jacket; UL listed.

PART 3 - EXECUTION

3.1 WIRE AND CABLE INSTALLATION SCHEDULE

A. Above Accessible Ceilings:

1. Building wire shall be installed in raceway.
2. Metal clad cable, Type MC, 1/2" size with minimum #12 conductors and ground, shall be allowed for flexible whips to individual luminaires on non-essential circuits. The flexible whips shall be between 18" to 72" in length per Electrical Code.

B. All Other Locations: Building wire in raceway.

C. Above Grade: All conductors installed above grade shall be type "THHN".

D. Underground or In Slab: All conductors shall be type "THWN".

E. Low Voltage Cable (less than 100 volts): Low voltage cables in ducts, plenums, and other air handling spaces shall be plenum listed. Low voltage cables in non-accessible areas shall be installed in conduit. Low voltage cable may be installed without conduit in accessible areas using the following types of cable supports. Cable support types/systems shall comply with the warranty requirements of the low voltage cable manufacturer.

1. J-hooks
2. Bridle rings with saddle supports

F. Low Voltage Cable (less than 100 volts): Low voltage cable shall be installed in raceway.

3.2 CONTRACTOR CHANGES

A. The basis of design is copper conductors installed in raceway based on ambient temperature of 30°C, CEC California Electrical Code edition Table 310.15(B)(16). Service entrance and fire pump feeder conductors are based on copper conductor installed in underground electrical ducts, CEC California Electrical Code Table B310.15(B)(2)(7).

B. The Contractor shall be responsible for derating and sizing conductors and conduits to equal or exceed the ampacity of the basis of design circuits, if he/she chooses to use methods or materials other than the basis of design.

C. Underground electrical duct ampacity rating shall be in accordance with NEC Table 310.16 (2011 - 2017 edition 310.15(B)(16)) or calculated in accordance with Annex B Application Information for Ampacity Calculation. The calculations and a sketch of the proposed installation shall be submitted prior to any conduit being installed.

D. Conductor length(s) listed on plans and schedules. The drawings are diagrammatic with intent to convey the components of the electrical distribution system. Conductor length(s) when listed on plans and schedules are for engineering calculation purposes. Conductor length(s) shall NOT be used for bidding purposes.

E. Record drawing shall include the calculations and sketches.

3.3 GENERAL WIRING METHODS

A. Use no wire smaller than 12 AWG for power and lighting circuits, and no smaller than 14 AWG for control wiring.

B. Use no wire smaller than 18 AWG for low voltage control wiring below 100 volts.

C. Use 10 AWG conductor for 20 ampere, 120-volt branch circuit home runs longer than 75 feet, and for 20 ampere, 277-volt branch circuit home runs longer than 200 feet.

D. Use no wire smaller than 8 AWG for outdoor lighting circuits.

E. The ampacity of multiple conductors in one conduit shall be derated per the Electrical Code. In no case shall more than 4 conductors be installed in one conduit to such loads as motors larger than 1/4 HP, panelboards, motor control centers, etc.

F. Where installing parallel feeders, place an equal number of conductors for each phase of a circuit in same raceway or cable.

G. Splice only in junction or outlet boxes.

H. Neatly train and lace wiring inside boxes, equipment, and panelboards.

I. Make conductor lengths for parallel circuits equal.

J. All conductors shall be continuous in conduit from last outlet to their termination.

K. Terminate all spare conductors on terminal blocks, and label the spare conductors.

L. Cables or wires shall not be laid out on the ground before pulling.

M. Cables or wires shall not be dragged over earth or paving.

N. Care shall be taken so as not to subject the cable or wire to high mechanical stresses that would cause damage to the wire and cable.

O. At least six (6)-inch loops or ends shall be left at each outlet for installation connection of luminaires or other devices.

P. All wires in outlet boxes not connected to fixtures or other devices shall be rolled up, spliced if continuity of circuit is required, and insulated.

3.4 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time. Use UL listed wire pulling lubricant for pulling 4 AWG and larger wires. Do not use wire pulling lubricant for isolated (ungrounded) power system wiring.

B. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

C. Pulling shall be continuous without unnecessary stops and starts with wire or cable only partially through raceway.

D. Where reels of cable or wire are used, they shall be set up on jacks close to the point where the wire or cable enters the conduit or duct so that the cable or wire may be unreeled and run into the conduit or duct with a minimum of change in the direction of the bend.

E. Conductors shall not be pulled through conduits until plastering or masonry work is completed and conduits are free from moisture. Care shall be taken so that long pulls of wire or pulls around several bends are not made where the wire may be permanently stretched and the insulation damaged.

F. Only nylon rope shall be permitted to pull cables into conduit and ducts.

G. Completely and thoroughly swab raceway system before installing conductors.

H. Conductor Supports in Vertical Raceways:

1. Support conductors in vertical raceways in accordance with the Electrical Code Spacing of Conductors Supports.
2. Supports shall be of insulated wedge type (OZ Gedney Type S, or equal) and installed in a tapered insulated bushing fitting or a metal woven mesh with a support ring that fits inside conduit fitting installed in an accessible junction box (Hubbell Kellems support grip or equal).

3.5 CABLE INSTALLATION

A. Provide protection for exposed cables where subject to damage.

B. Use suitable cable fittings and connectors.

C. Run all open cable parallel or perpendicular to walls, ceilings, and exposed structural members. Follow the routing as illustrated on the drawings as closely as possible. Cable routing on drawings scaled 1/4"=1'-0" or less shall be considered diagrammatical, unless noted otherwise. The correct routing, when shown diagrammatically, shall be chosen by the Contractor based on information in the contract documents; in accordance with the manufacturer's written instructions, applicable codes, the NECA's "Standard of Installation", recognized industry standards; and coordinated with other contractors.

D. Open cable shall be supported by the appropriate size J-hooks or other means if called for on the drawings. Wire and cable from different systems shall not be installed in the same J-hook. J-hooks shall be sized with 20% spare capacity. J-hooks shall provide proper bend radius support for data cable and fiber cables.

E. Open cable installed above suspended ceilings shall not rest on the suspended ceiling construction, nor utilize the ceiling support system for wire and cable support.

F. J-hook support spans shall be based on the smaller of the manufacturer's load ratings and code requirements. In no case shall horizontal spans exceed 5 feet and vertical spans exceed 4 feet. All J-hooks shall be installed where completely accessible and not blocked by piping, ductwork, inaccessible ceilings, etc. J-hooks shall be independently rigidly attached to a structural element. J-hooks shall be installed to provide 2" horizontal separation and 6" vertical separation between systems.

G. Open cable shall only be installed where specifically shown on the drawings, or permitted in these specifications.

3.6 WIRING CONNECTIONS AND TERMINATIONS

A. Splice and tap only in accessible junction boxes.

B. Use solderless, tin-plated copper, compression terminals (lugs) applied with circumferential crimp for conductor terminations, 8 AWG and larger.

C. Use solderless, tin-plated, compression terminals (lugs) applied with indenter crimp for copper conductor terminations, 10 AWG and smaller.

D. Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and smaller. For 10 AWG and smaller, use insulated spring wire connectors with plastic caps.

E. Use compression connectors applied with circumferential crimp for conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor. Cold shrink connector insulator with 1kV rating shall be used in damp and wet locations.

F. Thoroughly clean wires before installing lugs and connectors.

G. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

H. Phase Sequence: All apparatus shall be connected to operate in the phase sequence A-B-C representing the time sequence in which the phase conductors so identified reach positive maximum voltage.

I. As a general rule, applicable to switches, circuit breakers, starters, panelboards, switchgear and the like, the connections to phase conductors are intended thus:

1. Facing the front and operating side of the equipment, the phase identification shall be:

    a. Left to Right - A-B-C
    b. Top to Bottom - A-B-C

J. Connection revisions as required to achieve correct rotation of motors shall be made at the load terminals of the starters or disconnect switches.

K. Use antioxidant joint compound on all aluminum conductor terminations. Apply antioxidant joint compound per manufacturer's recommendations.

3.7 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Division 1.

B. Building Wire and Power Cable Testing: Perform an insulation-resistance test on each conductor with respect to ground and adjacent conductors. Test shall be made by means of a low-resistance ohmmeter, such as a "Megger". The applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. The test duration shall be one minute. Insulation resistance must be greater than 100 mega-ohm for 600 volt and 25 mega-ohm for 300 volt rated cables per NETA Acceptance Testing Standard. Verify uniform resistance of parallel conductors.

C. MI cable shall have the insulation resistance of each cable tested with a 500-volt dc megohmeter prior to energizing the cables. Tabulate resistance values and submit to Architect/Engineer for acceptance.

D. Inspect wire and cable for physical damage and proper connection.

E. Torque test conductor connections and terminations to manufacturer's recommended values.

F. Perform continuity test on all power and equipment branch circuit conductors. Verify proper phasing connections.

G. Provide documentation of the manufacturer's recommended lug torque value for copper and aluminum conductors, the date the lugs were torqued, and installed torque readings. Documentation indicating that the torque wrench has been calibrated not more than 30 days prior to tightening of lugs shall be provided.

H. Protection of wire and cable from foreign materials:

1. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any wire or cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited to, overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid, or compound that could come in contact with the cable, cable jacket, or cable termination components.

I. Overspray of paint on any wire or cable will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed.

END OF SECTION

SECTION 26 05 26 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Equipment grounding system

B. Bonding system

C. Grounding electrode system

D. Grounding of systems over 1kV

1.2 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the International Electrical Testing Association and that is acceptable to authorities having jurisdiction.

B. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association to supervise on-site testing specified in Part 3.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in Electrical Code, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with UL 467 Grounding and Bonding Equipment.

E. Comply with Electrical Code; for overhead-line construction and medium-voltage underground construction, comply with IEEE/ANSI C2 National Electrical Safety Code (NESC).

1.3 REFERENCES

A. NFPA 70 - National Electrical Code (NEC)

B. CEC California Electrical Code

1.4 SUBMITTALS

A. Submit shop drawings under provisions of Section 26 05 00.

B. Product Data: For the following:

1. Ground rods.

C. Indicate layout of ground field, location of system grounding electrode connections, and routing of grounding electrode conductor and ground ring.

1.5 SUMMARY

A. This section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

PART 2 - PRODUCTS

2.1 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 26 Section 26 05 13 "Wire and Cable".

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated. Refer to Section 26 05 53 for insulation color.

D. Grounding Electrode Conductors: Stranded cable.

E. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

F. GB; Grounding Bar:

1. Bare, annealed copper bars of rectangular cross section, with insulators. 1/4" x 2", length of technology or applicable room.

G. IBT; Intersystem Bonding Termination:

1. Copper bar, 1/4" x 2" x 24". Provide with wall mounting brackets, insulators and pre-tapped holes.
2. Manufacturers:

a. Harger GBI Series.
b. Erico EGB Series.

2.2 CONNECTOR PRODUCTS

A. Comply with UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Connectors: Hydraulic compression type Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

C. Bolted Connectors: Bolted-pressure-type connectors.

D. Substation connectors shall comply with IEEE 837 listed for use for specific types, sizes, and combinations of conductors and connected items.

PART 3 - EXECUTION

3.1 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

D. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

E. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

F. Structural Steel Connection: Exothermic-welded connections to structural steel. Coordinate with structure to provide physical protection.

G. Underground Connections: Exothermic-welded connections. Use for underground connections, except those at test wells.

H. Connections at back boxes, junction boxes, pull boxes, and equipment terminations: The equipment grounding conductor(s) associated with all circuits in the box shall be connected together and to the box using a suitable grounding screw. The removal of the respective receptacle, luminaire, or other device served by the box shall not interrupt the grounding continuity. The connection to the non-metallic boxes shall be made to any metallic fitting or device requiring grounding.

I. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

J. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.2 INSTALLATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Each grounding conductor that passes through a below grade wall must be provided with a waterstop.

C. Grounding electrode conductor (GEC) shall be protected from physical damage by rigid polyvinyl chloride conduit (PVC) in exposed locations.

D. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then use a bolted clamp. Bond straps directly to the basic structure, taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

E. In raceways, use insulated equipment grounding conductors.

F. Underground Grounding Conductors: Use tinned copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches below grade or bury 12 inches above duct bank when installed as part of the duct bank.

G. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, below access floors, and elsewhere as indicated, with bolted connections to form a continuous ground path.

3.3 EQUIPMENT GROUNDING SYSTEM

A. Comply with Electrical Code, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by Electrical Code are indicated.

B. Install equipment grounding conductors in all feeders and circuits. Terminate each end on a grounding lug or bus.

C. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by Electrical Code:

1. Lighting and receptacle circuits. Terminate each end on a grounding lug or bus.
2. Single-phase and three-phase motor and appliance branch circuits.
3. Flexible raceway runs, including FMC and LFMC.
4. Armored and metal-clad cable runs.

D. Busway Supply Circuits: Install insulated equipment grounding conductor from the grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

E. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.

F. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

3.4 BONDING SYSTEM

A. At building expansion joints, provide flexible bonding jumpers to connect to columns or beams on each side of the expansion joint.

B. Isolated Equipment Enclosure: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment bonding conductor.

C. Exterior Metallic Pull and Junction Box Covers, Metallic Hand Rails: Bond to grounding system using flexible grounding conductors.

D. Equipment Circuits: Install a bonding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, dampers, and heaters. Bond conductor to each unit and to air duct. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps or copper conductor sized equal to the equipment grounding conductor.

E. Bond metal ducts of dust collectors, particulate conveying, fume hoods, and other hazardous materials to the equipment grounding conductors of associated pumps, fans, or blowers. Use braided-type bonding straps. Provide braided bare copper bonding conductor in nonmetallic dust collector ductwork to each equipment inlet location, and bond to equipment.

F. Water Heater, Heat-Tracing, Metal Well Casing, and Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and anti-frost heating cable. Bond conductor to heater units, piping, well casing, connected equipment, and components.

G. Connect bonding conductors to metal water pipe using a suitable ground clamp. Make connections to flanged piping at street side of flange. Provide bonding jumper around water meter.

H. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 6 AWG minimum insulated bonding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location. Leave 10 feet of slack conductor at terminal board.

I. Telecom Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bar.

J. Industrial Control Panels, Terminal Cabinets, and Similar Installation: Terminate bonding conductor on cabinet grounding terminal. Provide an equipment grounding conductor and bond adjacent and associated control panels together.

K. Equipment Ground Conductor Continuity: All spliced equipment grounding conductors in junction boxes, cabinets, and distribution equipment shall be connected together and bonded to the metal enclosure.

L. Remote control, signaling, and fire alarm circuits shall be bonded in accordance with the most recent version of the National Electric Code.

M. Metal Poles Supporting Outdoor Lighting Fixtures > 15 feet: Provide a grounding electrode in addition to installing a separate equipment grounding conductor with supply branch-circuit conductors.

N. Common Ground Bonding with Lightning Protection System: Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

O. Medical Gas Piping: Bond to pipe with grounding clamp connectors. Bonding conductor shall be a #6 AWG minimum and may be connected to panelboard ground bar serving the area.

3.5 GROUNDING ELECTRODE SYSTEM

A. Ground Ring (Counterpoise):

1. Ground the steel framework of the building with a driven ground rod at the base of every corner column and at intermediate exterior columns at average distances not more than 60 feet apart. Provide a grounding conductor, electrically connected to each ground rod and to each steel column, extending around the perimeter of the building. Use tinned-copper conductor not less than No. 2 AWG for ground ring and for tap to building steel. Bury conductor not less than 30 inches below grade, 24 inches from building foundation, and 18 inches outside of roof drip line.

B. Supplementary Grounding Electrode: Use driven ground rod on exterior of building.

C. Provide bonding at Utility Company's metering equipment and pad mounted transformer.

D. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

E. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters, filtering devices, and similar equipment. Connect to pipe with grounding clamp connectors.

F. Natural Gas Service Piping: Bond to natural gas main service with grounding clamp connectors. Bonding conductor shall be connected to the main service ground bar. Provide grounding jumpers around all breaks in metallic continuity.

G. Natural Gas Equipment Piping: Bond each aboveground portion of natural gas metallic piping system at each equipment location with grounding clamp connectors. Bonding shall be performed after any flexible attachment nearest the equipment. The equipment grounding conductors may serve as the bonding means.

H. Install one test well for each service at the ground rod electrically closest to the service entrance. Set top of well flush with finished grade or floor.

3.6 EQUIPOTENTIAL (MULTI-POINT) GROUNDING SYSTEM

A. Provide an equipotential grounding system in the following locations:

1. Class I Div 1 and Div 2 locations as required in Electrical Code.
2. Swimming pool, fountains, and similar locations as required in Electrical Code.
3. Critical patient care and special care areas as indicated on drawings.

B. The non-current-carrying metal parts of equipment, raceways and other enclosures shall be bonded to the grounding system.

3.7 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

A. Manholes and Handholes: Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide a No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.

B. Connections to Manhole Components: Connect exposed-metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

C. Pad-Mounted Transformers and Switches: Install two ground rods and counterpoise circling pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 2 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 inches below grade and 6 inches from the foundation. The pad rebar shall be attached to the counterpoise conductor at the four corners.

3.8 OVERHEAD-LINE GROUNDING

A. Comply with IEEE C2 requirements. Use 2 or more parallel ground rods if a single ground rod electrode resistance to ground exceeds 25 ohms.

B. Drive ground rods to a depth of 12 inches below finished grade in undisturbed earth.

C. Ground Rod Connections: Use clamp-type connectors listed for the purpose for underground connections and connections to rods.

D. Lightning Arresters: Separate arrester grounds from other grounding conductors.

E. Secondary Neutral and Tank of Transformer: Interconnect and connect to grounding conductor.

F. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.

3.9 SUBSTATION GROUNDING

A. Provide an underground fence ground conductor, minimum 1/0 copper buried 18", located 3 feet outside the fence perimeter. Bond the fence ground grid into the substation ground grid. Ground fence at each side of gate or other openings. Gates shall be bonded to the grounding conductor, with a jumper to the gate. A buried bonding jumper shall be used across the gate or other openings. Provide an underground grounding conductor under the gate swing area. Barbed wire strands used above the fence fabric shall be bonded to the grounding conductor, jumper or fence. Fence posts shall be connected to the grounding conductor with suitable connecting means. Ground all corner posts and line post every 50 feet.

B. Provide a substation underground ground grid of 4/0 bare stranded copper cable buried 18" below grade in a minimum 10' by 20' grid. Exothermic weld connections of 4/0 cables at all junctions.

C. Provide grounding conductor for the grounded neutral for transformers, reactors and capacitors. Provide grounding conductor for lighting arrestors, gaps and similar devices. Provide grounding for all exposed metal parts of switches, structures, transformer tanks, metal walkway, steelwork of buildings, switchboards, instrument-transformer secondaries, etc.

D. Provide two ground rods/chemical electrodes, or as shown on drawings. Connect to underground grounding conductor.

3.10 GRADING AND PLANTING

A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 2. Maintain restored surfaces. Restore disturbed paving.

END OF SECTION

SECTION 26 05 27 - SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Conduit and Equipment Supports

B. Fastening Hardware

C. Concrete Housekeeping Pads

D. Foundation and Underground Sleeves and Seals

1.2 QUALITY ASSURANCE

A. Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry.

1.3 COORDINATION

A. Coordinate size, shape and location of concrete pads with section on Cast-in-Place Concrete or Concrete Topping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Allied Support Systems

B. Cooper B-Line

C. Erico, Inc.

D. Hilti

E. Power Fasteners

F. Orbit Industries

2.2 MATERIAL

A. Support Channel: Hot-dip galvanized for wet/damp locations; painted steel for interior/dry locations. All field cut ends shall be touched up with matching finish to inhibit rusting.

B. Hardware: Corrosion resistant.

C. Anchorage and Structural Attachment Components:

1. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to Authorities Having Jurisdiction.

    a. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

2. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.
3. Beam clamps for Steel Beams and Joists: Double sided or concentric open web joist hangars. Single-sided type is not acceptable.
4. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.
5. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.
6. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-05. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.
7. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

D. Conduit Sleeves and Lintels:

1. Each Contractor shall provide, to the General Contractor for installation, lintels for all openings required for the Contractor's work in masonry walls and conduit sleeves for floors, unless specifically shown as being by others.
2. Refer to Structural General Notes for lintel requirements in masonry construction.
3. Refer to Structural plans and specifications for lintel requirements and sizes.
4. Lintels:

    a. Lintels in non-bearing masonry wall openings can be sized in accordance with the note below. Lintels that occur in existing bearing walls are to be sized according to similar conditions and spans in the new construction and lintel schedule. Bottom plate size shall be a minimum of 3/8" thick. The width of the plate shall be 3/4" less than the field verified wall thickness. The plate shall be the full length of the lintel member. Lintels are not required over openings that are 12" wide or less and at least 1 course below the top of the wall.
    b. All lintels shall have a minimum of 8" end bearing.
    c. All lintels in exterior wall construction shall be hot-dip galvanized.
    d. For all openings not otherwise detailed or scheduled, minimum lintels shall be for each 4 inch of masonry width:

1) 0 to 2'-0" span: 5/16" plate (3/4" less than wall width)
2) 2'-0" to 4'-0" span: L 3 1/2 x 3 1/2 x 1/4
3) 4'-0" to 6'-0" span: L4 x 3 1/2 x 5/16 (llv)
4) 6'-0" to 8'-0" span: L5 x 3 1/2 x 5/16 (llv)

e. All angles that are back to back shall be welded top and bottom 3" at 12" minimum.

5. Fabricate all lintels from structural steel shapes or as indicated on the drawings. All lintels and grouped wall openings shall be approved by the Architect or Structural Engineer.
6. Fabricate all sleeves from standard weight black steel pipe. Provide continuous sleeve. Cut or split sleeves are not acceptable. Sleeves through concrete walls may be high density polyethylene pipe penetration sleeve with a water stop collar, suitable for use with Link-Seal mechanical seals. Century-Line Model CS.
7. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.
8. Sleeves shall not penetrate structural members without approval from the Structural Engineer.
9. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.
10. Install all sleeves concentric with conduits. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.
11. Where conduits rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (asphalt and cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.
12. Size sleeves large enough to allow expansion and contraction movement.

E. Concrete Housekeeping Pads:

1. Concrete bases for all floor mounted equipment and wall mounted equipment which is surface mounted and extends to within 6" of the finished floor, unless shown otherwise on the drawings, shall be 3-1/2" thick concrete.
2. Bases shall extend 3" on all sides of the equipment (6" larger than factory base).
3. Where the base is less than 12" from a wall, the base shall be carried to the wall to prevent a "dirt-trap".
4. Concrete materials and workmanship required for the Contractor's work shall be provided by the Contractor. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6" x 6", W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at twenty-eight days.

F. Rooftop Support System:

1. Provide pre-fabricated roof supports for all conduit and equipment installed above the roof. Support all conduit and equipment a minimum of 4" above roof.
2. Support system shall be compatible with single ply, bituminous, metal, and spray foam roof systems. The base shall be rounded to prevent damage to the roof, and drainage holes shall prevent ponding of water in the support.
3. All metal components shall be hot dipped galvanized. Mounting hardware shall be stainless steel or hot dipped galvanized. Support shall be UV, corrosion, and freeze/thaw resistant. Support shall include orange paint, reflective safety orange accents, or similar markings for increased visibility.
4. Products:

    a. Cooper B-Line Dura-Blok
    b. Erico Caddy Pyramid 50, 150, 300, or 600 (to match load).

G. Truss and Joist Support System: Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs. or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3' spacing between loads.
2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

    a. The hanger is attached within 6" from a web/chord joint.
    b. Additional L2x2x1/4 web reinforcement is installed per manufacturer's requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.
4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Architect/Engineer.

2.3 FOUNDATION - UNDERGROUND SLEEVES AND SEALS

A. Wall Seals ("Link-Seals"):

1. Where shown on the drawings, raceways passing through foundation walls to an underground condition shall have their annual space (sleeve or drilled hole – not tapered hole made with knockout plug) sealed by properly sized sealing element consisting of a synthetic rubber material compounded to resist aging, ozone, sunlight, water and chemical action.
2. Sleeves, if used, shall be standard weight steel with primed finish and waterstop/anchor continuously welded to sleeve.
3. Sleeves shall be at least 2 trade sizes larger than the penetrating raceway.
4. Pressure shall be maintained by stainless steel bolts and accessories. Pressure plates may be of composite materials for Models S and OS.
5. Sealing Elements shall be as follows:

| Model | Service | Element Material | Temperature Range |
|---|---|---|---|
| S | Standard (Stainless) | EPDM | -40°F to 250°F |
| T | Fire Seals (1 hour) | Silicone | -67°F to 400°F |
| FS | Fire Seals (3 hours) | Silicone | -67°F to 400°F |
| OS | Oil Resistant / Stainless | Nitrile | -40°F to 210°F |

6. Approved Manufacturers:

   a. Thunderline Corporation "Link-Seals"
   b. O-Z/Gedney Company
   c. Calpico, Inc
   d. Innerlynx

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using expansion anchors in concrete and beam clamps on structural steel.

B. Trapeze support installation: Cut hanger rods back at trapeze supports so they do not extend more than 3/4" below bottom face of lowest fastener and blunt any sharp edges.

C. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchor on concrete surfaces; sheet metal screws in sheet metal studs; and wood screws in wood construction.

D. Do not fasten supports to ceiling systems, piping, ductwork, mechanical equipment, or conduit, unless otherwise noted.

E. Do not use powder-actuated anchors without specific permission.

F. Do not drill structural steel members.

G. Fabricate supports from structural steel or steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts.

H. In wet locations and on all building floors below exterior earth grade install free-standing electrical equipment on concrete pads.

I. Install cabinets and panelboards with minimum of four anchors. Provide horizontal backing/support framing in stud walls for rigid mounting. Provide steel channel supports to stand surface-mounted panelboard or cabinet one inch off wall.

J. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.

K. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

L. Refer to Section 26 05 33 for special conduit supporting requirements.

3.2 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.

B. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1" of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6'-6" of finish floor and presents potential injury to personnel.

END OF SECTION

SECTION 26 05 33 - CONDUIT AND BOXES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Rigid metallic conduit and fittings (RMC)

B. Intermediate metallic conduit and fittings (IMC)

C. Electrical metallic tubing and fittings (EMT)

D. Flexible metallic conduit and fittings (FMC)

E. Liquidtight flexible metallic conduit and fittings (LFMC)

F. Rigid polyvinyl chloride conduit and fittings (PVC)

G. Wall and ceiling outlet boxes

H. Electrical connection

I. Pull and junction boxes

J. Rough-ins

K. Handholes

L. Accessories

1.2 RELATED WORK

A. Section 26 05 53 - Electrical Identification: Refer to electrical identification for color and identification labeling requirements.

1.3 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C80.1 - Rigid Steel Conduit, Zinc-Coated
2. ANSI C80.3 - Electrical Metallic Tubing, Zinc-Coated and Fittings
3. ANSI C80.4 - Fittings for Rigid Metal Conduit and Electrical Metallic Tubing
4. ANSI C80.6 - Intermediate Metal Conduit, Zinc Coated
5. ANSI/NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
6. ANSI/NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports

B. Federal Specifications (FS):

1. A-A-50553A - Fittings for Conduit, Metal, Rigid, (Thick-Wall and Thin-Wall (EMT) Type
2. A-A-55810 - Specification for Flexible Metal Conduit

C. NECA "Standards of Installation"

D. National Electrical Manufacturers Association (NEMA):

1. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
2. RN 1 - Polyvinyl chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit, Rigid Aluminum Conduit, and Intermediate Metal Conduit
3. TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit
4. TC 9 - Fittings for PVC Plastic Utilities Duct for Underground Installation

E. NFPA 70 - National Electrical Code (NEC)

F. CEC California Electrical Code

G. Underwriters Laboratories (UL): Applicable Listings

1. UL 1 - Flexible Metal Conduit
2. UL 6 - Rigid Metal Conduit
3. UL 360 - Liquid Tight Flexible Steel Conduit
4. UL514-B - Conduit Tubing and Cable Fittings
5. UL651-A - Type EB and a PVC Conduit and HDPE Conduit
6. UL651-B - Continuous Length HDPE Conduit
7. UL746A - Standard for Polymeric Materials - Short Term Property Evaluations
8. UL797 - Electrical Metal Tubing
9. UL1242 - Intermediate Metal Conduit

H. American Standard of Testing and Materials (ASTM):

1. ASTM D 570 - Standard Test Method for Water Absorption of Plastics
2. ASTM D 638 - Standard Test Method for Tensile Properties of Plastics
3. ASTM D 648 - Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edge Wise Position
4. ASTM D 2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
5. ASTM D 2447 - Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter
6. ASTM D 3350 - Standard Specification for Polyethylene Plastic Pipe and Fittings Material

I. Definitions:

1. Fittings: Conduit connection or coupling.

2. Body: Enlarged fittings with opening allowing access to the conductors for pulling purposes only.
3. Mechanical Spaces: Enclosed areas, usually kept separated from the general public, where the primary use is to house service equipment and to route services. These spaces generally have exposed structures, bare concrete and non-architecturally emphasized finishes.
4. Finished Spaces: Enclosed areas where the primary use is to house personnel and the general public. These spaces generally have architecturally emphasized finishes, ceilings and/or floors.
5. Concealed: Not visible by the general public. Often indicates a location either above the ceiling, in the walls, in or beneath the floor slab, in column coverings, or in the ceiling construction.
6. Above Grade: Not directly in contact with the earth. For example, an interior wall located at an elevation below the finished grade shall be considered above grade but a wall retaining earth shall be considered below grade.
7. Slab: Horizontal pour of concrete used for a floor or sub-floor.

1.4 SUBMITTALS

A. Include fittings and conduits 1.5" and larger in coordination files. Include all in--floor and underfloor conduit in coordination files. Refer to Section 26 05 00 for coordination drawing requirements.

PART 2 - PRODUCTS

2.1 RIGID METALLIC CONDUIT (RMC) AND FITTINGS

A. Manufacturers:

1. Allied
2. LTV
3. Steelduct
4. Calbond Calpipe
5. Wheatland Tube Co
6. O-Z Gedney
7. or approved equal.

B. Manufacturers of RMC Conduit Fittings:

1. Appleton Electric
2. O-Z/Gedney Co.
3. Electroline
4. Raco
5. Bridgeport
6. Midwest
7. Regal
8. Thomas & Betts
9. Crouse-Hinds
10. Killark

11. Orbit Industries
12. or approved equal.

C. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted.

D. Fittings and Conduit Bodies:

1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.
2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.
3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.
4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. High impact phenolic threaded type bushings are not acceptable.
5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

E. PVC Externally Coated Conduit: Compliant with UL 6, ANSI C80.1 and NEMA RN 1; rigid galvanized steel conduit with external 40 mil PVC coating and internal 2 mil urethane coating surface. All fittings and conduit bodies shall be complete with coating. Threads shall be hot galvanized and coated with a clear coat of urethane.The PVC coated system shall include necessary PVC coated fittings, boxes and covers to form a complete encapsulated system.

1. Acceptable Manufacturers:

a. Calbond Calpipe
b. Robroy
c. T&B Ocal
d. or approved equal.

2.2 INTERMEDIATE METALLIC CONDUIT (IMC) AND FITTINGS

A. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted.

B. Manufacturers:

1. Allied
2. LTV
3. Steelduct
4. Wheatland Tube Co
5. O-Z Gedney
6. or approved equal.

C. Fittings and Conduit Bodies:

1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.
2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.
3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.
4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. High impact phenolic threaded type bushings are not acceptable.
5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

2.3 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

A. Minimum Size Electrical Metallic Tubing: 3/4 inch, unless otherwise noted.

B. Manufacturers of EMT Conduit:

1. Allied
2. Calbond Calpipe
3. LTV
4. Steelduct
5. Wheatland Tube Co
6. or approved equal.

C. Fittings and Conduit Bodies:

1. 2" Diameter or Smaller: Compression type of steel designed for their specific application.
2. 1/2" and 3/4" Conduit: Push-on connectors and couplers with locking ring and washer of zinc plated steel, listed for use in dry locations.
3. Larger than 2": Compression type of steel designed for their specific application.
4. Manufacturers of EMT Conduit Fittings:

    a. Appleton Electric
    b. O-Z/Gedney Co.
    c. Electroline
    d. Raco
    e. Bridgeport
    f. Midwest
    g. Regal
    h. Thomas & Betts
    i. Orbit Industries
    j. or approved equal.

2.4 FLEXIBLE METALLIC CONDUIT (FMC) AND FITTINGS

A. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted. Lighting branch circuit wiring to an individual luminaire may be a manufactured, UL listed 3/8" flexible metal conduit and fittings with #14 AWG THHN conductors and an insulated ground wire. Maximum length of 3/8" FMC shall be six (6) feet.

B. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel. Provide a separate equipment grounding conductor when used for equipment where flexibility is required.

C. Fittings and Conduit Bodies:

1. Threadless hinged clamp type, galvanized zinc coated cadmium plated malleable cast iron or compression type, die-cast zinc.
2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.

2.5 LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT (LFMC) AND FITTINGS

A. Manufacturers:

1. Anaconda Type UA
2. Electri-Flex Type LA
3. Alflex
4. Carlon (Lamson & Sessions)
5. or approved equal.

B. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel and an extruded PVC cover.

C. Fittings and Conduit Bodies:

1. Watertight, compression type, galvanized zinc coated cadmium plated malleable cast iron, UL listed.
2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.

2.6 RIGID NON-METALLIC CONDUIT (PVC) AND FITTINGS

A. Minimum Size Rigid Smooth-Wall Nonmetallic Conduit: 3/4 inch, unless otherwise noted.

B. Construction: Schedule 40 and Schedule 80 rigid polyvinyl chloride (PVC), UL labeled for 90°C.

C. Fittings and Conduit Bodies: NEMA TC 3; sleeve type suitable for and manufactured especially for use with the conduit by the conduit manufacturer.

D. Plastic cement for joining conduit and fittings shall be provided as recommended by the manufacturer.

| ASTM Test | Description | Values HDPE |
|---|---|---|
| D-1505 | Density g/CM 3 | less than 0.941 |
| D-1238 | Melt Index, g/10 min Condition E | greater than 0.55 grams/10 min. |
| D-638 | Tensile Strength at yield (psi) | 3000 min. |
| D-1693 | Environmental Stress Crack Resistance Condition B, F 20 | 96 hrs. |
| D-790 | Flexural Modulus, MPa (psi) | less than 80,000 |
| D-746 | Brittleness Temperature | -75°C Max |

2.7 OUTLET BOXES

A. Sheet Metal Outlet Boxes: ANSI/NEMA OS 1; galvanized steel, 16 gauge (approximately 0.0625 inches), with 1/2-inch male fixture studs where required.

B. Nonmetallic Outlet Boxes: ANSI/NEMA OS 2.

C. Cast Boxes: NEMA FB1, Type FD, Aluminum, cast feralloy, or stainless steel deep type, gasketed cover, threaded hubs.

D. Outlet boxes for luminaires to be not less than 1-1/2" deep, deeper if required by the number of wires or construction. The box shall be coordinated with surface luminaires to conceal the box from view or provide a finished trim plate.

E. Switch outlet boxes for local light control switches, dimmers and occupancy sensors shall be 4 inches square by 2-1/8 inches deep, with raised cover to fit flush with finish wall line. Multiple gang switch outlets shall consist of the required number of gang boxes appropriate to the quantity of switches comprising the gang. Where walls are plastered, provide a plaster raised cover. Where switch outlet boxes occur in exposed concrete block walls, boxes shall be installed in the block cavity with a raised square edge tile cover of sufficient depth to extend out to face of block or masonry boxes.

F. Outlet boxes for telephone substations in walls and columns shall be 4 inches square and 2-1/8 inches deep with single gang raised cover to fit flush with finished wall line equipped with flush telephone plate.

G. Wall or column receptacle outlet boxes shall be 4 inches square with raised cover to fit flush with finished wall line. Boxes in concrete block walls shall be installed the same as for switch boxes in block walls.

2.8 ECONN; ELECTRICAL CONNECTION

A. Electrical connection to equipment and motors, sized per Electrical Code. Coordinate requirements with contractor furnishing equipment or motor. Refer to specifications and general installation notes for terminations to motors.

2.9 JB; PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: ANSI/NEMA OS 1; galvanized steel.

B. Sheet metal boxes larger than 12 inches in any dimension that contain terminations or components: Continuous hinged enclosure with 1/4 turn latch and white back panel for mounting terminal blocks and electrical components.

C. Cast Metal Boxes for Outdoor and Wet Location Installations: NEMA 250; Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as raintight. Galvanized cast iron box and cover with ground flange, neoprene gasket, and stainless steel cover screws.

D. Cast Metal Boxes for Underground Installations: NEMA 250; Type 4, inside flanged, recessed cover box for flush mounting, UL listed as raintight. Galvanized cast iron box and plain cover with neoprene gasket and stainless steel cover screws.

E. Flanged type boxes shall be used where installed flush in wall.

2.10 ROUGH-IN

A. Provide with one (1) flush mount double gang box with single gang plaster ring and appropriate cover plate,

B. Conduit stubbed to above the lay-in ceiling.

C. RI-TECH; Technology Rough-in:

1. Rough-in shall have one (1) 1" conduit.

D. RI-TECH-W; Technology Rough-in - Wall Phone:

1. Mount on wall +54" or as noted in plans. Rough-in shall have one (1) 1" conduit.

E. RI-TECH-C; Technology Rough-in - Ceiling Flush Mounted:

1. Mount flush in finished ceiling or as noted in plans. Rough-in shall have one (1) 1" conduit.

F. RI-TV; Television Antenna Outlet Box Rough-in:

1. Rough-in shall have one (1) 3/4" conduit.

2.11 HANDHOLES

A. HH-#; Handhole, concrete traffic box and galvanized steel checkered cover. Stainless steel hardware. Bolted cover and box rated for H/20 vehicular traffic. Reinforced concrete slab for bottom. 11"W, 18"L, 24"D or dimensions as shown on plans.

1. Manufacturer:

    a. Oldcastle Precast B1017 Box

2.12 ACCESSORIES

A. Fire Rated Moldable Pads: UL #9700, moldable sheet putty at required thickness on all five sides of back boxes. Kinetics Noise Control - IsoBacker Pad, SpecSeal - SSP Putty and Pads, 3M #MPP-4S or equal.

B. Sound Barrier Insulation Pads: Mastic, non-hardening, sheet material, minimum 1/8" thickness applied to all five sides of back boxes. Kinetics Noise Control - SealTight Backer Pad, L.H. DOTTIE Co., #68 or equal.

PART 3 - EXECUTION

3.1 CONDUIT INSTALLATION SCHEDULE AND SIZING

A. In the event the location of conduit installation represents conflicting installation requirements as specified in the following schedule, a clarification shall be obtained from the Architect/Engineer. If this Contractor is unable to obtain a clarification as outlined above, concealed rigid galvanized steel conduit installed per these specifications and the Electrical Code shall be required.

B. Installation Schedule: Refer to drawings.

C. Size conduit as shown on the drawings and specifications. Where not indicated in the contract documents, conduit size shall be according to the Electrical Code. Conduit and conductor sizing shall be coordinated to limit conductor fill to less than 40%, maintain conductor ampere capacity as required by the Electrical Code (to include enlarged conductors due to temperature and quantity derating values) and to prevent excessive voltage drop and pulling tension due to long conduit/conductor lengths.

D. Minimum Conduit Size (Unless Noted Otherwise):

1. Above Grade: 3/4 inch. (The use of 1/2 inch would be allowed for installation conduit to individual light switches, individual receptacles and individual fixture whips from junction box.)
2. Below Grade 5' or less from Building Foundation: 1 inch.
3. Below Grade More than 5' from Building Foundation: 1 inch.
4. Telecommunication Conduit: 1 inch.
5. Controls Conduit: 3/4 inch.

E. Conduit Embedded in Slabs above Grade:

1. Embedded installation NOT allowed in elevated slabs with metal composite decks nor structural pour in place slabs less than 6 inches in depth unless specifically noted or shown on drawings otherwise.
2. Maximum size 1-1/4 inch for conduits crossing each other.

F. Conduit sizes shall change only at the entrance or exit to a junction box, unless specifically noted on the drawings.

3.2 CONDUIT ARRANGEMENT

A. In general, conduit shall be installed concealed in walls, in finished spaces and where possible or practical, or as noted otherwise. Conduit shall be installed parallel or perpendicular to walls, ceilings, and exposed structural members. In unfinished spaces, mechanical and utility areas, conduit may run either concealed or exposed as conditions dictate and as practical unless noted otherwise on drawings. Installation shall maintain headroom in exposed vicinities of pedestrian or vehicular traffic.

B. Exposed conduit on exterior walls or above roof will not be allowed without prior written approval of Architect/Engineer. A drawing of the proposed routing and a photo of the location shall be submitted 14 days prior to start of conduit rough-in. Routing shall be shown on coordination drawings.

C. Conduit arrangement in elevated slabs (restricted to applications specifically noted or shown on drawings):

1. Conduit size shall not exceed one-third of the structural slab thickness. Place conduit between the top and bottom reinforcing with a minimum of 3" concrete cover.
2. Parallel conduits shall be spaced at least 8 inches apart. Exception: Within 18 inches of commonly served floor boxes, junction boxes, or similar floor devices. Arrange conduits parallel or perpendicular to building lines and walls.

D. Conduit shall not share the same cell as structural reinforcement in masonry walls.

E. Conduit runs shall be routed as shown on large scale drawings. Conduit routing on drawings scaled 1/4"=1'-0" or less shall be considered diagrammatic, unless noted otherwise. The correct routing, when shown diagrammatically shall be chosen by the Contractor based on information in the contract documents, in accordance with manufacturer's written instructions, applicable codes, the NECA's "Standard of Installation", in accordance with recognized industry standards, and coordinated with other contractors.

F. Contractor shall adapt Contractor's work to the job conditions and make such changes as required and permitted by the Architect/Engineer, such as moving to clear beams and joists, adjusting at columns, avoiding interference with windows, etc., to permit the proper installation of other mechanical and/or electrical equipment.

G. Contractor shall cooperate with all contractors on the project. Contractor shall obtain details of other contractor's work to ensure fit and avoid conflict. Any expense due to the failure of This Contractor to do so shall be paid for in full by Contractor. The other trades involved as directed by the Architect/Engineer shall perform the repair of work damaged as a result of neglect or error by This Contractor. The resultant costs shall be borne by This Contractor.

3.3 CONDUIT SUPPORT

A. Conduit runs installed above a suspended ceiling shall be properly supported. In no case shall conduit rest on the suspended ceiling construction, nor utilize ceiling support system for conduit support.

1. Support wire used to independently support raceway and wiring systems above suspending ceilings shall be supported on both ends, minimum 12 gauge suspended ceiling support wire, and distinguishable from ceiling support systems by color (field paint), tagging, or equivalent means.

B. Conduit shall not be supported from ductwork, water, sprinkler piping, or other non-structural members, unless approved by the Architect/Engineer. All supports shall be from structural slabs, walls, structural members, and bar joists, and coordinated with all other applicable contractors, unless noted otherwise.

C. Conduit shall be held in place by the correct size of galvanized one-hole conduit clamps, two-hole conduit straps, patented support devices, clamp back conduit hangers, or by other means if called for on the drawings.

D. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

E. Spring-steel conduit clips specifically designed for supporting single conduits or tubing may be used in lieu of malleable-iron hangers for 1-1/2" and smaller raceways serving lighting and receptacle branch circuits above accessible ceilings and for securing raceways to slotted channel and angle supports.

F. Group conduits in parallel runs where practical and use conduit racks or trapeze hangers constructed of steel channel, suspended with threaded solid rods or wall mounted from metal channels with conduit straps or clamps. Provide space in each rack or trapeze for 25% additional conduits.

G. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Supports for metallic conduit shall be no greater than 10 feet. A smaller interval may be used if necessitated by building construction, but in no event shall support spans exceed the Electrical Code requirements. Conduit shall be securely fastened within 3 feet of each outlet box, junction box, device box, cabinet, or fitting.

J. Supports of flexible conduit shall be within 12 inches of each outlet box, junction box, device box, cabinet, or fitting and at intervals not to exceed 4.5 feet.

K. Supports for non-metallic conduit shall be at sufficiently close intervals to eliminate any sag in the conduit. The manufacturer's recommendations shall be followed, but in no event shall support spans exceed the Electrical Code requirements.

L. Where conduit is to be installed in poured concrete floors or walls, provide concrete-tight conduit inserts securely fastened to forms to prevent conduit misplacement.

M. Finish:

1. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.
2. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1" of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6'-6" of finish floor and presents potential injury to personnel.

3.4 CONDUIT INSTALLATION

A. Conduit Connections:

1. Shorter than standard conduit lengths shall be cut square using industry standards. The ends of all conduits cut shall be reamed or otherwise finished to remove all rough edges.
2. Metallic conduit connections in slab on grade installation shall be sealed and one coat of rust inhibitor primer applied after the connection is made.
3. Where conduits with tapered threads cannot be coupled with standard couplings, then approved split or Erickson couplings shall be used. Running threads will not be permitted.
4. Install expansion/deflection joints where conduit crosses structure expansion/seismic joints.

B. Conduit terminations for all low voltage wiring shall have nylon bushings installed on each end of every conduit run.

C. Conduit Bends:

1. Use a hydraulic one-shot conduit bender or factory elbows for bends in conduit 2" in size or larger. All steel conduit bending shall be done cold; no heating of steel conduit shall be permitted.
2. All bends of rigid polyvinyl chloride conduit (PVC) shall be made with the manufacturer's approved bending equipment. The use of spot heating devices will not be permitted (i.e. blow torches).
3. A run of conduit shall not contain more than the equivalent of four (4) quarter bends (360°), including those bends located immediately at the outlet or body.
4. Telecommunications conduits shall have no more than two (2) 90-degree bends between pull points and contain no continuous sections longer than 100 feet. Insert pull points or pull boxes for conduits exceeding 100 feet in length.

a. A third bend is acceptable if:

1) The total run is not longer than (33) feet.
2) The conduit size is increased to the next trade size.

5. Telecommunications pull boxes shall not be used in lieu of a bend. Align conduits that enter the pull box from opposite ends with each other. Pull box size shall be twelve (12) times the diameter of the largest conduit. Slip sleeves or gutters can be used in place of a pull box.
6. Telecommunications Conduit(s): Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of less than 2", maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter 2" or greater, maintain a bend radius of at least 10 times the internal diameter.
7. Rigid polyvinyl chloride conduit (PVC) runs longer than 100 feet or runs which have more than two 90° equivalent bends (regardless of length) shall use rigid metal or RTRC factory elbows for bends.
8. Use conduit bodies to make sharp changes in direction (i.e. around beams).

D. Conduit Placement:

1. Conduit shall be mechanically continuous from source of current to all outlets. Conduit shall be electrically continuous from source of current to all outlets, unless a properly sized grounding conductor is routed within the conduit. All metallic conduits shall be bonded per the Electrical Code.
2. Route exposed conduit and conduit above suspended ceilings (accessible or not) parallel/perpendicular to the building structural lines, and as close to building structure as possible. Wherever possible, route horizontal conduit runs above water and steam piping.
3. Route conduit through roof openings provided for piping and ductwork where possible. If not provided or routing through provided openings is not possible, route through roof jack with pitch pocket. Coordinate roof penetrations with other trades.
4. Conduits, raceway, and boxes shall not be installed in concealed locations in metal deck roofing or less than 1.5" below bottom of roof decking.
5. Avoid moisture traps where possible. Where unavoidable, provide a junction box with drain fitting at conduit low point.
6. All conduits through walls shall be grouted or sealed into openings. Where conduit penetrates firewalls and floors, seal with a UL listed sealant. Seal penetrations with intumescent caulk, putty, or sheet installed per manufacturer's recommendations. All materials used to seal penetrations of firewalls and floors shall be tested and certified as a system per ASTM E814 Standard for fire tests or through-penetration fire stops as manufactured by 3M or approved equal; refer to Section 26 05 03 for through penetration firestopping requirements.
7. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL OPENINGS REQUIRED IN MASONRY OR EXTERIOR WALLS UNDER THIS DIVISION. A QUALIFIED MASON AT THE EXPENSE OF THIS CONTRACTOR SHALL REPAIR ALL OPENINGS TO MATCH EXISTING CONDITIONS.

8. Seal interior of conduit at exterior entries, air handling units, coolers/freezers, etc., and where the temperature differential can potentially be greater than 20°F, to prevent moisture penetration. Seal shall be placed where conduit enters warm space. Conduit seal fitting shall be a drain/seal, with sealing compound, identified for use with cable and raceway system, equal to O-Z/Gedney type EYD.
9. Horizontal conduit routing through slabs above grade

    a. Conduits, if run in concrete structure, shall be in middle one-third of slab thickness, and leave at least 3" min. concrete cover. Conduits shall run parallel to each other and spaced at least 8" apart centerline to centerline. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement. Maximum conduit outside diameter 1".
    b. No conduits are allowed in concrete on metal deck unless expressly approved in writing by the Structural Engineer.
    c. No conduits are allowed to be routed horizontally through slabs above grade.

10. Do not route conduits across each other in slabs on grade.
11. Rigid polyvinyl chloride conduit (PVC) shall be installed when material surface temperatures and ambient temperature are greater than 40°F.
12. Where rigid polyvinyl chloride conduit (PVC) is used below grade, in a slab, below a slab, etc., a transition to rigid galvanized steel or PVC-coated steel conduit shall be installed before conduit exits earth. The metallic conduit shall extend a minimum of 6" into the surface concealing the non-metallic conduit.
13. Contractor shall provide suitable mechanical protection around all conduits stubbed out from floors, walls or ceilings during construction to prevent bending or damaging of stubs due to carelessness with construction equipment.
14. Contractor shall provide a polypropylene pull cord with 2000 lbs. tensile strength in each empty conduit (indoor and outdoor), except in sleeves and nipples.
15. Telecommunications conduits that protrude through the structural floor shall be installed 1 to 3" above finished floor (AFF).
16. Telecommunications conduits that enter into Telecommunications rooms below the finished ceiling shall terminate a minimum of 4" below ceiling and as close to the wall as possible.
17. Telecommunications conduits that are below grade and enter into a building shall terminate a minimum of 4" above finished floor (AFF) and as close to the wall as possible.

## 3.5 CONDUIT TERMINATIONS

A. Where conduit bonding is indicated or required in the contract documents, the bushings shall be a grounding type sized for the conduit and ground bonding conductor as manufactured by O-Z/Gedney, Appleton, Thomas & Betts, Burndy, Regal, Orbit Industries or approved equal.

B. Conduits with termination fittings shall be threaded for one (1) lock nut on the outside and one (1) lock nut and bushing on the inside of each box.

C. Where conduits terminate in boxes with knockouts, they shall be secured to the boxes with lock nuts and provided with approved screw type tinned iron bushings or fittings with plastic inserts.

D. Where conduits terminate in boxes, fittings, or bodies with threaded openings, they shall be tightly screwed against the shoulder portion of the threaded openings.

E. Conduit terminations to all motors shall be made with flexible metallic conduit (FMC), unless noted otherwise. Final connections to roof exhaust fans, or other exterior motors and motors in damp or wet locations shall be made with liquidtight flexible metallic conduit (LFMC). Motors in hazardous areas, as defined in the Electrical Code, shall be connected using flexible conduit rated for the environment. Flexible conduit shall not exceed 6' in length. Route equipment ground conductors from circuit ground to motor ground terminal through flexible conduit.

F. Rigid polyvinyl chloride conduit (PVC) shall be terminated using fittings and bodies produced by the manufacturer of the conduit, unless noted otherwise. Prepare conduit as per manufacturer's recommendations before joining. All joints shall be solvent welded by applying full even coat of plastic cement to the entire areas that will be joined. Turn the conduit at least a quarter to one half turn in the fitting and let the joint cure for 1-hour minimum or as per the manufacturer's recommendations.

G. All conduit ends shall be sealed with plastic immediately after installation to prevent the entrance of any foreign matter during construction. The seals shall be removed and the conduits blown clear of all foreign matter prior to any wires or pull cords being installed.

3.6 RIGID POLYVINYL CHLORIDE CONDUIT (PVC) OVERHEAD CONDUIT INSTALLATION

A. Conduit shall be installed away from high temperature piping and equipment.

B. Conduit shall be installed to prevent exposure to ultraviolet radiation.

C. Proper allowances shall be made for expansion and/or contraction of the conduit during installation.

D. Expansion fittings shall be installed in any 100' continuous run of conduit and at each 100' thereafter.

E. Supports shall be made from non-corroding materials and spacing shall not be greater than the listing in the Electrical Code, but also shall not exceed the manufacturer's recommendations depending on the expected surface temperature.

3.7 UNDERGROUND CONDUIT INSTALLATION

A. Conduit Connections:

1. Conduit joints in a multiple conduit run shall be staggered at least one foot apart.

B. Conduit Bends (Lateral):

1. Conduits shall have long sweep radius elbows instead of standard elbows wherever special bends are indicated and noted on the drawings, or as required by the manufacturer of the equipment or system being served.
2. Telecommunications conduit bend radius shall be six times the diameter for conduits under 2" and ten times the diameter for conduits over 2". Where long cable runs are involved, sidewall pressures may require larger radius bends. Coordinate with Architect/Engineer prior to conduit installation to determine bend radius.

C. Conduit Elbows (vertical):

1. Minimum metal or RTRC elbow radiuses shall be 30 inches for primary conduits (greater than 600V) and 18 inches for secondary conduits (less than 600V). Increase radius, as required, based on pulling tension calculation requirements.

D. Expansion Fittings at Finished Grade: Provide underground raceways with an expansion fitting after emerging from finished grade and exterior equipment pads. Field locate the expansion fitting above and within 24 inches of finished grade. Raceways extending less than 12 inches above finished grade, transitioning to LFMC within 12 inches of finished grade, and interior concrete building slabs do not require an expansion fitting unless required by code.

E. Conduit Placement:

1. Conduit runs shall be pitched a minimum of 4" per 100 feet to drain toward the terminations. Duct runs shall be installed deeper than the minimum wherever required to avoid any conflicts with existing or new piping, tunnels, etc.
2. For parallel runs, use suitable separators and chairs installed not greater than 4' on centers. Band conduit together with suitable banding devices. Securely anchor conduit to prevent movement during concrete placement or backfilling.
3. Where concrete is required, the materials for concreting shall be thoroughly mixed to a minimum f'c = 2500 and immediately placed in the trench around the conduits. No concrete that has been allowed to partially set shall be used.
4. Before the Contractor pulls any cables into the conduit, Contractor shall have a mandrel 1/4" smaller than the conduit inside diameter pulled through each conduit and if any concrete or obstructions are found, the Contractor shall remove them and clear the conduit. Spare conduit shall also be cleared of all obstructions.
5. Conduit terminations in manholes, masonry pull boxes, or masonry walls shall be with malleable iron end bell fittings.
6. All spare conduits not terminated in a covered enclosure shall have its terminations plugged as described above.
7. Ductbanks and conduit shall be installed a minimum of 24" below finished grade, unless otherwise noted on the drawings or elsewhere in these specifications.
8. All non-metallic conduit installed underground outside of a slab shall be rigid.

F. Horizontal Directional Drilling:

1. Entire drill path shall be accurately surveyed, with entry and exit stakes placed and coordinated with other contractors. If using a magnetic guidance system, entire drill path shall be surveyed for any surface geo-magnetic variations or anomalies.
2. Any utility locates within 20 feet of the bore path shall have the exact location physically verified by hand digging or vacuum excavation. Restore inspection holes to original condition after verification.

G. Raceway Seal:

1. Where a raceway enters a building or structure, it shall be sealed with a sealing bushing or duct seal to prevent the entry of liquids or gases. Seal must be compatible with conductors and raceway system. Spare or unused raceway shall also be sealed.
2. All telecommunications conduits and innerducts, including those containing cables, shall be plugged at the building and vault with "JackMoon" or equivalent duct seal, capable of withstanding a 10-foot head of water (5 PSI).
3. Duct Seal Alternative Option: Inflatable duct seal system. Capable of withstanding a 10-foot head of water (5 PSEI).

a. Manufacturers:

1) Raychem Rayflate Duct Sealing Systems RDSS
2) Approved equal

3.8 BOX INSTALLATION SCHEDULE

A. Galvanized steel boxes may be used in:

1. Concealed interior locations above ceilings and in hollow studded partitions.
2. Exposed interior locations in mechanical rooms and in rooms without ceilings; higher than 8' above the highest platform level.
3. Direct contact with concrete except slab on grade.
4. Recessed in stud wall of kitchens and laundries.

B. Cast boxes shall be used in:

1. Exterior locations.
2. Hazardous locations.
3. Exposed interior locations within 8' of the highest platform level.
4. Direct contact with earth.
5. Direct contact with concrete in slab on grade.
6. Wet locations.
7. Kitchens and laundries when exposed on wall surface.

3.9 COORDINATION OF BOX LOCATIONS

A. Provide electrical boxes as shown on the drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.

B. Electrical box locations shown on the Contract Drawings are approximate, unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

C. Locate and install boxes to allow access. Avoid interferences with ductwork, piping, structure, equipment, etc. Recessed luminaires shall not be used as access to outlet, pull, and junction boxes. Where installation is inaccessible, provide access doors. Coordinate locations and sizes of required access doors with the Architect/Engineer and General Contractor.

D. Locate and install to maintain headroom and to present a neat appearance.

E. Coordinate locations with Heating Contractor to avoid baseboard radiation cabinets.

3.10 OUTLET BOX INSTALLATION

A. Do not install boxes back-to-back in walls.

1. Provide a minimum horizontal separation of 6 inches between boxes installed on opposite sides of non-rated stud walls. When the minimum separation cannot be maintained, install sound insulation pads on all five sides of the back box in accordance with the manufacturer's instructions.
2. Provide a minimum horizontal separation of 24 inches between boxes installed on opposite sides of fire-rated walls. When the minimum separation cannot be maintained, the box is greater than 16 square inches or the total box area (all trades) per 100 square feet is greater than or equal to 100 square inches, install fire-rated moldable pads to all five sides of the back box to maintain the fire rating of the wall. Install moldable pads in accordance with UL listing for the specific product. Sound insulation pads are not acceptable for use in fire-rated wall applications unless the product carries the necessary fire rating.

B. Install sound insulation pads on all five sides of the back of all boxes in sound-rated wall assemblies. Sound-rated wall assemblies are defined as partition types carrying a Sound Transmission Class (STC) rating.

C. The Contractor shall anchor switch and outlet box to wall construction so that it is flush with the finished masonry, paneling, drywall, plaster, etc. The Contractor shall check the boxes as the finish wall surface is being installed to assure that the box is flush. (Provide plaster rings as necessary.)

D. Mount at heights shown or noted on the drawings or as generally accepted if not specifically noted.

E. Locate boxes in masonry walls to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat openings for boxes.

F. Provide knockout closures for unused openings.

G. Support boxes independently of conduit.

H. Use multiple-gang boxes where more than one device is mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.

I. Install boxes in walls without damaging wall insulation.

J. Coordinate mounting heights and locations of outlets mounted above counters, benches, backsplashes, and below baseboard radiation.

K. Position outlets to locate luminaires as shown on reflected ceiling drawings.

L. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioned to allow for surface finish thickness. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.

M. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

N. Provide cast outlet boxes in exterior locations and wet locations, and where exposed rigid or intermediate conduit is used.

3.11 PULL AND JUNCTION BOX INSTALLATION

A. Locate pull boxes and junction boxes above accessible ceilings or in unfinished areas.

B. Support pull and junction boxes independent of conduit.

C. Do not install boxes back-to-back in walls.

1. Provide a minimum horizontal separation of 6 inches between boxes installed on opposite sides of non-rated stud walls. When the minimum separation cannot be maintained, install sound insulation pads on all five sides of the back box in accordance with the manufacturer's instructions.
2. Provide a minimum horizontal separation of 24 inches between boxes installed on opposite sides of fire-rated walls. When the minimum separation cannot be maintained, the box is greater than 16 square inches or the total box area (all trades) per 100 square feet is greater than or equal to 100 square inches, install fire-rated moldable pads to all five sides of the back box to maintain the fire rating of the wall. Install moldable pads in accordance with UL listing for the specific product. Sound insulation pads are not acceptable for use in fire-rated wall applications unless the product carries the necessary fire rating.

D. Install sound insulation pads on all five sides of the back of all boxes in sound-rated wall assemblies. Sound-rated wall assemblies are defined as partition types carrying a Sound Transmission Class (STC) rating.

3.12 EXPOSED BOX INSTALLATION

A. Boxes shall be secured to the building structure with proper size screws, bolts, hanger rods, or structural steel elements.

B. On brick, block and concrete walls or ceilings, exposed boxes shall be supported with no less than two (2) Ackerman-Johnson, Paine, Phillips, or approved equal screw anchors or expansion shields and round head machine screws. Cast boxes shall not be drilled.

C. On steel structures, exposed boxes shall be supported to the steel member by drilling and tapping the member and fastening the boxes by means of round head machine screws.

D. Boxes may be supported on steel members by APPROVED beam clamps if conduit is supported by beam clamps.

E. Boxes shall be fastened to wood structures by means of a minimum of two (2) wood screws adequately large and long to properly support. (Quantity depends on size of box.)

F. Wood, plastic, or fiber plugs shall not be used for fastenings.

G. Explosive devices shall not be used unless specifically allowed.

END OF SECTION

SECTION 26 05 48 - SEISMIC REQUIREMENTS FOR EQUIPMENT AND SUPPORTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Seismic Requirements.

1.2 QUALITY ASSURANCE

A. General:

1. The contractor shall retain a specialty consultant or equipment manufacturer to develop a seismic restraint and support system and perform seismic calculations in accordance with these specifications, state, and local codes.
2. Items used for seismic restraint of equipment and systems shall be specifically manufactured for seismic restraint.
3. These requirements are beyond those listed in Section 26 05 27 of these specifications. Where a conflict arises between the seismic requirements of this section and any other section, the Architect/Engineer shall be immediately notified for direction to proceed.

B. Manufacturer:

1. System Supports/Restraints: Company specializing in the manufacture of products specified in this Section.
2. Equipment: Each company providing equipment that must meet seismic requirements shall provide certification included in project submittals the equipment supplied for the project meets or exceeds the seismic requirements of the project.

C. Testing Agency: An independent testing agency, acceptable to Authorities Having Jurisdiction, with experience and capability to conduct the testing indicated.

D. Installer: Company specializing in performing the work of this Section.

1.3 REFERENCES

A. International Building Code, 2021.

B. California Building Code (CBC)

C. ASHRAE - A Practical Guide to Seismic Restraint.

D. ASCE 7-02, Chapter 9.

E. ASCE 7-05, Chapter 13.

F. ASCE 7-10, Chapter 13.

G. ASCE 7-16, Chapter 13.

1.4 SUBMITTALS

A. Submit under provisions of Section 26 05 00.

B. Submittal to Code Official:

1. Contractor shall submit copies of the seismic shop drawings to the governing code authority for approval.

C. Shop Drawings:

1. Calculations, restraint selections, and installation details shall be designed and sealed by a Professional Structural Engineer licensed in the state where the project is located experienced in seismic restraint design and installation.
2. Coordination Drawings: Plans and sections drawn to scale, coordinating seismic bracing of electrical components with other systems and equipment in the vicinity, including other seismic restraints.
3. Manufacturer's Certifications: Professional Structural Engineer licensed in the state where the project is located shall review and approve manufacturer's certifications of compliance.
4. System Supports/Restraints - Submit for each condition requiring seismic bracing:

    a. Calculations for each seismic brace and detail utilized on the project.
    b. Plan drawings showing locations and types of seismic braces on contractor fabrication/installation drawings.
    c. Cross-reference between details and plan drawings to indicate exactly which brace is being installed at each location. Details provided are to clearly indicate attachments to structure, correctly representing the fastening requirements of bracing.
    d. Clear indication of brace design forces and maximum potential component forces at attachment points to building structure for confirmation of acceptability by the Structural Engineer of Record.

5. Equipment - Submit for each piece of equipment supplied:

    a. Certification that the equipment supplied for the project meets or exceeds the seismic requirements specified. Equipment certification is to be provided by the manufacturer
    b. Specific details of seismic design features of equipment and maximum seismic loads imparted to the structural support.
    c. Engineering calculations and details for equipment anchorage and support structure.

D. State of California HCAI:

1. The State of California requires certain equipment and components installed for this project to have special seismic certification. The Contractor and vendor shall provide the special seismic certification per HCAI CAN 2-1708A.5.
2. Seismic restraint calculations or HCAI pre-approved seismic restraint tables (ISAT or equivalent) HCAI series OPM pre-approval shall be provided. Calculations shall include restraint selections and installation details. Utilize ICC approved seismic brackets for suspended utilities.
3. Seismic restraint design shall be sealed by a Structural Engineer licensed in the State of California. The Structural Engineer / vendor shall be HCAI certified and include a copy of certification with submittals. Calculations shall substantiate equipment mountings and foundations and their seismic restraints can meet the required external forces, "G", load for all rigidly and resiliently supported equipment without failure and permanent displacement. Submit similar calculations for life safety equipment restraints for "G" loading. Restrain all resiliently mounted conduit with cable seismic bracing per HCAI series OPM pre-approval.
4. Anchor Bolts and Studs: Tabulate types and sizes, complete with report numbers and rated strength in tension and shear as evaluated by ICBO Evaluation Services.

E. A seismic restraint designer shall be provided whether or not exceptions listed in the applicable building code are met. If seismic restraints are not provided for a system that requires seismic bracing, the seismic designer shall submit a signed and sealed letter to the Architect/Engineer and Authorities Having Jurisdiction stating the exceptions, along with code reference, utilized for each item. Seismic designer shall review system installation for general conformance to the exception requirements stated in the code and document, in writing, the system has been installed in accordance to the exception.

1.5 TESTING AND INSPECTION

A. Special Inspection and Testing shall be done in accordance with Chapter 17 of the International Building Code.

B. The Contractor shall employ a Special Inspection Agency to perform the duties and responsibilities specified in Section 1704 and 1705.

C. Work performed on the premises of a fabricator approved by the building official need not be tested and inspected. The fabricator shall submit a certificate of compliance that the work has been performed in accordance with the approved plans and specifications to the building official and the Architect and Engineer of Record.

D. The Special Inspection Agency shall furnish inspection reports to the building official, the Owner, the Architect, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work. A final signed report stating whether the work requiring special inspection was, to the best of the Special Inspection Agency's knowledge, in conformance with the approved plans and specifications shall be submitted.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site. Accept material on site in factory containers and packing. Inspect for damage. Protect from damage and contamination by maintaining factory packaging until installation. Follow manufacturer's instructions for storage.

1.7 DESIGN REQUIREMENTS

A. This project is subject to the seismic bracing requirements of the International Building Code, 2021 edition.

B. This project is subject to the seismic bracing requirements of California Building Code, Health Care Access and Information (HCAI).

C. The following criteria are applicable to this project:

1. Seismic Use Group: I
2. Occupancy Category: I
3. Risk Category: I
4. Seismic Importance Factor: $I_E = 1.25$
5. Seismic Design Category: A
6. Component Amplification Factors (ap) and Component Response Modification Factors (Rp) shall be taken from Table 1621.3 in IBC 2000 for the individual equipment or system being restrained.
7. Component Importance Factors (Ip) shall be taken from Section 1621.1.6 in IBC 2000 for the individual equipment or system being restrained.
8. The total height of the structure and the height of the system to be restrained within the structure shall be determined in coordination with architectural plans and the General Contractor.

D. Forces shall be calculated with the above requirements and Equation 16-67, 68, & 69 in section 1621.1.4 of IBC 2000, unless exempted by 1621.1.1 .

E. Equipment shall meet California Building Code and ASCE 7 seismic qualification requirements in concurrence with ICC ES AC156 Acceptance Criteria for Seismic Qualification by Shake-Table Testing of Nonstructural Components and Systems.

F. All seismic anchorage and bracing shall comply with the St. Louis County Rules & Regulations on Anchorage & Sway Bracing - Mechanical, Electrical & Plumbing (MEP) System Components.

G. All seismic anchorage and bracing shall comply with FM Global Property Loss Prevention Data Sheet 1-11, Fire Following Earthquakes.

1.8 COORDINATION

A. Coordinate layout and installation of seismic bracing with building structural systems and architectural features, and with mechanical, fire-protection, electrical and other building features in the vicinity.

B. Coordinate concrete bases with building structural system.

1.9 WARRANTY

A. Provide one-year warranty on parts and labor for manufacturer defects and installation workmanship.

PART 2 - PRODUCTS

2.1 SUPPLIERS

A. Following is a partial list of manufacturer/supplier contact information for seismic restraints:

1. B-Line Systems, Inc. (800) 851-7415, www.b-line.com.
2. Unistrut Corporation http://www.unistrut.us/
3. Kinetics Noise Control (877) 457-2695, www.kineticsnoise.com.
4. Mason Industries, Inc. www.mason-ind.com.
5. Loos & Co., Inc. (800) 321-5667, www.loosnaples.com.
6. Tolco (909) 737-5599, www.tolco.com
7. ISAT 877.523.6060, www.isatsb.com
8. Vibro-Acoustics (416) 291-7371, https://virs.vibro-acoustics.com/

2.2 SEISMIC DESIGN CRITERIA

A. This section describes the requirements for seismic restraint of systems and equipment related to continued operation of the facility after a design seismic event.

B. Definitions:

1. Stay in Place:

a. All systems and equipment shall be anchored and restrained such that the anchoring system is intended not to fail and equipment and/or system components will not fall.

2. Remain Operational:

a. Requirements for "Stay in Place" listed above shall be met.
b. The following systems and associated equipment are intended not to fail externally or internally and are intended to continue operation following a seismic event:

1) Life Safety Power
2) Emergency Power System
3) Fire Alarm

2.3 SEISMIC BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS

A. General:

1. Seismic restraint designer shall coordinate all attachments with the Structural Engineer of Record; refer to submittal requirements.
2. The seismic restraint design shall be based on actual equipment data obtained from manufacturer's submittals or the manufacturer. The equipment manufacturer shall verify and provide written certification the attachment points on the equipment can accept the combination of seismic, weight, and other imposed loads.
3. Design analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
4. Analysis shall detail anchoring methods, bolt diameter, embedment, and weld length.
5. All seismic restraint devices shall be designed to accept without failure the forces calculated per the applicable building code.
6. All seismic restraints and combination isolator/restraints shall have verification of their seismic capabilities witnessed by an independent testing agency.

B. Friction from gravity loads shall not be considered resistance to seismic forces.

C. Housekeeping Pads:

1. Reinforced housekeeping pads shall be provided to handle shear, tension, and compression forces with proper reinforcement, doweling, and attachments connecting the pad to the structural slab.

2.4 SEISMIC RESTRAINT AND CONSTRUCTION OF EQUIPMENT

A. Equipment supplied for the project shall be designed to meet the requirements of lateral forces calculated using the applicable code and method described above.

B. The following is a partial list of equipment that shall be restrained and that shall be constructed to meet seismic forces described in this section:

1. Switchboards, Distribution Panelboards, Panelboards, Load Centers
2. Emergency Feeders
3. Transformers
4. Disconnect Switches
5. Magnetic, Manual, Combination Starters
6. Variable Frequency Drives
7. Automatic/Manual Transfer Switches
8. Interior Luminaires
9. Emergency Luminaires and Exit Signs
10. Emergency Power Supply
11. Engine Generator Systems
12. Fire Alarm Panel, Initiating and Notification Appliances

2.5 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoors and Damp Locations: Galvanized steel.
3. Corrosive Locations: Stainless steel.

2.6 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICC Evaluation Service or another agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type. Comply with IBC, ACI and ICC ES requirements for cracked concrete anchors.

C. Concrete Inserts: Steel-channel type.

D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM F3125, Grade A 325.

E. Welding Lugs: Comply with MSS SP-69, Type 57.

F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.7 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch cross section, formed from 0.1046-inchthick steel, with 9/16-by-7/8-inch slots at a maximum of 2 inches o.c. in webs, and flange edges turned toward web.

1. Materials for Channel: ASTM A 1011, GR 33.
2. Materials for Fittings and Accessories: ASTM A 635, ASTM A 576, or ASTM A 36.
3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.

4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.

C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.

1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
2. Wire Rope Cable: Comply with ASTM A 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to the applicable code sections and Authority Having Jurisdiction for the exact seismic restraint requirements of conduit, equipment, etc.

B. Layout of transverse and longitudinal bracing shall follow recommendations of approved design standards listed in Part 1 of this specification section.

C. All rigid floor mounted equipment shall have a resilient media between the equipment mounting hole and the anchor bolt in concrete.

D. All seismic restraint systems shall be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

E. Installation of seismic restraints shall not cause any change in position of equipment lighting or conduits resulting in stresses or misalignment.

F. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.

G. Do not install any equipment or conduit that makes rigid connections with the building unless isolation is not specified.

H. Coordinate work with all other trades to avoid rigid contact with the building. Any conflicts with other trades that will result in rigid contact with equipment or conduit due to inadequate space or other unforeseen conditions shall be brought to the Architect/Engineer's attention prior to specific equipment selection.

I. Prior to installation, bring to the Architect/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.

J. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or International Code Council approved seismic anchors for installation in concrete.

K. Cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment or conduit.

L. Cable assemblies shall be installed taut on non-isolated systems. Solid braces may be used in place of cables on rigidly attached systems only.

M. Do not install cables over sharp corners.

N. Brace support rods when necessary to accept compressive loads. Welding of compression braces to the vertical support rods is not acceptable.

O. Provide reinforced clevis bolts when required.

P. The vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not acceptable.

Q. Post-Installed anchors shall be provided to meet seismic requirements.

R. Vertical conduit risers flexibly supported to accommodate thermal motion and/or conduit vibration shall be guided to maintain conduit stability and provide horizontal seismic restraint.

S. Seismic restraints shall be mechanically attached to the system. Looping restraints around the system is not acceptable.

T. Conduit crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the conduit, equipment connections, or support connections. Conduit offsets, loops, anchors, and guides shall be installed as required to provide required motion capability and limit motion of adjacent conduit.

U. Do not brace a system to two different structures such as a wall and a ceiling.

V. Provide appropriately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire seal systems in fire-rated walls.

W. Positively attach all roof-mounted equipment to roof curbs. Positively attach all roof curbs to building structure.

X. Exposed seismic supports in occupied areas shall be guarded or covered to protect occupants.

3.2 SEISMIC RESTRAINT EXCLUSIONS

A. Refer to the applicable code sections and Authority Having Jurisdiction for allowable exclusions.

END OF SECTION

SECTION 26 05 53 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Adhesive Markings and Field Labels

B. Nameplates and Signs

C. Product Colors

1.2 REFERENCES

A. NFPA 70E - National Electrical Safety Code

B. NFPA 70 - National Electrical Code (NEC)

C. CEC California Electrical Code

D. ANSI A13.1 - Standard for Pipe Identification

E. ANSI Z535.4 - Standard for Product Safety Signs and Labels

1.3 QUALITY ASSURANCE

A. Electrical identification products shall be suitable for the environment installed. Identification labels damaged by the environment due to ultraviolet light fading, damp or wet conditions, physical damage, corrosion, or other conditions shall be replaced with labels suitable for the environment.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Division 1 Specification Sections and under provisions of Section 26 05 00.

1. Product Data for each type of product specified.
2. Schedule of nomenclature to be used for identification signs and labels for each piece of equipment including, but not limited to, the following equipment types as specified in Division 26.
3. Samples of each color, lettering style and other graphic representation required for identification materials including samples of labels and signs.
4. Identification required in this section shall apply to equipment furnished in Division 26 and any other applicable Divisions including Division 21/22/23.

PART 2 - PRODUCTS

2.1 ADHESIVE MARKINGS AND FIELD LABELS

A. Adhesive Marking Labels for Raceway: Pre-printed, flexible, self-adhesive vinyl labels with legend indicating voltage and service (Emergency, Lighting, Power, HVAC, Communications, Control, Fire).

1. Label Size as follows:

a. Raceways: Kroy or Brother labels 1-inch high by 12-inches long (minimum).

2. Color: As specified for various systems.

B. Colored Adhesive Marking Tape for banding Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch to 2 inches in width.

C. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.

D. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from -40°F to 185°F (-40°C to 85°C), type 2/2S or type 21/21S based on application. Provide ties in specified colors when used for color coding. Cable ties shall be listed and identified for the application, securement, and support.

E. Underground Plastic Markers: Bright colored continuously printed plastic ribbon tape of not less than 6 inches wide by 4 mil thick, printed legend indicating type of underground line, manufactured for direct burial service. Tape shall contain a continuous metallic wire to allow location with a metal detector.

F. Brass or Aluminum Tags: 2" (50mm) by 2" (50mm) by .05-inch metal tags with stamped legend, punched for fastener.

G. Indoor/Outdoor Number and Letters: Outdoor grade vinyl label with acrylic adhesive designed for permanent application in severe indoor and outdoor environments.

H. Text Sizes:

1. The following information shall be used for text heights, fonts, and size, unless otherwise noted.

a. Font: Normal 721 Swiss Bold
b. Adhesive Labels: 3/16 inch minimum text height
c. Vinyl / Plastic Laminate Labels: 3/4" inch minimum text height

2.2 NAMEPLATES AND SIGNS

A. Engraved, Plastic-Laminated Labels, Signs and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes. Labels shall be punched for mechanical fasteners.

B. Text Sizes:

1. The following information shall be used for text heights, fonts, and size, unless otherwise noted.

a. Text Height: 3/8 inch minimum

C. Baked-Enamel Signs for interior Use: Preprinted aluminum signs, punched, or drilled for fasteners, with colors, legend, and size required for application. Mounting ¼" grommets in corners.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396 inch galvanized-steel backing: and with colors, legend, and size required for application. Mounting 1/4" grommets in corners.

E. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

F. Fasteners for Plastic-Laminated Signs; Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.

2.3 PRODUCT COLORS

A. Adhesive Markings and Field Labels:

1. All Labels: Black letters on white face
2. Normal Power and General Labels: Black letters on white face
3. Control Labels: Black letters on white face
4. Fire Alarm: Red letters on white face
5. Emergency: Red letters on white face

B. Nameplates and Signs:

1. NORMAL POWER: Black letters on white face
2. Control Labels: Black letters on white face
3. EMERGENCY: White letters on red face
4. GROUNDING: White letters on green face.
5. CAUTION or UPS: Black letters on yellow face

C. Raceways and Conduit:

1. Provide color coded conduit as indicated below. Conduit shall be colored by the manufacturer:

a. Normal Power and General Distribution: Silver

b. Emergency Power Distribution System:

1) All Emergency: Orange
2) Legally Required Standby: Yellow
3) Optional Standby: Orange
4) Life Safety and Critical Branch: Yellow
5) Equipment Branch: Orange

c. Fire Alarm System: Red
d. Temperature Controls: Refer to mechanical cover sheet for color
e. Ground: Green
f. Low Voltage and Telephone: Purple

D. Box Covers:

1. Box covers shall be painted to correspond with system type as follows:

a. Normal Power and General: Silver

b. Fire Alarm System: Red
c. Temperature Controls: Refer to mechanical cover sheet for color

2. Box cover colors shall match conduit colors listed above.

E. Conductor Color Identification: Refer to Part 3 for additional information.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.

B. Exposed Ceilings and Finished Spaces: The project includes exposed ceilings in finished spaces. The installation of colored raceways and labeling may not be aesthetically desirable in finished spaces. The contractor shall coordinate identification requirements in exposed ceilings of finished spaces with the Architect/Engineer prior to installation and ordering of materials.

C. Electrical System Color Chart: This Contractor shall furnish and install framed 8" x 12" charts of the color-coded identification scheme used for the electrical system in all electrical rooms and next to the main fire alarm panel.

D. Install identification devices in accordance with manufacturer's written instruction and requirements of Electrical Code.

E. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work. All mounting surfaces shall be cleaned and degreased prior to identification installation.

F. Circuit Identification: Tag or label conductors as follows:

1. Multiple Power or Lighting Circuits in Same Enclosure: Where multiple branch circuits are terminated or spliced in a box or enclosure, label each conductor with source and circuit number.
2. Multiple Control Wiring and Communication/Signal Circuits in Same Enclosure: For control and communications/signal wiring, use wire/cable marking tape at terminations in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tape.
3. Match identification markings with designations used in panelboards shop drawings, Contract Documents, and similar previously established identification schemes for the facility's electrical installations.

G. Apply Danger, Warning, Caution and instruction signs as follows:

1. Install Danger, Warning, Caution or instruction signs where required by Electrical Code, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
2. 'Danger' indicates a hazardous situation which, if not avoided, will result in death or serious injury. ANSI standard red background, white letters.
3. 'Warning' indicates a hazardous situation which, if not avoided, could result in death or serious injury. ANSI standard orange background, black letters.
4. 'Caution' indicates a hazardous situation which, if not avoided, may result in minor or moderate injury. ANSI standard yellow background, black letters.
5. Emergency Operating Signs: Install, where required by Electrical Code, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect, engraved laminate signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.

H. Apply circuit/control/item designation labels of engraved plastic laminate for pushbuttons, pilot lights, alarm/signal components, and similar items, except where labeling is specified elsewhere.

I. Install labels parallel to equipment lines at locations as required and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

J. Install ARC FLASH WARNING signs on all power distribution equipment per Section 26 05 73.

K. Install ARC FLASH WARNING signs on all switchboards, switchgear, distribution panels, branch panelboards, industrial control panels, and motor control centers.

1. Sample Label:

   ! WARNING
   ARC FLASH AND SHOCK HAZARD
   APPROPRIATE PPE REQUIRED
   FAILURE TO COMPLY CAN RESULT IN DEATH OR INJURY
   REFER TO NFPA 70E

L. Circuits with more than 600V: Identify raceway and cable with "DANGER-HIGH VOLTAGE" in black letters 2 (50mm) inches high on orange background at 10'-0 foot intervals.

1. Entire floor area directly above conduits running beneath and within 12 inches of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to conduits concealed within wall.
3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in building, or concealed above suspended ceilings.

M. Selective Coordination Label: Install caution signs on all switchboards, distribution panels, panelboards, disconnects, and other equipment with selectively coordinated overcurrent protection devices. Sign at a minimum shall contain:

1. CAUTION: OVERCURRENT DEVICES IN THIS ENCLOSURE ARE SELECTIVELY COORDINATED. EQUIVALENT REPLACEMENTS AND TRIP SETTINGS ARE REQUIRED.

N. Underground Electrical Lines: For exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 (150mm) to 8 (205mm) inches below grade. A single plastic line marker is permitted when the width of the common trench does not exceed 16 inches; provide a second plastic line marker to mark each edge of the trench when 16 inches of width is exceeded. Limit line markers to direct-buried cables.

END OF SECTION

SECTION 26 05 73 - POWER SYSTEM STUDY

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. low voltage distribution system power study.

B. Short-circuit analysis and report.

C. Selective coordination analysis and report.

D. Arc-flash hazard analysis and report.

1.2 RELATED SECTIONS

A. Section 26 05 00 - Basic Electrical Requirements

B. Section 26 11 00 - Secondary Unit Substation

C. Section 26 23 00 - Low Voltage Switchgear

D. Section 26 24 13 - Switchboards

E. Section 26 24 16 - Panelboards

F. Section 26 32 13 - Packaged Engine Generator Systems

G. Section 26 36 00 - Transfer Switch

1.3 QUALITY ASSURANCE

A. Analyses shall be performed by an agent authorized by the manufacturer of equipment specified in the related specification sections.

1.4 SUBMITTALS

A. Documentation shall bear the seal/signature of the licensed Professional Engineer who performed the analysis.

B. The input for the power system study shall be based on the contract documents, with estimated conductor lengths and field investigation of existing equipment types, sizes, ratings provided by the Electrical Contractor. IMEG will provide a preliminary Power Tools for Windows project file for information, if requested.

C. Documentation of the analyses shall be submitted in a single bound electronic (PDF or equal) format and shall accompany the shop drawing submittals for equipment provided under the related work specification sections. The submittal of these related specification sections will not be reviewed without this documentation. Submit a sample arc-flash hazard label for Owner review and approval prior to printing.

D. Power system study project model shall be submitted on electronic media for review and the Owner's operating and maintenance records.

1.5 REFERENCES

A. NFPA 70 - National Electrical Code (NEC)

B. CEC California Electrical Code

C. NFPA 70E - Standard for Electrical Safety in the Workplace

D. IEEE 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations, latest version

E. ANSI Z535.4 - Products Safety Signs and Labels

1.6 SCOPE

A. Provide a power system study of the electrical system shown on the plans. The study shall include arc-fault analysis, selective coordination analysis and arc flash hazard analysis.

B. Contractor is required to provide a fully coordinated system for the normal and emergency electrical system or emergency electrical system and the associated normal side of each transfer switch and all other locations indicated on the one line diagram. Contractor shall provide overcurrent protective devices with the appropriate models, frame sizes, trip units, etc. as required to provide a selectively coordinated system.

PART 2 - PRODUCTS

2.1 POWER SYSTEM STUDY

A. Power systems study shall be completed in Power Tools for Windows (PTW) version 10 or later version or pre-approved equivalent program.

B. Power system studies including, but not limited to short-circuit analysis, selective coordination, and arc-flash analysis are inherently iterative in nature. The initial and subsequent analysis commonly requires engineering evaluation, equipment modification, setting adjustments, and revised analysis report. The power system analysis scope shall not be considered complete until all outstanding engineering, equipment and device setting solutions have been resolved and documented by a final report. The power system study vendor shall provide inclusive bid provisions for the initial, subsequent, final analysis and associated reports.

PART 3 - EXECUTION

3.1 SHORT-CIRCUIT ANALYSIS

A. Provide a complete short-circuit analysis from the utility service to and including the entire building distribution as shown on the drawings.

B. Analysis shall include the entire distribution system from the point of connection to the utility power source to the distribution panels and branch circuit panelboards.

C. Short-circuit analysis documentation shall be made in one-line diagram form showing the magnitude and location of each calculated fault. Fault current calculations shall be made at the main bus of each switchboard, distribution panel, and branch circuit panel. A summary of the fault currents available shall also be submitted and made available to the AHJ if requested.

3.2 SELECTIVE COORDINATION ANALYSIS

A. Provide a complete selective coordination analysis comparing time/current curves of the protective devices to be installed to assure coordination between main and downstream devices. Overcurrent protection devices shall be coordinated based on the maximum available fault current results of the short-circuit analysis report.

B. Provide a complete selective coordination analysis, comparing time/current curves of the protective devices to be installed to assure complete selectivity between main and downstream devices for code-required branches and branches identified on one-line drawings. Overcurrent protective devices serving the essential electrical system shall selectively coordinate for the period of time that a fault's duration extends beyond 0.01 second. Overcurrent protective devices serving the normal shall selectively coordinate for the period of time that a fault's duration extends beyond.

C. Existing Distribution, Selective Coordination, and Analysis:

1. The scope of work includes modification, replacement, adjustments, or additions of the emergency distribution system. A complete analysis and evaluation of the existing Emergency branch is required in addition to the evaluation and analysis of the new distribution system components.
2. The contractor shall provide field investigation service to collect all pertinent information required for a complete analysis and evaluation including but not limited to:

    a. Over Current Protection Device (OCPD): Manufacturer, model, ratings, and settings
    b. Feeder and Branch Circuit Conductor: Wire gauge sizes, lengths, and material type
    c. Transformers: Manufacturer, model, transformer KVA, impedance, phase, voltage, configuration
    d. Transfer Switch: Manufacturer, model, transfer switch voltage, amp rating, 3 or 4 pole configurations, switch style, short circuit withstand current rating

e. Emergency Power Supply: Manufacturer, model, power source type, voltage, amperage, ratings, fault current contribution values
f. Existing Distribution System Documentation: One line or riser diagram relationship of all distribution equipment including switchboards, switchgear, distribution panels, branch panelboards, transformers, transfer switches, emergency power supply, all line side normal and emergency power systems serving the applicable branches from the main electrical service and emergency power supply to the final branch circuit over current protection device.

D. Provide trip settings for all (selectively coordinated and non-selectively coordinated) adjustable trip over current protection devices including long time delay, long time pickup, short time delay, short time pickup, instantaneous and ground fault. Selectively coordinated branches shall be based on the selective coordination study results. Non-selective coordinated branches shall be based on the design trip ratings. Provide selective coordination between all ground fault trip settings.

E. The analysis shall include primary protective device, secondary main switchboard/switchgear device(s), switchboard/switchgear branch feeder devices, generator breaker, distribution panel, panelboard main devices, and branch feeder devices.

F. The analysis shall include all normal, critical, equipment overcurrent protection devices served by the same electrical bus and directly in parallel with the emergency branch requiring selective coordination.

G. The coordination plots provided shall indicate graphically the coordination proposed for the system on full-size log forms and shall define the types of protective devices selected, together with proposed time dial and pickup settings required. The plots shall include titles, representative one-line diagrams, legend, complete parameters for transformer(s), and complete operating bands for circuit breaker trip devices, fuses, etc.

1. The long-time region of the coordination plots shall designate the pickups required for the circuit breakers.
2. The short-time region shall indicate the magnetizing in-rush and ASA-withstand-transformer parameter, the circuit breaker, short-time and instantaneous trip devices, fuse-manufacturing tolerance bands, significant symmetrical fault currents, etc.
3. Each primary protective device required for the transformer shall be selected so the characteristics or operating band is within the transformer parameters, which shall include a parameter equivalent to 58% of the withstand point to afford protection for secondary line-to-ground faults. The transformer damage curve shall be included for the transformer when the selected protective device is not within the associated parameters.
4. Molded case circuit breakers shall be separated from each other and the associated primary protective device by a 16% current margin for coordination and protection in the event of secondary line-to-line faults.

5. Include zone selective interlocking, differential relaying, and other selective coordination technology in the study when required by other specification sections.
6. The protective device characteristics or operating bands shall be suitably indicated to reflect the actual symmetrical fault currents sensed by the device.
7. The drawings and specifications indicate the general requirements for motors, motor-starting equipment, and medium-voltage and low-voltage equipment, but additional specific requirements of equipment furnished shall be determined in accordance with the results of the coordination study.

    a. The study shall include verification of equipment ratings and settings. The Contractor shall keep the study up-to-date with any project changes which affect the study and submit the revised study for review. A final electronic copy shall be submitted with the record drawings.

H. Provide summary table of adjustable overcurrent protective devices settings for the operating and maintenance manual.

3.3 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, unit substations, motor-control centers, panelboards, busway, and splitters) where work could be performed on energized parts.

C. Safe working distances shall be based on the calculated arc flash boundary considering an incident energy of 1.2 cal/cm$^2$.

D. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit analysis and coordination study models. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

E. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared, and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

F. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3 to 5 cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

G. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

H. Include Arc Energy Reduction (AER) analysis in the study when required by other specification sections.

I. When performing incident energy calculations on the line side of a main breaker (as required per the above), the line side and load side contributions must be included in the fault calculation.

J. Miscoordination should be checked among all devices within the branch containing the immediate protective device upstream of the calculation location, and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

K. Where it is not physically possible to move outside the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

L. Create and install NFPA 70E compliant labels describing the arc flash hazard level at all switchboards, panelboards, and other locations in the electrical distribution system where work could be performed on energized parts.

M. Labels shall be vinyl or laminated, with a self-adhesive backing, conform with ANSI Z535.4 Products Safety Signs and Labels standard, and include the following:

1. Arc flash boundary
2. Available incident energy calculated in the analysis and the corresponding working distance, or the arc flash personal protective equipment (PPE category) for the equipment, but not both.

N. Examples showing the minimum required information follow:

O. A list of all hazard categories and the corresponding PPE requirements shall be posted in the main electric room, engineering office, or other location. The list shall be plastic laminate or typewritten and housed in a plastic frame.

3.4 ADJUSTMENTS

A. Manufacturer's authorized representative or Contractor shall set all adjustable protective devices to values indicated in the approved coordination study. Apply settings prior to placing equipment into operation. When the scope of work or execution includes remodel or phases construction, the contractor shall adjust applicable settings as required prior to each system component placed in operation.

B. Wherever the arc flash incident energy exceeds Arc Flash Category 2 (i.e. greater than 8 cal/cm^2), provide options for adjusting breaker trip times, if possible, to reduce energies to Category 2 or below.

3.5 TRAINING

A. Provide four hours of Owner training to explain the implications of arc-flash requirements and work permit procedure.

END OF SECTION

SECTION 26 09 13 - POWER MONITORING AND CONTROL SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Power monitoring and control system is defined to include, but is not limited to, remote devices for monitoring, control and protection communication interface hardware, inter-communications wiring, network software, printer, and personal computer workstations.

B. The system shall utilize Ethernet as the high-speed backbone network that supports direct connection of personal computer workstations anywhere on the network. Each personal computer workstation shall have equal access to information provided by the power monitoring devices for data display, data logging, alarming, event recording, and other monitoring operations.

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram for rating, location and configuration.

B. Section 26 24 13 - Switchboards

1.3 QUALITY ASSURANCE

A. Manufacturer: Company with three (3) years of experience in power measurements and controls.

1.4 REFERENCES

A. ANSI C12 - Code for Electrical Metering

B. ANSI C57.13 - Requirements for Instrument Transformers

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Provide product data showing the type, size, rating, catalog number, manufacturer's names, and/or data sheets for all items to ensure compliance with these specifications. Submit operation and programming manual.

C. Submit shop drawings of the complete layout of the entire system, showing wiring and all equipment.

1.6 REGULATORY REQUIREMENTS

A. System: UL listed.

1.7 SYSTEM DESCRIPTION

A. The power monitoring and controls (PMCS) shall consist of electronic power monitoring devices as designated on the project drawings and described herein. The system shall be capable of monitoring, displaying, logging, and communicating the true RMS measurements in this specification as a minimum level of performance. The system shall be designed so the maximum response time from an event or reading to displaying shall be 5 seconds.

B. Each personal computer workstation connected to the network shall have web-based access to information provided by the PMCS.

C. Minimum accuracy of readings shall be:

1. Frequency ± 0.01 Hz.
2. Current and voltage ± 0.5% of reading.
3. Energy ± 1% of reading.

D. The high-speed network shall allow integration of programmable logic controllers that may directly access data provided by the power monitoring devices for implementing automatic control, load shedding and curtailment.

1.8 PROJECT RECORD DOCUMENTS

A. Provide installation and maintenance manuals under provisions of Section 26 05 00. Include name, address and telephone number of service location within 100 miles of project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D - POWERLOGIC and ION Enterprise

B. Eaton Power Xpert

C. ABB

2.2 POWER MONITORING NETWORK

A. The PMCS shall be connected by means of an Ethernet high-speed backbone. The high-speed network shall consist of gateways, switches, patch cords, backbone cabling, and any required equipment.

B. Ethernet gateways or communications cards shall be provided and installed by the PMCS vendor as required. Ethernet network connections shall be established using industry standard Ethernet protocol, such as TCP/IP.

C. Wireless Ethernet and interface hardware shall be provided and installed by the PMCS vendor in Electrical Code classified areas.

D. Ethernet Gateways:

1. The Ethernet gateways shall be modular in design to allow for easy future expansion or modification of the system. Ethernet gateway shall support Ethernet UTP (10/100 Mbps). Each Ethernet gateway shall provide a web-based interface for device configuration, diagnostics, and access for users to power monitoring information from any location on a local area network (LAN) or wide area network (WAN).

E. The PMCS shall be connected by mean of the facilities Ethernet backbone. Provide Ethernet gateway or communication cards as required to connect system to network jacks installed as part of the facility's Ethernet network. Network connections shall be established using industry standard Ethernet protocol, such as TCP/IP. All components shall work with facility's Ethernet switches, router, and hub technology.

2.3 INTERFACE TO EXTERNAL SYSTEMS

A. The high-speed network utilized by the PMCS system shall permit easy interface with the Facilities Management and Control System (FMCS).

B. Data located in the power monitoring devices and PLC registers and associated inputs/outputs shall be made available to the FMCS vendor via meters and/or programmable controller register lists. Hardware and software required by the FMCS to retrieve this data from the PMCS data highway shall be the responsibility of the FMCS vendor.

2.4 POWER MONITORING DEVICES INSTALLATION

A. All metering devices, electronic trip units motor protection devices shall be installed by the equipment manufacturer for all circuits as indicated by the project drawings.

B. All control power, CT, PT, and data communications wire shall be factory wired and harnessed within the equipment enclosure. Where external circuit connections are required, terminal blocks shall be provided, and the manufacturer's drawings must clearly identify the interconnection requirements, including wire type to be used.

C. Provide control transformers, current transformers, and fused potential transformers sized as required.

2.5 POWER MONITORING DEVICE CHARACTERISTICS

A. DEM; Energy Meter:

1. The following instantaneous readings shall be monitored, displayed, and communicated by the energy meter:

a. Frequency
b. Current, per phase RMS, 3-phase average RMS, apparent RMS, peak demand
c. Voltage, phase-to-phase and phase-to-neutral

d. Power factor, per phase and 3-phase total
e. Real power (kW), 3-phase total, peak demand, cumulative (kWH)
f. Reactive power (kVAR), 3-phase total

2. The current and voltage signals shall be digitally sampled at a rate high enough to provide true-RMS sensing. All setup parameters required by the energy meter shall be stored in nonvolatile memory and retained in the event of a control power interruption. The meter shall maintain in nonvolatile memory maximum and minimum values for each of the instantaneous values reported, as well as the time and date of the highest peak for all peak demand readings.
3. The energy meter shall be equipped with a display to provide local access to all metered quantities where indicated on plans.
4. Reset of the following electrical parameters shall also be allowed from the front of the meter:

   a. Peak demand current
   b. Peak demand power
   c. Energy (MWH)
   d. Reactive energy (MVARH)

5. Manufacturers:

   a. Square D Power Logic PM5000
   b. Eaton
   c. ABB M4M Series

B. DPM; Power Meter:

1. The following instantaneous readings shall be monitored, displayed, and communicated by the power meter:

   a. Frequency, monthly maximum and minimum
   b. Current, per phase RMS, 3-phase average RMS, apparent RMS, peak demand (15-minute sliding window)
   c. Voltage, phase-to-phase and phase-to-neutral
   d. Power factor, per phase and 3-phase total
   e. Real power (kW), 3-phase total, peak demand, cumulative (kWH)
   f. Reactive power (kVAR), 3-phase total
   g. Total harmonic distortion (current and voltage)

2. The current and voltage signals shall be digitally sampled at a rate high enough to provide true-RMS sensing through the 31$^{st}$ harmonic. All setup parameters required by the power meter shall be stored in nonvolatile memory and retained in the event of a control power interruption. The meter shall maintain, in nonvolatile memory, maximum and minimum values for each of the instantaneous values reported, as well as the time and date of the highest peak for all peak demand readings.
3. The power meter shall be equipped with a display to provide local access to all metered quantities.

4. Reset of the following electrical parameters shall also be allowed from the front of the display or energy meter:

    a. Peak demand current
    b. Peak demand power
    c. Energy (MWH)
    d. Reactive energy (MVARH)

5. Waveform Capture Capability: Waveform capture shall be for three (3) cycles and initiated manually using software.
6. The data points shall be sampled in a manner that allows the original power signals with proper magnitude and phase relationships to be reconstructed. Reconstruction of the original power signal from the stored data points shall have sufficient accuracy to allow steady-state power harmonic analysis that provides valid information on harmonic content for up to the 81st harmonic of the fundamental power frequency.
7. The power meter shall have one (1) digital input and one (1) digital solid state output/KY pulse output.
8. The power meter shall be provided with a six (6) digital input and two (2) digital output (relay) output accessory card.
9. Manufacturers:

    a. Square D Power Logic
    b. Eaton
    c. ABB M4M Series

C. Transformer Temperature Monitors:

1. Transformer temperature monitors shall be provided for each dry-type and cast resin transformer shown on the project drawings.

D. Electronic Motor Protective Devices:

1. Historical operating information, such as running hours since last commissioning, number of starts/trips since last commissioning, number of overload trips/ground fault trips, and similar data, shall be displayed on the front of the device and be available via data communications to programmable logic controllers and personal computer workstations throughout the PMCS network for control, alarming, etc.
2. The motor protective devices shall provide fault diagnosis data such as pre-trip motor and ground fault currents, unbalance ratio, and maximum stator RTD temperature.

## 2.6 SYSTEM DISPLAY UNITS

A. System display units shall be provided to display the data available from selected electronic trip units connected on the individual data transfer network.

B. The system display unit shall utilize a 4 line by 20 character, high contrast display with backlighting. The level of backlighting as well as the contrast shall be adjustable.

C. The system display shall be equipped with a screen saver feature to extend the life of the display.

D. Data shall be displayed in a logically organized manner, complete with the proper scaling and units.

E. The system display unit shall allow for easy operation by providing a keypad with large keys for operator selections. The keys shall have a raised perimeter and tactile feedback to provide a positive response, even with gloved-hand operation.

F. The keys shall be clearly marked to indicate the function and separated into meaningful groups, with display prompting to assist the user in operation.

G. Each system display unit shall be configured by the manufacturer with all necessary data. It shall be possible to change the configuration for each system display unit using the keypad provided on each display. Access to configuration functions shall be password protected to prevent unauthorized or accidental modification.

H. The system display unit shall permit the reset of the stored min-max values in the power monitoring devices. It shall also permit the reset of the accumulated energy values and the time and date stamps stored in the metering devices. These resets shall be limited to authorized persons by means of password protection.

2.7 AUTOMATIC CONTROL

A. Programmable logic controllers (PLCs) that communicate with the meter devices, electronic trip units, transformer temperature monitors, motor protective devices, and other compatible devices for performing control operations shall be provided.

B. Each PLC shall include ladder programs that will direct the automatic control operations as specified.

C. Processor, input, output, and network interface cards shall be provided as necessary to implement the sensing and automatic control operations.

D. Data pertaining to the automatic control system shall be transmitted via the PMCS network to the remote personal computers.

E. At a minimum, the application software at the personal computer shall provide the following:

1. Interactive color-graphics, one-line of automatic control system (breaker status, relays status, etc.).
2. All automatic control operations (open/close breaker, relay operation, etc.) shall be date/time stamped and recorded in an event log.
3. Setup and display alarm conditions for automatic control operations shall be possible, with each alarm condition entered in the event log.

4. Manual operator intervention via the keyboard or interactive one-line graphics shall be provided such that any point in the process may be controlled. Manual intervention shall be password protected to prevent inadvertent or unauthorized override of the control scheme.
5. Protective relaying functions, anti-paralleling interlocks, or load limits shall not be defeatable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. PMCS components, including system display units, metering devices, electronic trip units, transformer temperature monitors, and electronic motor protective devices, shall be installed by the manufacturer, and wired and tested in the equipment as indicated on the drawings. All control power, CT, PT, and data communications wire shall be factory wired and harnessed within the equipment enclosure.

B. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements, including wire type to be used.

C. All wiring required to externally connect equipment lineups shall be installed by the Electrical Contractor.

3.2 COMMISSIONING

A. Power Monitoring and Control Systems shall be commissioned by architect/engineer.

B. The contractor shall provide provisions to administrate and support the commissioning process. Refer to the commissioning plan specifications for additional requirements. The commissioning plan documents and requirements shall be developed in reference to approved shop drawings, published manufacturer installation and startup information, and the custom project requirements by the commissioning agent. The commissioning documents and requirements shall be available to the contractor post bid and prior to commissioning commencement.

C. Witness Testing: Provide written notification a minimum of two weeks prior to commencing any final system commissioning. The Architect/Engineer, owner, and Authority Having Jurisdiction shall provide witness testing of the commissioning process.

END OF SECTION

SECTION 26 09 16 - ELECTRICAL CONTROLS AND RELAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Relays and Timers

B. Control Power Cabinets

PART 2 - PRODUCTS

2.1 CONTROL RELAYS

A. Mount relays in separate NEMA 1 4 enclosure or in control terminal cabinet.

B. R-Insert##; Power Relay:

1. Visible contacts, coil burden less than 10 V.A. Insert24 volt A.C. coil, 600-volt A.C. contacts, 2 normally open contacts, 30-amp continuous contacts electrically held.
2. Manufacturers:

a. Square D Type C Class 8501 CO Insert
b. Eaton
c. ABB

2.2 CONTROL POWER CABINET (CPC)

A. Provide a 12"x8"x4" screw cover NEMA 1 enclosure, single pole specification grade 20-amp switch in a single gang box, fuse block, fuses and equipment for interface of temperature control system. Mount above accessible ceiling. Insert

B. Manufacturers:

1. Enclosure - Hoffman A-SE12X8X4, Weigmann, Hammond Manufacturing

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with Mechanical Division 23 in connection of control conduit into control terminal cabinet.

B. Install line voltage thermostats for single phase motors. Provided by Division 21/22/23.

C. Provide remote control connection to remote devices.

END OF SECTION

SECTION 26 09 33 - LIGHTING CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Line and low voltage standalone lighting controls

B. Automatic load control relay (ALCR20)

C. Distributed lighting control

D. Time switches

1.2 RELATED SECTIONS

A. The lighting system design includes a combination of luminaire sources, lighting control components, programming sequences, and supplementary components for building and energy code compliance. The design uses performance-based specifications for portions of the lighting system to account for the limitation of comparable product solutions available by competitive manufacturers. The Contractor shall reference related specification sections, plans, schedules, and details prior to submitting pricing, submittals, and installation. The Contractor shall coordinate system component compatibility among various manufacturers and suppliers for a turnkey lighting system. Referenced sections include, but are not limited to, the following:

1. 26 51 19 LED Lighting
2. 26 52 15 Emergency Lighting Inverter
3. Electrical Drawings: Plans, luminaire schedules, lighting control sequence of operations, diagrams, and details.

1.3 RELATED WORK

A. Section 23 09 00 - Control

B. Section 26 51 19 - LED Lighting

1.4 QUALITY ASSURANCE

A. Manufacturers shall be regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. All components and assemblies are to be factory pre-tested prior to delivery and installation.

C. Comply with Electrical Code as applicable to electrical wiring work.

D. Comply with applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.

E. Panels and accessory devices are to be UL listed under UL 916 Energy Management Equipment. Panels and accessories used for control of life safety and critical branch circuits shall be listed under UL 924 Emergency Lighting and Power Equipment.

F. All assemblies are to be in compliance with FCC emissions standards specified in Part 15 Subpart J for Class A applications.

1.5 REFERENCES

A. FCC Rules and Regulations, Part 15, Subpart J - Radio Frequency Interference

B. FS W S 896 Switch, Toggle

C. California Energy Code - Building Energy Efficiency Standards Title 24

D. NEMA WD 1 - General Color Requirements for Wiring Devices

E. NEMA WD 7 - Occupancy Motion Sensors

F. NFPA 70 - National Electrical Code (NEC)

G. CEC California Electrical Code

H. UL Standard 916 Energy Management Equipment

I. UL 924 - Emergency Lighting and Power Equipment

J. UL 1472 - Solid-State Dimming Controls

1.6 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Submit a comprehensive package including devices, hardware, software, product specification, finishes, dimensions, installation instructions, warranty, system software requirements, and roles and responsibilities of all persons and groups involved in installation, execution, and commissioning.

C. Provide floor plan showing location, orientation, and coverage area of each control device, sensor, and controller/interface. For areas requiring multiple sensor devices for appropriate coverage, submit specific manufacturer-approved sensor layout as an overlay directly on the project drawings, either in print or approved electronic form.

D. Submit a list of devices and equipment that will be installed for each sequence of operation.

E. Submit project specific control wiring diagrams showing all equipment, line voltage, and control wiring requirements for all components including, but not limited to, dimmers, relays, low voltage switches, occupancy sensors, control stations, dimmer panels, relay panels, and communication interfaces and programming instructions for each sequence of operation. Include network cable specification and end-of-line termination details, if required.

F. Project specific network riser diagram including floor and building level details. Illustrate points of connection to integrated systems. Coordinate integration with mechanical and/or other trades.

G. Verify acceptance of communications connection to building automation system. Submit BACnet IP parameters.

1.7 EXTRA STOCK

A. Provide extra stock under provisions of Section 26 05 00.

B. Sensors, Controls, Power Supplies, and Relays: Five (5) percent of quantity installed. Minimum of two (2) of each configuration and type.

C. Relays and Dimmer Modules: Five (5) percent of quantity installed. Minimum of two (2) of each size and type.

D. Control Stations: One (1) of each configuration and type, except for LCD touch screens requiring factory setup prior to installation.

1.8 PROJECT RECORD DOCUMENTS

A. Submit project record documents under provisions of Section 26 05 00.

B. Accurately record location of all controls and devices. Include description of switching sequences and circuiting arrangements.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit emergency, operation, and maintenance data under provisions of Section 26 05 00. Data shall also include the following:

1. Schedule for routine maintenance, inspection, and calibration of all lighting control devices and system components. Recommended schedule for inspection and recalibration of sensors.
2. Complete narrative describing intended operation and sequence for each control scenario and system component, updated to reflect all changes resulting from commissioning of systems. Narrative shall indicate recommended settings for devices where applicable.
3. Replacement part numbers for all system components.

B. Identify installed location and labeling for each luminaire controlled by automated lighting controls.

C. Submit software operating and maintenance manuals, program software backup on compact disc or compatible media with data files, device address list, and a printout of software application and graphic screens, where applicable.

1.10 SYSTEM DESCRIPTION

A. Performance Statement: This specification section and the accompanying lighting design documents describe the minimum material quality, required features, and operational requirements of the lighting control system (LCS). These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the performance required of the system, as presented in these documents, the Contractor and system manufacturer/vendor are solely responsible for determining all equipment, wiring, and programming required for a complete and operational system.

B. Provide an integrated lighting controls system consisting of panels, power supplies, controllers, sensors, relays, switches, devices, wiring, etc. necessary to perform the Lighting Control Sequence of Operation as defined on the plans and specifications. Contractor is responsible for confirming that all components and luminaires interoperate as a single system.

1. Sequence of Operation: Describes the required operation and performance for lighting control in each space. Sequences of operation are indicated on the drawings.
2. Drawings: The drawings include sequences of operation, locations of control interface devices, sensors, and control zones. Wiring and additional equipment to make a complete and functioning system has not been shown, but shall be submitted with the shop drawings.

C. The following control types and features are acceptable. Acceptable control locations are shown on the drawings.

1. Line Voltage Control: Control equipment consists of traditional line voltage wiring devices and equipment such as switches, dimmers and combination occupancy/vacancy sensor switches, etc.
2. Distributed Control: Control equipment is in the space/zone being controlled; not reliant on centralized controllers.

    a. All locations shall have the ability to be networked for remote control and monitoring, but network connections are not required.

3. Centralized Control: Control equipment is in a central location serving multiple spaces/zones and provides time-based schedule and remote control.

    a. The lighting control system (LCS) shall be networked with BACnet IP capabilities.
    b. The lighting control system (LCS) shall have DMX512 capabilities.

4. Digital Addressable Lighting Interface (DALI): DALI provides digital communications to each addressable ballast / driver or group. Lamp and device faults are sent to DALI server.
5. Wireless Control: Equipment that uses radio frequency to transmit lighting control signals.

1.11 MOCKUP

A. Provide and install luminaires with power and control connections in mockup rooms as identified in Division 1. Approved luminaires and controls in mockup may be reused as part of complete work if in original condition.

1.12 COMMISSIONING

A. Commissioning of a system or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Owner's Representative and the Commissioning Agent. Project closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Division 1 for detailed commissioning requirements.

B. The Contractor shall provide all services necessary for compliance with the IECC Section C408 Commissioning. The commissioning shall include, but not be limited to, a commissioning plan, preliminary commissioning report, construction documents, manuals, final commissioning report, and lighting system functional testing.

C. This project will have selected building systems commissioned. The Contractor is responsible to execute commissioning. The commissioning process, equipment, and systems to be commissioned are defined in Division 1. A third-party Commissioning Agent will direct the commissioning process.

D. The Contractor shall notify the Commissioning Agent, Architect/Engineer and Owner's Representative ten (10) working days prior to scheduled commissioning date.

E. The commissioning process requires meeting attendance. Refer to Division 1 for meeting requirements.

F. The system shall be functionally tested by a factory-authorized engineer and comply with the Sequence of Operation. All loads shall be tested live for continuity and freedom from defects, and all control wiring shall be tested for continuity and connections prior to energizing the system.

1.13 WARRANTY

A. Manufacturer shall warrant products under normal use and service to be free from defects in materials and workmanship for a period of two (2) years from date of commissioning.

B. Occupancy, vacancy, daylight sensors and controls shall have a five (5) year warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROLS

A. All items of material having a similar function (e.g., switches, dimmers, sensors, contactors, relays, etc.) shall be of the same manufacturer, unless specifically stated otherwise on drawings or elsewhere in the specifications. Lighting control switches, systems, and components shall be listed.

B. Color of lighting controls and sensors shall match the receptacle wiring devices specified in the space.

C. The functions described in the lighting sequence of operation shall dictate the actual lighting control device required to accomplish the functions described for the space.

2.2 DEVICE COLOR

A. All switch, lighting controls, and coverplate colors shall be the same as wiring devices, unless indicated otherwise.

2.3 COVERPLATES

A. All switches and lighting controls shall be complete with coverplates that match material and color of the wiring device coverplates in the space.

B. Where several devices are ganged together, the coverplate shall be of the ganged style for the number of devices used.

C. Install nameplate identification as indicated in Section 26 05 53.

D. Plate-securing screws shall be metal with head color matching the wall plate finish.

2.4 WALL SWITCHES

A. Refer to Electrical Symbols List for device type.

B. Switch touch surfaces shall have an antimicrobial additive that suppresses the growth of harmful bacteria, mold, mildew, and fungi. Coverplate color shall match the switch color.

1. Manufacturers:

a. Cooper 7621 CuVerro
b. Leviton A5621

C. **SW-1P**; Single Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Toggle handle, side and back wired.
2. Manufacturers:

a. Hubbell HBL1221
b. Leviton 1221-2
c. Pass & Seymour PS20AC1
d. Cooper AH1221

D. **SW-2P;** Two Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Toggle handle, side and back wired.
2. Manufacturers:

a. Hubbell HBL 1222
b. Leviton 1222-2
c. Pass & Seymour PS20AC2
d. Cooper 2222.

2.5 WALL DIMMERS

A. UL listed with integral air-gap switch for on/off control.

B. Integral EMI/RFI suppression.

C. Non-viewable heat sink.

D. Dimmer compatibility and wiring with the load being controlled shall be verified by Contractor prior to purchase and installation.

E. Dimmer to match device color.

F. **SW-D-LED;** LED Electronic Driver Dimmer:

1. 120 277-volt, decora style linear slider operator with positive off. Color to match adjacent devices. Luminaire manufacturer shall list compatible dimmer manufacturers and models. 0-10V dimmers shall comply with IEC 60629 Annex E.

G. **SW-D3-LED;** LED Electronic Driver Three-Way Dimmer:

1. 277-volt, decora style linear slider operator with positive off. Color to match adjacent devices. Luminaire manufacturer shall list compatible dimmer manufacturers and models. 0-10V dimmers shall comply with IEC 60929 Annex E.
2. Manufacturers:

a. Compatible with provided LED driver.

H. **SW-OD;** Wall 0-10V Dimmer / Occupancy sensor:

1. Wall switch with manual on/auto off. 120VAC load rating of 0-800 W for electronic ballast, LED. 277VAC load rating of 0-1,800 W for electronic ballast, LED. adjustable OFF delay. 0-10V dimming with up to 30ma sink. Automatic ON/OFF, manual ON/automatic OFF, or occupancy on to predetermined dimming level go to last dimming setting upon occupancy.
2. Manufacturers:

    a. Sensor Switch WSX D Series

2.6 LOCAL DAYLIGHTING CONTROLS

A. **SW-LS-PC;** Standalone Exterior Photo Sensors:

1. Sensor shall be within a weatherproof enclosure, with design operation in temperatures of -30°F to +130°F. Sensor shall have threaded stem for box mounting, with knuckle to permit aiming of receptor after installation. Sensor shall be mounted facing north.
2. Sensor shall contain an integral switching contactor rated for 277-volt operation, with loads of up to 1,800 VA. Contacts shall be configured for zero-crossing closure to provide 100,000 cycle minimum operation.
3. Sensor shall detect changes in daylight levels to provide triggering of exterior lighting equipment based on the sequence of operation.
4. Sensor shall be field configurable at the device or via handheld wireless remote controller. Configurable settings shall include:

    a. Ambient sensitivity range of 5 to 1,500 foot-candles.
    b. Adjustable setpoint.
    c. Deadband adjustment by percentage of setpoint.
    d. Time delay of up to five minutes.

5. Sensor shall be equipped with a lens cover that can be applied for system testing during daylight conditions.
6. Manufacturers:

    a. Tork
    b. Intermatic

2.7 INDOOR OCCUPANCY AND VACANCY SENSORS

A. Dual-Technology Type: Detect occupancy by using a combination of PIR and ultrasonic or acoustic detection methods in area of coverage. Particular technology or combination of technologies that controls on and off functions shall be selectable in the field by operating controls on unit.

1. **SW-VS-D or SW-OC-D;** 360 Degree Coverage Pattern:

a. Frequency greater than 40 KHz. Dual sensing verifications (requires both technologies to activate), either technology maintains on status. Integrated ambient light level sensor (2 to 200 FC range), adjustable sensitivity and time delay, integrated isolated relay contact. Sensor shall control all circuits in area, unless noted otherwise. Initial settings: ambient sensor 40 FC.
b. Manufacturers:

1) Watt Stopper DT 300 Series
2) Hubbell OMNI-DT2000 or ATD2000C
3) Leviton OSC##-MOW
4) Sensor Switch CM PDT 10

2. **SW-O;** Wall Switch:

a. Wall switch with manual on/auto off. 120/277 VAC load rating of 0-800 W for ballast, LED or tungsten. 5-, 15-, 30-minute adjustable OFF delay. Coverage of minor motion in 12' x 15' pattern.
b. Manufacturers:

1) Watt Stopper DW-100 Series
2) Hubbell LHMTS, Leviton OSSMT series
3) Sensor Switch WSX-PDT SA Series

3. **SW-O2;** Wall Switch:

a. Multi-relay wall switch with manual on/auto off for two separate loads. 120/277 VAC load relay rating of 0-800 W for ballast, LED or tungsten. 5-, 15-, 30-minute adjustable OFF delay. Coverage of minor motion in 12' x 15' pattern.
b. Manufacturers:

1) Watt Stopper DW-200 Series
2) Hubbell LHMTD
3) Leviton OSSMD series
4) Sensor Switch WSX-PDT 2P Series

4. Sensitivity Adjustment: Separate for each sensing technology.

B. Mask sensors where necessary to prevent nuisance switching from adjacent areas.

| Lighting Load | Load A | Load B |
|---|---|---|
| Step 1: | On | Off |
| Step 2: | Off | On |
| Step 3: | On | On |
| Step 4: | Off | Off |

2.8 DISTRIBUTED LIGHTING CONTROL

A. Manufacturers: as listed below meet the qualifications as outlined in this specification. Contractor is responsible for verifying that selected manufacturer is capable of furnishing the complete system as specified herein.

1. Acuity Controls nLight Series

B. System Description: The lighting control system shall be a network of remote modules connected to a digital network via network hubs and controlled through a system server / central station. Lighting control devices connect to the modules and communicate via the digital network with the system server. System includes all associated wiring, relay modules, photocells, switches, dimmers, time clock, occupancy sensors, network interfaces, and hubs. System shall utilize distributed relays modules, allowing these relay modules to be located above accessible ceilings in or adjacent to rooms they are controlling.

C. Control Devices: All occupancy sensors (ultrasonic, IR and dual technology type), photocells, switches, and timers shall be provided with system and designed to operate on system network. Supplemental power packs shall be provided as required for multiple control devices. This equipment shall be identified in shop drawing submission.

D. Relay Modules: Mounted in NEMA enclosure with physically separate 120/277-volt wiring compartment from low voltage control wiring. Provide low voltage digital communication to control devices as shown on drawings and schedules. Supplemental power packs shall be provided as required for multiple control devices. This equipment shall be identified in shop drawing submission. Dimmable relay modules shall be provided where indicated. Relay modules shall contain up to four (4) relays. Relay modules shall be labeled with room number that relays control lighting within.

E. Single-Pole Relays: Mechanically held unless otherwise indicated; split-coil, momentary-pulsed type, rated 20 A, 125-volt AC for tungsten filaments and 20 A, 277-volt AC for electronic ballasts, 50,000 cycles at rated capacity.

F. System shall include server / central station with operating software, data network, and BACnet IP communication with other systems as described. System communication protocol shall be compatible with the building automation system.

G. System server / central station shall provide programmable operation of lights connected via system relays and controlled with system devices. System software shall provide control of relays and control devices, time and sequence scheduling, timed out and blink light operation, and monitoring and reporting of system events and components. Initial programming shall be as shown on plans and schedules.

H. Server / Central Control Station: Lighting control system manufacturer shall be responsible to assure coordination between relay modules, network hubs, and control system server/ central station such that system performs as described. Server shall be provided with monitor, keyboard, and mouse, and plugged into a receptacle connected to an equipment emergency circuit as a minimum.

I. Network Hub: Network Hub shall contain processor and astronomic time clock for control and monitoring of lighting. Network hub shall be fed from an equipment emergency circuit at a minimum.

2.9 TIME SWITCH

A. **TC-7;** Time switch, 7-day, 2 channel, electronic, two SPDT 15-amp contacts, two separate programs with 16 setpoints available, LCD display, 12 or 24-hour format, minimum 100 hours carry-over, UL listed.

1. Manufacturers:

a. Tork DTS 200A
b. Intermatic ET70215C

B. **TC-1;** Astronomical time switch, 7-day, 1 channel, electronic, one SPDT 5-amp contact, LCD display, 12 or 24-hour format, minimum 100 hours carryover, UL listed.

1. Manufacturers:

a. Tork DWZ100A
b. Intermatic ET70115C

2.10 CONDUCTORS AND CABLES

A. Control Wiring:

1. Where installed with the line-voltage wiring, control wiring shall be copper conductors not smaller than No. 16 AWG with insulation voltage rating and temperature rating equal to that of the line-voltage wiring, complying with Division 26 Section 26 05 13 "Wire and Cable."
2. Tap conductors to switches or relays: Stranded copper conductors of 16 AWG or solid 16 or 18 AWG with insulation rating equal to that of the line-voltage wiring.
3. Tap conductors to dimming ballasts: Solid copper conductors of 18 AWG with insulation voltage rating equal to that of the line-voltage wiring and insulation temperature rating not less than 90°C.
4. Network cabling as required by manufacturer.

PART 3 - EXECUTION

3.1 PRE-CONSTRUCTION MEETING

A. Schedule a pre-construction meeting with the controls representative, installing contractor, Architect/Engineer, and Owner to explain the proposed lighting control centralized, wireless, and distributed systems.

3.2 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify field dimensions and coordinate physical size of all equipment with the architectural requirements of the spaces into which they are to be installed. Allow space for adequate ventilation and circulation of air.

C. Verify that required utilities are available, in proper location, and ready for use.

D. Beginning of installation means installer accepts existing conditions.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions and approved shop drawings.

B. All wiring shall be installed in conduit. Class II low voltage control wiring may be open wiring and shall maintain 150 mm (6 inch) spacing from electronic ballast and other RFI/EMI sources.

C. All branch load circuits shall be live tested before connecting the loads to the lighting control panel.

3.4 SUPPORT SERVICES

A. System Startup:

1. Manufacturer shall provide factory authorized technician to confirm proper installation and operation of all system components.

B. Testing:

1. System shall be completely functional tested by a factory-authorized technician. All loads shall be tested live for continuity and freedom from defects, and all control wiring shall be tested for continuity and connections prior to energizing the system components.
2. Programming of initial zones, schedules, lighting levels, control station groups, and sensor settings shall be performed by a factory-authorized technician. Lighting Control Sequence of Operation shall serve as a basis for programming, However, all final decisions regarding groups and schedules shall be at the direction of the Owner. The following procedures shall be performed at a minimum:
    a. Confirm occupancy sensor placement, sensitivity, and time delay settings to meet specified performance criteria.
    b. Confirm daylight sensor placement, sensitivity, deadband, and delay settings to meet specified performance criteria.
    c. Confirm that schedules and time controls are configured to meet specified performance criteria and Owner's operating requirements.
3. Verify occupancy/vacancy and daylight sensor operation is correct after furniture and equipment is installed in each area. Make adjustments to sensor settings and time delays to allow proper operation.

4. Verify occupancy/vacancy sensors are located to provide complete coverage for the area served with no nuisance switching.

    a. Relocate sensors or provide additional sensors as necessary to provide adequate coverage.
    b. Mask occupancy sensors where necessary to prevent nuisance switching from adjacent areas.

C. Training:

1. Manufacturer shall provide competent factory-authorized technician to train Owner personnel in the operation, maintenance and programming of the lighting control system. Submit training plan with notification seven (7) days prior to proposed training dates.
2. Training duration shall be no less than three (3) days, with one (1) day being scheduled at least two (2) weeks after initial training.

D. Documentation:

1. Manufacturer shall provide system documentation including:

    a. System one-line showing all panels, number and type of control stations and sensors, communication line, and network or BMS/BAS interface unit.
    b. Drawings for each panel showing hardware configuration and numbering.
    c. Panel wiring schedules.
    d. Typical diagrams for each component.

3.5 SYSTEM COMMISSIONING

A. Contractors' tests shall be scheduled and documented in accordance with the commissioning requirements. Refer to Section 01 09 00, General Commissioning, for further details.

B. System verification testing is part of the commissioning process. Verification testing shall be performed by the Contractor and witnessed and documented by the Commissioning Agent. Refer to Section 01 09 00, General Commissioning, for system verification tests and commissioning requirements.

C. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner's Representative. The instruction shall be scheduled in coordination with the Owner's Representative after submission and approval of formal training plans. Refer to Section 01 09 00, General Commissioning, for Contractor training requirements.

END OF SECTION

SECTION 26 20 00 - SERVICE ENTRANCE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Arrangement with Utility Company for permanent electric service.

B. Underground service entrance

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram for additional information.

1.3 QUALITY ASSURANCE

A. Utility Company: InsertSCE.

B. Install service entrance in accordance with Utility Company's rules and regulations.

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Submit Utility Company prepared drawings (if applicable).

1.5 SYSTEM DESCRIPTION

A. System Voltage: 480Y/277 volts, three phase, three- four-wire, 60 Hertz.

PART 2 - PRODUCTS

2.1 METERING EQUIPMENT

A. Meter: Furnished by the Utility Company.

B. Meter Base: Furnished by the Contractor, as approved by the Utility Company. (Manufacturers: Milbank, Superior, Duncan, or Anchor).

C. Metering Transformer Compartment: Furnished as part of the main switchboard to Utility Company's specifications.

D. **M-#;** Meter Distribution Center:

1. 480/277 volt, 3 phase, 4 wire, 800 amp main circuit breaker/ 800 amp main fusible switch/main lugs only, 1200 copper bus, 42K AIC,Normal branch, 3 phase, 4 wire meter sockets each protected with a 30 amp,3 pole circuit breaker. Meter sockets shall conform to electric utility company metering department requirements. UL listed.
2. Manufacturers:

    a. Square D EZ Meter-Pak
    b. General Electric
    c. Cutler Hammer

2.2 IDENTIFICATION

A. Provide a permanent plaque or sign denoting all services, feeders, and branch circuits supplying the building or structure and the area served by each. Install plaque or sign at each service disconnecting means.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Make arrangements with Utility Company to obtain permanent electric service to the Project.

B. Primary distribution equipment and pad-mounted transformers shall be furnished and installed by the Utility Company.

C. Primary conductors shall be furnished, installed, and terminated by the Utility Company. Primary conduit shall be furnished and installed by the Contractor, as shown on the drawings, to the Utility Company's requirements.

D. Underground: Install service entrance conduits in concrete envelope from Utility Company's pad mounted transformer to meter cabinet and building service entrance equipment. Utility Company will connect service conductors to transformer secondary lugs.

E. Overhead: Install a rigid metal weather head and service entrance conductors. Service entrance conductors shall have a 3' drip loop beyond the weather head. Overhead service shall comply with NEC 230 Part II.

F. Concrete Pad for Transformer: Furnished and installed by the Contractor to Utility Company's specifications.

END OF SECTION

SECTION 26 22 00 - DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Dry type two winding transformers **(TR-#)**

1.2 REFERENCES

A. NEMA ST 20 - Dry Type Transformers for General Applications

B. ANSI/IEEE C57.12.01 - General Requirements for Dry Type Distribution and Power Transformers

C. ANSI/IEEE C57.12.91 - Test Code for Dry Type Distribution and Power Transformers

D. Department of Energy 10 CFR Part 431 - Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation Standards; Final Rule.

E. NEMA TP 2 - Standard Test Method for Measuring the Energy Consumption of Distribution Transformers

F. NEMA TP 3 - Standard for the Labeling of Distribution Transformer Efficiency

1.3 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, KVA, and impedance ratings and characteristics, loss data, efficiency at 35, 50, 75 and 100 percent rated load, sound level, tap configurations, insulation system type, and rated temperature rise.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products under provisions of Section 26 05 00.

B. Store in a warm, dry location with uniform temperature. Cover ventilating openings to keep out dust.

C. Handle transformers using only lifting eyes and brackets provided for that purpose. Protect units against entrance of rain, sleet, or snow if handled in inclement weather.

PART 2 - PRODUCTS

2.1 DRY TYPE TWO WINDING TRANSFORMERS

A. Acceptable Manufacturers:

1. Square D 7400 EX##T / SK300##KB Series
2. Eaton V48M / H48M / B48M Series
3. ABB 9T Series
4. Hammond SG / SMK Series

B. Dry Type Transformers: NEMA ST 20, factory-assembled copper windings, air-cooled dry type transformers; ratings as shown on the drawings. Transformers supplied under this project shall meet the US Department of Energy (DOE) 2016 Efficiency requirements or the most current DOE CFR in effect.

C. Insulation system and average winding temperature rise for rated KVA as follows:

| Ratings | Class | Rise (degree C) |
|---|---|---|
| Less than 15 | 185 | As shown on the drawings |
| or higher | 220 | As shown on the drawings |

D. Case temperature shall not exceed 40°C rise above ambient at its warmest point.

E. Winding Taps, Transformers Less than 15 KVA: Two 5 percent below rated voltage, full capacity taps on primary winding.

F. Winding Taps, Transformers 15 KVA and Larger: Two (2) 2-1/2% below and two (2) 2-1/2% above rated voltage, full capacity taps on primary winding.

G. Sound Levels: Average audible sound level shall not exceed the values given below when tested to NEMA ST 20 standards:

| | Average Sound Level, Decibels | | | |
|---|---|---|---|---|
| | Self-Cooled Ventilated | | | Self-Cooled Sealed |
| Equivalent Winding kVA Range | K-Factor = 1<br>K-Factor = 4<br>K-Factor = 9 | K-Factor = 13<br>K-Factor = 20 | Forced Air w/ Fans Running | |
| 0-9 | 40 | 40 | 67 | 45 |
| 9.01-30.00 | 45 | 45 | 67 | 50 |
| 30.01-50.00 | 45 | 48 | 67 | 50 |
| 50.01-150.00 | 50 | 53 | 67 | 55 |
| 150.01-300.00 | 55 | 58 | 67 | 57 |

| | Average Sound Level, Decibels | | | |
|---|---|---|---|---|
| | Self-Cooled Ventilated | | | Self-Cooled Sealed |
| Equivalent Winding kVA Range | K-Factor = 1<br>K-Factor = 4<br>K-Factor = 9 | K-Factor = 13<br>K-Factor = 20 | Forced Air w/ Fans Running | |
| 300.01-500.00 | 60 | 63 | 67 | 59 |
| 500.01-700.00 | 62 | 65 | 67 | 61 |
| 700.00-1000.00 | 64 | 67 | 67 | 63 |

H. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

I. Mounting: Transformers 75 KVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger than 75 KVA shall be suitable for floor or trapeze mounting.

J. Coil Conductors: Continuous copper windings with terminations brazed or welded.

K. Enclosure: NEMA ST 20; Type 1. Provide lifting eyes or brackets.

L. Isolate core and coil from enclosure using vibration-absorbing mounts.

M. Nameplate: NEMA TP 3; Include transformer connection data and overload capacity based on rated allowable temperature rise.

| KVA Rating | Insulation Class | Temperature Rise (degree C) |
|---|---|---|
| 0.25-2 | 185 | 80 |
| 3-7.5 | 220 | 115 |

| KVA Rating | Insulation Class | Temperature Rise (degree C) |
|---|---|---|
| 0.25-2 | 185 | 80 |
| 3-7.5 | 220 | 115 |

| KVA Rating | Insulation Class | Temperature Rise (degree C) |
|---|---|---|
| 1-9 | 185 | 115 |
| 10-500 | 220 | 130 |

| | Average Sound Level, Decibels |
|---|---|

| | Self-Cooled Ventilated | | | Self-Cooled Sealed |
|---|---|---|---|---|
| Equivalent Winding kVA Range | K-Factor = 1<br>K-Factor = 4<br>K-Factor = 9 | K-Factor = 13<br>K-Factor = 20 | Forced Air w/ Fans Running | |
| 0-9 | 40 | 40 | 67 | 45 |
| 9.01-30.00 | 45 | 45 | 67 | 50 |
| 30.01-50.00 | 45 | 48 | 67 | 50 |
| 50.01-150.00 | 50 | 53 | 67 | 55 |
| 150.01-300.00 | 55 | 58 | 67 | 57 |
| 300.01-500.00 | 60 | 63 | 67 | 59 |
| 500.01-700.00 | 62 | 65 | 67 | 61 |
| 700.00-1000.00 | 64 | 67 | 67 | 63 |

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set transformer plumb and level.

B. Use flexible conduit, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

C. Mount transformers on four 3”x3”x1/2” thick, 50 durometer rubber vibration isolating pads suitable for isolating the transformer noise from the building structure.

D. Ventilated transformers: Provide factory label on horizontal surface to prohibit storage on top, front, or adjacent to transformer.

E. Install primary, secondary, and grounding electrode conductors using factory or field fabricated enclosure entries. Conductors shall not be routed through ventilated openings.

3.2 FIELD QUALITY CONTROL

A. Check for damage and tight connections prior to energizing transformer.

B. Measure primary and secondary voltages and make appropriate tap adjustments. Adjustments shall be made at completion of project and at approximately 6 months following project acceptance when requested by the Owner.

END OF SECTION

SECTION 26 24 13 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Main and distribution switchboards: SB-

1.2 RELATED SECTIONS AND WORK

A. Refer to the Electrical Distribution Diagram and Electrical Schedules for size, rating, and configuration.

B. Section 26 09 13 - Energy Metering and Management System

1.3 REFERENCES

A. ANSI C12 - Code for Electricity Metering

B. ANSI C39.1 - Requirements for Electrical Analog Indicating Instruments

C. ANSI C57.13 - Requirements for Instrument Transformers

D. NEMA AB 1 - Molded Case Circuit Breakers

E. NEMA KS 1 - Enclosed Switches

F. NEMA PB 2 - Dead Front Distribution Switchboards

G. NEMA PB 2.1 - Instructions for Safe Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or less

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Include front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, neutral, and ground; switchboard instrument details; instructions for handling and installation of switchboard; and electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves of all equipment and components.

C. Selective Coordination Study: Submit study to prove that all essential electrical systems, emergency systems and legally required standby system panelboards are selectively coordinated with all supply side overcurrent protective devices.

D. Arc Energy Reduction Documentation: Submit documentation to demonstrate the arc energy reduction system is set to operate at a value below the available arcing current.

E. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.5 SPARE PARTS

A. Keys: Furnish four each to the Owner.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under provisions of Section 26 05 00.

B. Deliver in 48-inch maximum width shipping splits, unless approved otherwise by both the Contractor and Architect/Engineer, individually wrapped for protection, and mounted on shipping skids.

C. Store and protect products under provisions of Section 26 05 00.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

E. Handle in accordance with NEMA PB2.1 and manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

PART 2 - PRODUCTS

2.1 GENERAL

A. Approved Manufacturers:

1. Square D Class 2700 QED-2, I-Line, Powerstyle
2. ABB Spectra / Evolution
3. Eaton

2.2 RATINGS

A. Definitions:

1. Series rated equipment shall be defined as equipment that can achieve a required UL AIC rating with an upstream device such as a main breaker or a combination of devices to meet or exceed a required UL AIC rating. All series rated equipment shall have a permanently attached nameplate indicating that device rating must be maintained. Refer to Section 26 05 53 for additional requirements.
2. Fully rated equipment shall be defined as equipment where all devices in that equipment shall carry a minimum of the AIC rating that is specified.

B. The switchboards for this project shall be fully rated unless otherwise specifically noted in the Drawings or Specifications.

2.3 SWITCHBOARD CONSTRUCTION AND RATINGS

A. Factory-assembled, dead front, metal-enclosed, and self-supporting switchboard assembly conforming to NEMA PB2, and complete from incoming line terminals to load-side terminations.

B. Switchboard electrical ratings and configurations as shown on the drawings.

C. Line and Load Terminations: Accessible from the front only of the switchboard, suitable for the conductor materials used.

D. Main Section Devices: Individually mounted and compartmented.

E. Distribution Section Devices: Group mounted.

F. Auxiliary Section Devices: Individually mounted and compartmented.

G. Bus Material: Copper with tin plating, sized in accordance with NEMA PB 2.

H. Bus Connections: Bolted, accessible from front only for maintenance. Plug-on connections may be utilized with Architect/Engineer's pre-approval by addenda.

I. Bus bars shall be fully isolated, braced for minimum ampere rms symmetrical rating as indicated on drawings.

J. The bus shall extend the full height of the distribution sections to provide space for future breakers.

K. Provide a 1 X 1/4-inch copper ground bus through the length of the switchboard.

L. Provide metering transformer compartment for Utility Company's use. Compartment size, bus spacing and drilling, door, and locking and sealing requirements shall be in accordance to Section 26 20 00 and Utility Company specifications.

M. Enclosure shall be NEMA PB 2; Type 1 - General-Purpose. Sections shall align at front and rear. Provide removable panel access or hinged door with flush lock and all keyed alike. Door hardware shall provide swing clear operation (180-degree swing).

N. Switchboard Height: NEMA PB 2; 92 inches, excluding floor sills, lifting members and pull boxes.

O. Maximum Dimensions: 24Insert "L x Insert42 "W x Insert90 "H.

P. Finish: Manufacturer's standard light gray enamel over external surfaces. Coat internal surfaces with minimum one coat corrosion-resisting paint, or plate with cadmium or zinc.

Q. Pull Section: Same construction as switchboard, size as shown on the drawings. Depth and height to match switchboard. Arrange as shown on the drawings.

R. Future Provisions: In addition to the spare devices shown, provide a minimum of 15 inches of fully equipped space for future devices with bussing and bus connections, suitably insulated and braced for short circuit currents. Continuous current rating as indicated on the drawings.

S. Suitable for use as service entrance equipment. Provide line side (service style) barriers.

2.4 SWITCHING, OVER-CURRENT PROTECTIVE DEVICES, AND ARC ENERGY REDUCTION

A. Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole. Provide breaker interrupting ratings as indicated on the plans. Where necessary to meet interrupting ratings, breakers shall be provided with automatically resetting current limiting elements in each pole.

B. Solid State Molded Case Circuit Breakers: (All breakers identified on plans as solid-state with 2,500 ampere frame sizes and below.) Provide molded case switch with electronic sensing, timing, and tripping circuits for fully adjustable time current characteristic settings including ground fault trip, instantaneous trip, long time trip, long time delay, short time trip, and short time delay. Trip setting shall be field programmable with restricted access and a sealable clear cover. Provide stationary mounting. Ground fault sensing shall be breaker integral with circuit breaker. Provide breaker interrupting ratings as indicated on the plans.

C. Solid-State Insulated Case Circuit Breakers: (All breakers identified on plans as solid state with frame sizes above 2,500 ampere.) Provide insulated case switch with two-step stored energy closing. Provide manual charging handle, and electric charging motor where indicated as electrically operated. Provide with rating plug as required on drawings and electronic circuits for true rms current sensing, timing, and tripping for fully adjustable time current characteristics including ground fault trip, instantaneous trip, long time trip, long time delay, short time trip, and short time delay. Trip settings shall be field programmable with restricted access and a sealable clear cover. Ground fault sensing shall be summation type integral to breaker. Provide stationary mounting. Provide breaker interrupted ratings as indicated on the plans.

D. Arc Energy Reduction with Selective Coordination:

1. Provide an arc energy reduction system to reduce the clearing time of an arc flash event. The arc energy reduction system shall be provided for overcurrent protection devices rated 1,200 amps or larger.
2. Energy-Reducing Maintenance Switch: Provide an energy-reducing maintenance switch visual status indication when engaged. Install the maintenance switch at the entrance to the electrical room.

3. The following selective coordination and arc energy reduction system options are acceptable:

   a. Zone-selective interlocking with permanent arc energy reduction
   b. Differential relaying with permanent arc energy reduction
   c. Listed energy-reducing active arch flash mitigating system

2.5 INSTRUMENTS AND SENSORS

A. Current Transformers: ANSI C57.13; 5 ampere secondary, bar or window type, with single secondary winding, unless otherwise required for application, and secondary shorting device, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

B. Potential Transformers: ANSI C57.13; 120-volt single secondary, disconnecting type with integral fuse mountings, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

C. Ground Fault Sensor: Zero sequence type.

D. Ground Fault Relay: Adjustable ground fault sensitivity from 200 to 1200 amperes, time delay adjustable from 0 to 15 seconds. Provide monitor panel with lamp to indicate relay operation, TEST and RESET control switches.

E. Energy Metering and Management System: Refer to Section 26 09 13.

1. Provide integral Digital Power Meters DPM with harmonic analysis and Digital Energy Meters DEM when scheduled and shown on the plans.
2. Provide individual Circuit Breaker Metering CBM when scheduled and shown on the plans.

   a. The scheduled circuit breaker shall be provided with integral metering. Provide a separately integrated meter when the scheduled circuit breaker is not integral meter functional.

2.6 ACCESSORIES

A. Provide REQUIRED accessories as described below. Provide SCHEDULED accessories when listed with plan schedules. Refer to plan schedules for additional requirements.

B. Barriers (Service Equipment): Provide solid barriers for lineside uninsulated and ungrounded terminations and components which remain energized when the main disconnecting device is 'OPEN'. REQUIRED

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install switchboard in locations shown on the drawings, in accordance with manufacturer's written instructions and NEMA PB 2.1.

B. Tighten accessible bus connections and mechanical fasteners after placing switchboard.

C. Install fuses in each switch.

3.2 FIELD QUALITY CONTROL

A. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.

B. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute each. Test voltage shall be 1000 volts, and minimum acceptable value for insulation resistance is 2 megohms.

C. Check tightness of accessible bolted bus joints using a calibrated torque wrench. Tightness shall be in accordance with manufacturer's recommended values.

D. Physically test key interlock systems to ensure proper function.

3.3 ADJUSTING AND CLEANING

A. Adjust all operating mechanisms for free mechanical movement.

B. Touch up scratched or marred surfaces to match original finish.

C. Provide time/current trip curves for all adjustable protection devices that require setting. Also provide curves and equipment information for associated new and existing fixed devices that require coordination with new protection devices. Submit time/current curves in hard copy or electronic format.

D. Adjust trip and time delay settings to values as scheduled, or as instructed by the Architect/Engineer.

E. Where two levels of ground fault are provided, test ground fault circuit breakers to prove selective coordination in accordance with manufacturer's directions. Provide testing documentation with Operating & Maintenance Manual submittals.

END OF SECTION

SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Service and distribution panelboards: **DP-#**, **DP-#**

B. Lighting and appliance branch circuit panelboards: **Panel '###'**

1.2 RELATED SECTIONS AND WORK

A. Refer to the Electrical Distribution Diagram and Electrical Schedules for size, rating, and configuration.

B. Section 26 09 13 - Energy Metering and Management System

1.3 REFERENCES

A. NEMA AB 1 - Molded Case Circuit Breakers

B. NEMA FU 1 - Low voltage cartridge fuses

C. NEMA KS 1 - Enclosed Switches

D. NEMA PB 1 - Panelboards

E. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less

F. NEMA PB 1.2 - Application Guide for Ground-fault Protective Devices for Equipment

G. UL 248 - Low-Voltage Fuses

H. UL 67 - Panelboards

1.4 SUBMITTALS

A. Submit shop drawings for equipment and component devices under provisions of Section 26 05 00.

B. Include outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.

C. Arc Energy Reduction Documentation: Submit documentation to demonstrate the arc energy reduction system is set to operate at a value below the available arcing current.

D. Refurbished branch panel enclosure documentation for new branch panelboards installed in existing enclosures.

E. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.5 SPARE PARTS

A. Keys: Furnish four (4) each to the Owner.

B. Fuses: Furnish 10% or a minimum of three (3) spare fuses of each type and rating installed to the Owner.

C. Fuse Pullers: Furnish one (1) fuse puller to the Owner.

PART 2 - PRODUCTS

2.1 RATINGS

A. Definitions:

1. Series rated equipment shall be defined as equipment that can achieve a required UL AIC rating with an upstream device such as a main breaker or a combination of devices to meet or exceed a required UL AIC rating. All series rated equipment shall have a permanently attached nameplate indicating that device rating must be maintained. See Section 26 05 53 for additional requirements.
2. Fully rated equipment shall be defined as equipment where all devices in that equipment shall carry a minimum of the AIC rating that is specified.

B. The panelboards for this project shall be fully rated unless otherwise specifically noted in the Drawings or Specifications.

2.2 MAIN AND DISTRIBUTION PANELBOARDS

A. General

1. Manufacturers:

a. Square D QMB, I-Line
b. ABB ReliaGear Entelleon
c. Eaton PRL4, PRL5

B. Panelboards: NEMA PB 1; type as shown on the drawings.

C. Enclosure: NEMA PB 1; Type 1.

D. Provide cabinet front with concealed trim clamps and hinged trim on door to allow access to wiring gutters without removal of trim and flush lock. Door hardware shall provide swing clear operation (180-degree swing). Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

F. All spaces shown on the one-line diagram shall be fully prepared spaces for future breakers.

G. Minimum Integrated Short Circuit Rating: 100,000 amperes rms symmetrical for 240-volt panelboards; 50,000 amperes rms symmetrical for 480-volt panelboards, or as shown on the drawings.

H. Fusible Switch Assemblies: NEMA KS 1; quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle. Provide interlock to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

I. Fuse Clips (Switches 600 Amperes and Smaller): Provide with Class 'R' rejection clips. Fuse Clips (601 Amperes and Larger): Designed to accommodate Class 'L' fuses.

J. Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole.

K. Molded Case Circuit Breakers with Current Limiters: Provide circuit breakers with replaceable current limiting elements, in addition to integral thermal and instantaneous magnetic trip in each pole.

L. Current Limiting Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole, coordinated with automatically resetting current limiting elements in each pole. Interrupting rating 100,000 symmetrical amperes, let-through current and energy level less than permitted for same size Class RK-5 fuse.

M. Solid State Molded Case Circuit Breakers: (All breakers identified on plans as solid-state with 1,200 ampere frame sizes and below.) Provide molded case switch with electronic sensing, timing, and tripping circuits for fully adjustable time current characteristic settings including ground fault trip, instantaneous trip, long time trip, long time delay, short time trip, and short time delay. Trip setting shall be field programmable with restricted access and a sealable clear cover.

N. Arc Energy Reduction:

1. Provide an arc energy reduction system to reduce the clearing time of an arc flash event. The arc energy reduction system shall be provided for overcurrent protection devices rated 1,200 amps or larger.
2. Energy-Reducing Maintenance Switch: Provide an energy-reducing maintenance switch visual status indication when engaged. Install the maintenance switch in the first section of the electrical equipment.

O. Suitable for use as service entrance equipment. Provide line side (service style) barriers.

P. Maximum Dimensions: 6Insert "L x 20Insert "W x Insert48 "H.

2.3 BRANCH CIRCUIT PANELBOARDS

A. General

1. Manufacturers:

a. Square D NQ, NF
b. ABB A Series
c. Eaton PRL1, PRL2

B. Lighting and Appliance Branch Circuit Panelboards: NEMA PB 1; circuit breaker type.

C. Enclosure: NEMA PB 1; Type 1.

D. Provide cabinet front with hinged trim to allow access to wiring gutters without removal of trim and flush lock all keyed alike. Hinged trim shall be secured with screws. Door hardware shall provide swing clear operation (180-degree swing). Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copperbus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

F. All unlabeled circuits shown on the panelboard schedule shall be fully prepared spaces for future breakers.

G. All multiple-section panelboards shall have the same dimensional back box and cabinet front size.

H. Minimum Integrated Short Circuit Rating: As shown on the drawings.

I. Provide handle lock-on devices for all breakers serving exit sign and lighting circuits with emergency battery units. Provide handle lock-on devices and red handles for breakers serving fire alarm panels.

J. Molded Case Circuit Breakers: Bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles. Provide circuit breakers UL listed as Type SWD for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where scheduled on the drawings. Do not use tandem circuit breakers.

K. Current Limiting Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole, coordinated with automatically resetting current limiting elements in each pole. Interrupting rating 100,000 symmetrical amperes, let-through current and energy level less than permitted for same size Class RK-5 fuse.

L. Suitable for use as service entrance equipment. Provide line side (service style) barriers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards plumb as indicated on the drawings in conformance with NEMA PB 1.1.

B. Height: 6 feet to handle of highest device.

C. Provide filler plates for unused spaces in panelboards.

D. Provide custom typed circuit directory for each branch circuit panelboard. Provide updated custom typed circuit directory for each existing branch circuit panelboard with new or revised circuits per the scope of work. Label shall include equipment name or final approved room name, room number, and load type for each circuit (examples: SUMP SP-1 or ROOM 101 RECEPT). Revise directory to reflect circuit changes required to balance phase loads. Printed copies of the bid document panel schedules are not acceptable as circuit directories.

E. Stub five (5) empty one-inch conduits to accessible location above ceiling out of each recessed panelboard.

3.2 FIELD QUALITY CONTROL

A. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent. Take care to maintain proper phasing for multi-wire branch circuits.

B. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

END OF SECTION

SECTION 26 24 19 - MOTOR CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Manual motor starters and switches

B. Magnetic motor starters

C. Combination magnetic motor starters

1.2 RELATED SECTIONS AND WORK

A. Refer to the Disconnect and Starter Schedule and One-Line Diagram for rating and configuration.

1.3 REFERENCES

A. ANSI/UL Standard 508. Standard for Industrial Control Equipment

B. FCC Rules and Regulations, Part 15, Subpart J- Radio Frequency Interference

C. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service

D. FS W-F-870 - Fuseholders (For Plug and Enclosed Cartridge Fuses)

E. FS W-P-115 - Power Distribution Panel

F. FS W-S-865 - Switch, Box, (Enclosed), Surface-Mounted

G. IEEE Standard 519-1981 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters

H. NEMA AB 1 - Molded Case Circuit Breakers

I. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies

J. NEMA ICS 6 - Enclosures for Industrial Controls and Systems

K. NEMA KS 1 - Enclosed Switches

L. NEMA PB 1 - Panelboards

M. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or less

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Indicate on shop drawings, front and side views of motor control center enclosures with overall dimensions. Include conduit entrance locations and requirements; wiring diagrams that differentiate between manufacturer-installed and field-installed wiring; nameplate legends; size and number of bus bars per phase, neutral, and ground; electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves of all equipment and components.

C. Provide product data on motor starters and combination motor starters, relays, pilot devices, and switching and over-current protective devices.

D. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.5 SPARE PARTS

A. Keys: Furnish four (4) each to the Owner.

B. Fuses: Furnish three (3) spare fuses of each type and rating installed to the Owner.

C. Fuse Pullers: Furnish one (1) fuse puller to the Owner.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Deliver in 60-inch maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids.

C. Store and protect products under provisions of Section 26 05 00.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from fumes, dirt, water, construction debris, traffic, and physical damage.

E. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to motor control center components, enclosure, and finish.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

PART 2 - PRODUCTS

2.1 MANUAL MOTOR STARTERS MS-# AND SWITCHES MX-#

A. Manual Motor Starter: NEMA ICS 2; AC general-purpose Class A manually operated non-reversing full-voltage controller for induction motors rated in horsepower, with overload relay, and toggle operator.

B. Enclosure: NEMA ICS 6; Type 1.

2.2 MAGNETIC MOTOR STARTERS

A. Acceptable Manufacturers:

1. Square D
2. Eaton
3. ABB

B. Magnetic Motor Starters: NEMA ICS 2; AC general-purpose Class A magnetic controller for induction motors rated in horsepower.

C. Full Voltage Starting: Non-reversing type, unless otherwise indicated.

D. Size: NEMA ICS 2; size as shown on the drawings.

E. Enclosure: NEMA ICS 6; Type 1.

F. Combination Motor Starters: Combine motor starters with disconnect switch in common enclosure. Provide with disconnecting means as indicated on drawings.

G. Auxiliary Contacts: NEMA ICS 2; two normally open, field convertible contacts in addition to seal-in contact.

H. Pushbuttons: NEMA ICS 2; START/STOP in front cover.

I. Indicating Lights: NEMA ICS 2; RUN: red in front cover.

J. Selector Switches: NEMA ICS 2; HAND/OFF/AUTO, in front cover.

K. Relays: NEMA ICS 2; Insert2.

L. Control Power Transformers: 120 volt fused secondary, fused primary, minimum VA as scheduled:

1. Size 1 - 100 VA
2. Size 2 - 100 VA
3. Size 3 - 150 VA
4. Size 4 - 300 VA
5. Size 5 - 300 VA
6. Size 6 - 300 VA

M. Provide phase loss protection relay with contacts to de-energize the starter for each starter serving motors 5 HP or greater.

2.3 ACCESSORIES

A. Provide REQUIRED accessories as described below. Provide SCHEDULED accessories when listed with plan schedules. Refer to plan schedules for additional requirements.

B. Barriers: Provide finger safe barriers for lineside uninsulated and ungrounded terminations and components which remain energized when the main disconnecting device is 'open'. REQUIRED

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor control equipment in accordance with manufacturer's instructions on concrete bases.

B. Install fuses in fusible switches.

C. Select and install heater elements in motor starters to match installed motor characteristics.

D. Set field-adjustable switches and circuit-breaker trip ranges.

E. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

F. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

END OF SECTION

SECTION 26 27 16 - CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hinged cover enclosures

B. Cabinets

C. Terminal blocks and accessories

1.2 REFERENCES

A. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

B. ANSI/NEMA ICS 1 - Industrial Control and Systems

C. ANSI/NEMA ICS 4 - Terminal Blocks for Industrial Control Equipment and Systems

D. ANSI/NEMA ICS 6 - Enclosures for Industrial Control Equipment and Systems

1.3 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Shop Drawings for Equipment Panels: Include wiring schematic diagram, wiring diagram, outline drawing and construction diagram as described in ANSI/NEMA ICS 1.

PART 2 - PRODUCTS

2.1 HINGED COVER ENCLOSURES

A. Construction: NEMA 250; Type 1 3R 14 gauge steel. Provide stainless steel construction for operating rooms, invasive procedure rooms, and medical scanning rooms.

B. Finish: Manufacturer's standard polyester powder paint finish.

C. Covers: Continuous hinge with stainless steel hinge pin. Covers longer than 24 inches shall have 3-point latching.

D. Provide interior white painted metal panel for mounting terminal blocks and electrical components.

2.2 CABINETS

A. Cabinet Boxes: Galvanized steel with removable endwalls, Insert inches wide, Insert inches high, Insert inches deep. dimensions as indicated on the drawings. Provide stainless steel construction for operating rooms, invasive procedure rooms, and medical scanning rooms.

B. Cabinet Fronts: Steel, flush type with concealed trim clamps, concealed hinge and flush lock keyed to match branch circuit panelboard; finish in gray baked enamel.

2.3 TERMINAL BLOCKS AND ACCESSORIES

A. Terminal Blocks: ANSI/NEMA ICS 4; UL listed.

B. Signal and Control Terminals: Modular construction type, channel mounted; tubular pressure screw connectors, rated 300 volts.

2.4 FABRICATION

A. Shop assemble enclosures and cabinets housing terminal blocks or electrical components in accordance with ANSI/NEMA ICS 6.

B. Provide conduit hubs on enclosures.

C. Provide protective pocket inside front cover with schematic diagram, connection diagram, and layout drawing of control wiring and components within enclosure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cabinets and enclosures plumb; anchor securely to wall and structural supports at each corner, minimum.

B. Provide accessory feet for free-standing equipment enclosures.

C. Install trim plumb.

END OF SECTION

SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Device plates and box covers

B. Receptacles (REC-#)

C. Pendant cord/connector devices

D. Cord and plug sets

1.2 RELATED SECTIONS

A. Section 26 05 38 - Underfloor Ducts.

1.3 QUALITY ASSURANCE

A. Provide similar devices from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the Electrical Code, by a testing agency to Authorities Having Jurisdiction and marked for intended use.

C. Comply with the Electrical Code.

1.4 REFERENCES

A. DSCC W-C-896F - General Specification for Electrical Power Connector

B. FS W-C-596 - Electrical Power Connector, Plug, Receptacle, and Cable Outlet

C. NEMA WD 1 - General Color Requirements for Wiring Devices

D. NEMA WD 6 - Wiring Devices - Dimensional Requirements

E. NFPA 70 - National Electrical Code (NEC)

F. CEC California Electrical Code

G. UL 498 - Standard for Attachment Plugs and Receptacles

H. UL 943 - Standard for Ground Fault Circuit Interrupters

1.5 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Provide product data showing configurations, finishes, dimensions, and manufacturer's instructions.

C. Provide a non-returnable sample of each countertop and furniture-mounted receptacle assembly as part of the submittal process.

1.6 COORDINATION

A. Receptacles for Owner Furnished Equipment: Match plug configurations.

B. Cord and Plug Sets: Match equipment requirements.

C. Coordinate installation of receptacle assemblies in countertops and furniture with the Contractor providing the countertop or furniture. Contractor shall coordinate penetrations and conduit routing in countertops and furniture with drawings and other obstacles below the installation surface.

PART 2 - PRODUCTS

2.1 DEVICE COLOR

A. All switch, receptacle, and outlet colors shall be verified with Architect, unless indicated otherwise.

2.2 COVERPLATES

A. All switches, receptacles, and outlets shall be complete with the following:

1. Unbreakable thermoplastic/thermoset plastic and match device color coverplates in finished spaces where walls are finished.
2. Decorator Grade - Public: Decorator #302 stainless steel wallplates in public finished spaces where walls are finished.

    a. Manufacturer:

        1) Leviton Decora
        2) Hubbell Decorator
        3) Cooper Decorator
        4) or approved equal

3. #302 stainless steel coverplates in unfinished spaces for flush boxes.
4. Galvanized steel coverplates in unfinished spaces for surface mounted boxes.

B. Where several devices are ganged together, the coverplate shall be of the ganged style for the number of devices used.

C. Install nameplate identification as indicated in Section 26 05 53.

D. Plate securing screws shall be metal with head color matching the wall plate finish.

2.3 RECEPTACLES

A. Refer to Electrical Symbols List for device type.

B. Devices that are shaded on the drawings shall be red.

C. Devices that are shaded on the drawings shall be red and shall have an illuminated face or indicator light to indicate that there is power to the device.

D. REC-DUP: NEMA 5-20R Duplex Receptacle:

1. Heavy Duty: 125-volt, 20 amp, 3-wire grounding type heavy duty industrial grade with impact resistant thermoplastic face and one-piece brass back strap with integral ground contacts.

a. Manufacturers:

1) Hubbell 5362
2) Leviton 5362
3) Pass & Seymour 5362A
4) Cooper AH5362

E. REC-DUP-GFI: NEMA 5-20R Ground Fault Duplex Receptacle:

1. Standard Grade: 125-volt, 20 amp, 3-wire grounding type with test and reset buttons in impact resistant thermoplastic face, listed.

a. Device shall perform self-test of GFCI circuitry in accordance with UL 943.
b. Manufacturers:

1) Hubbell GF20L
2) Leviton GFNT2
3) Pass & Seymour 2097
4) Cooper SGF20

F. REC-DUP-WP: NEMA 5-20R Weatherproof Ground Fault Duplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type with test and reset buttons in impact resistant thermoplastic face, weather resistant WR listed. Provide extra-duty NEMA 3R rated while-in-use cast aluminum cover.
2. Device shall perform self-test of GFCI circuitry in accordance with UL 943.

a. Manufacturers:

1) Hubbell:

a) GFTWRST20 with aluminum housing WP826

2) Leviton GFWT2 with aluminum housing M5979
3) Pass & Seymour 2097TRWR with aluminum housing WIUCAST1
4) Cooper WRSGF20 with aluminum housing WIUMV-1

G. REC-TAMP-GFI: NEMA 5-20R GFI Tamper Resistant Receptacle:

1. Standard Grade: 125-volt, 20 amp, 3-wire grounding type tamper-resistant with test and reset buttons in impact resistant thermoplastic face, listed.

a. Device shall perform self-test of GFCI circuitry in accordance with UL 943.
b. Manufacturers:

1) Hubbell GFTR20
2) Cooper TRSGF20
3) Pass & Seymour 2097TR
4) Leviton GFTR2

H. Back wired devices shall be complete with eight holes that are screw activated with metal clamps for connection to #12 or #10 copper conductors.

I. Side wired devices shall have four binding screws that are undercut for positive wire retention.

J. Ground fault circuit interrupter (GFCI) receptacles shall be listed and comply with UL 943 requiring increased surge immunity, improved corrosion resistance, improved resistance to false tripping and diagnostic indication for miswiring if the line and load conductors are reversed during installation.

K. Isolated ground receptacles shall have the equipment ground contacts connected only to the green grounding screw terminal of the device with inherent electrical isolation from the mounting strap.

L. Hazardous (Classified) location receptacles shall comply with NEMA FB 11.

2.4 PENDANT CORD/CONNECTOR DEVICES

A. Description: Matching, locking type plug and receptacle body connector, NEMA WD 6, Configurations L5-20P and L5-20R, heavy-duty grade or refer to Details as shown on drawings.

1. Body: Nylon with screw-open cable gripping jaws and provisions for attaching external cable grip.

B. External Cable Grip: Woven wire mesh type made of high strength galvanized steel wire stand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.5 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded copper conductors, with Type SOW-A jacket; with green insulated grounding conductor and equipment rating ampacity plus a minimum of 30 percent.
2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection, FS/UL listed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install convenience receptacles at elevations indicated in the General Installation Notes on the contract drawings.

B. Install specific-use receptacles at heights shown on the contract drawings. Install devices level, plumb, and square with building lines. Coordinate installation of adjacent devices of separate systems with common mounting heights, including lighting, power, systems, technology, and temperature control device rough-ins.

C. Ground Fault Protection: Provide ground fault protection for all branch circuit breakers serving 120/208 receptacles and electrical outlets rated 50 amps or less single-phase and 100 amps or less three-phase in the following locations, as shown on drawings, or required by adopted code:

1. Bathrooms, locker rooms, shower rooms
2. Kitchens' all 120-volt through 250-volt receptacles
3. Buffet, serving, food preparation areas; all 120-volt through 250-volt receptacles
4. Rooftops
5. Interior/Exterior locations subject to damp/wet conditions
6. When located within 6 feet of sinks, bathtubs, and shower stalls
7. Plug-and-cord receptacles when the utilization appliance is located within 6 feet of a sink edge.
8. Garages, accessory buildings, service bays
9. Specific Appliances: Auto vacuum machines, water drink/bottle fill coolers, pressure staying machines, tire inflation machines, vending machines, sump pumps, dishwashers, electric ranges, ovens, clothes dryers, microwave ovens
10. Future Provisions: Provide a conduit raceway and backbox for the future addition of countertop pop-receptacle when receptacles are not installed in kitchen islands and peninsulas.

D. Arc-Fault Protection: Provide arc-fault protection for all branch circuit breakers serving the following spaces, or required by adopted code.

1. Dwelling unit living and occupied areas including but not limited to kitchens, family, dining, living, parlors, libraries, dens, bedrooms, sunrooms, recreation, closets, hallways, laundry, and similar spaces.
2. Dormitory bedrooms, living rooms, hallways, closets, bathrooms, and similar rooms
3. Guest rooms and guest suites

4. Sleeping rooms for nursing homes, limited care, and similar non-dwelling living quarters dedicated to sleeping

E. Tamper Resistant Protection: Provide tamper resistant protection for all 15 / 20-amp 120/208 straight blade wiring devices in the following locations, as shown on the drawings, or required by adopted code.

1. Public Buildings: Corridors, waiting rooms, common areas
2. Public Spaces involving: Transportation waiting, gymnasiums, fitness centers, auditoriums, public use venue common areas

F. Drill opening for poke-through fitting installation in accordance with manufacturer's instructions. This Contractor is responsible for taking any measures required to ensure no conduits or other services are damaged. This may include X-ray or similar non-destructive means.

G. Install receptacles vertically with ground slot up or where indicated on the drawings, horizontally with ground slot to the left.

H. Install decorative plates on switch, receptacle, and blank outlets in finished areas, using jumbo size plates for outlets installed in masonry walls.

I. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

J. Install devices and wall plates flush and level.

K. Install nameplate identification to receptacle cover plates indicated. Identification shall identify panel name and circuit number. Refer to Specification Section 26 05 53 - Electrical Identification.

L. Test receptacles and modular wiring connectors for proper polarity, ground continuity and compliance with requirements.

END OF SECTION

SECTION 26 28 13 - FUSES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fuses

B. Spare Fuse Cabinet

1.2 REFERENCES

A. UL 198C - High-Interrupting Capacity Fuses; Current Limiting Types

B. UL 198E - Class R Fuses

C. FS W-F-870 - Fuseholders (For Plug and Enclosed Cartridge Fuses)

D. NEMA FU 1 - Low Voltage Cartridge Fuses

E. NFPA 70 - National Electrical Code (NEC)

F. CEC California Electrical Code

1.3 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

1.4 EXTRA MATERIALS

A. Provide two fuse pullers.

B. Provide three of each size and type of fuse installed.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40°F or more than 100°F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS - FUSES

A. Bussman, Division of Eaton

B. Edison Fuse, Division of Cooper Industries

C. Littelfuse Inc

2.2 FUSES

A. Dimensions and Performance: NEMA FU 1, Class as specified or indicated.

B. Voltage: Provide fuses with voltage rating suitable for circuit phase-to-phase voltage.

C. Fuses with ratings larger than 600 amperes: Class L (time delay), unless otherwise noted on the drawings.

D. Fuses with ratings larger than 200 amperes but equal to or less than 600 amperes: Class RK-1 (time delay), unless otherwise noted on the drawings.

E. Fuses with ratings less than or equal to 200 amperes (not including control transformer fuses): Class RK-5, unless otherwise noted on the drawings.

F. Control transformer fuses: Class CC (time delay).

G. Fuses for packaged equipment: Size and type as recommended by equipment manufacturer.

2.3 SPARE FUSE CABINET

A. Cabinet: Wall-mounted, 0.05-inch- thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
4. Fuse Pullers: For each size of fuse.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fuses where indicated on the drawings and specifications.

B. Install fuses in accordance with manufacturer's instruction.

C. Install fuses in packaged equipment as required by equipment manufacturer.

D. Install fuse with label oriented such that manufacturer, type, and size are easily read.

E. Install spare fuse cabinet in the Main Electrical Room.

END OF SECTION

SECTION 26 28 16 - DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fusible switches

B. Non-fusible switches

C. Molded case circuit switches

D. Molded case switches

E. Motor disconnect switch

F. Enclosures

1.2 RELATED SECTIONS AND WORK

A. Refer to the Disconnect and Starter Schedule for rating and configuration.

1.3 REFERENCES

A. NEMA KS 1 - Enclosed Switches

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Product Data: For each type of enclosed switch, circuit breakers, accessory and component indicated, include dimensions, weights, and manufacturer's technical data on features, performance, and ratings.

C. Electrical Characteristics: For each type of enclosed switch, enclosure types, current and voltage ratings, short-circuit current ratings, UL listing for series rating of installed devices, features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.5 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE AND NON-FUSIBLE SWITCHES

A. Acceptable Manufacturers:

1. Square D 3110 Series
2. Eaton DH Series
3. ABB TH Series

B. FDS-##; Fusible Switch Assemblies: NEMA KS 1; Type heavy duty, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position without a tool. Handle lockable in OFF position. Fuse Clips: Class 'R' fuse clips only, unless indicated otherwise on the drawings.

C. DS-##; Non-fusible Switch Assemblies: NEMA KS 1; Type heavy duty, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position without a tool. Handle lockable in OFF position.

D. Enclosures: Type as indicated on the disconnect schedule.

E. Accessories: Provide the following accessories. Refer to Disconnect Schedule for additional requirements for each application.

1. Lockable
2. Provide finger safe barriers for exposed line-side terminations and energized components when the switch is in the open position.

2.2 MOLDED CASE CIRCUIT BREAKERS AND SWITCHES

A. Acceptable Manufacturers:

1. Square D
2. Eaton
3. ABB

B. CB-##; Molded Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip settings.
3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:

a. Instantaneous trip.

b. Long- and short-time pickup levels.
c. Long- and short-time adjustments.
d. Ground-fault pickup level, time delay, and I2t responses.

4. Current Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.

2.3 MOTOR DISCONNECT SWITCH

A. Acceptable Manufacturers:

1. Square D 3110 Series
2. Eaton r5 Series
3. ABB ML Series

B. Enclosures: Type as indicated on the Disconnect Schedule.

C. Ground lug connection provided in enclosure.

D. Accessories: Provide the following accessories. Refer to Disconnect Schedule for additional requirements for each application.

1. Lockable
2. Provide finger safe barriers for exposed line-side terminations and energized components when the switch is in the open position.

E. Listed UL 508 suitable for motor control.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install disconnect switches where indicated on the drawings.

B. Install fuses in fusible disconnect switches.

C. Field coordinate installation with other contractors and equipment to maintain code required working space requirements.

D. Provide adhesive label on inside door of each switch indicating UL fuse class and size for replacement.

3.2 ADJUSTING

A. Set field-adjustable circuit breaker trip ranges.

END OF SECTION

SECTION 26 28 21 - CONTACTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. General-purpose contactors

B. Lighting contactors

C. Enclosures

1.2 RELATED SECTIONS AND WORK

A. Refer to Lighting Contactor Schedule.

1.3 REFERENCES

A. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems

B. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies

C. UL 508 - Industrial Control Equipment

1.4 SUBMITTALS

A. Submit shop drawings under provisions of Section 26 05 00.

B. Include outline drawings with dimensions, and equipment ratings for voltage, capacity, and poles.

C. Submit manufacturer's instructions under provisions of Section 26 05 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Schneider Electric 8903 Series

B. Eaton Corporation C30CN / CN35 Series

C. ABB

2.2 **C-#;** GENERAL-PURPOSE CONTACTORS

A. Contactors: NEMA ICS 2 and UL 508; electrically held,-wire control.

B. Coil Operating Voltage: 24 volts, 60 Hertz.

C. Size: NEMA ICS 2; size as indicated on the drawings.

D. Contacts: 30 amp, 600 volts, 60 Hertz.

E. Poles: 3 Field convertible NO and NC configurations.

F. Enclosure: ANSI/NEMA ICS 6; Type 1.

G. Provide solderless pressure wire terminals.

H. Provide Hand-Off-Auto selector switch.

2.3 **LC-#;** LIGHTING CONTACTORS

A. Contactors: NEMA ICS 2 and UL 508;-wire control.

B. Coil Operating Voltage: 24 volts, 60 Hertz.

C. Contacts: 30 amp, 600 volts, 60 Hertz.

D. Poles: 2 Field convertible NO and NC configurations.

E. Enclosure: ANSI/NEMA ICS 6; Type 1 3R.

F. Provide solderless pressure wire terminals.

G. Provide Hand-Off-Auto selector switch.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction boxes: and equipment enclosures.

E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

END OF SECTION

SECTION 26 29 23 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Variable frequency drives (VFD-#)

1.2 RELATED SECTIONS AND WORK

A. Refer to the Variable Frequency Drive Schedule for rating and configuration.

B. Division(s) 21, 22, 23 - Fire Protection, Plumbing, and Mechanical when referenced.

1.3 REFERENCES

A. ANSI/UL Standard 508

B. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems

C. Standard for Harmonic Control in Electrical Power Systems IEEE 519-2022 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters

D. FCC Rules and Regulations, Part 15, Subpart J - Radio Frequency Interference

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Shop Drawings: Include front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

C. Product Data: Provide catalog sheets showing PWM configuration (6, 12, 18 pulse, Active Front End AFE), voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

D. Product Data for Accessories and Options: Provide catalog sheets showing voltage, dimensions, ratings, for accessories and options. Include information for passive harmonic filters, active harmonic filters, line reactors, shielded VFD cabling, output filters, etc. as an inclusive submittal package provided by the VFD supplier. The VFD supplier shall act as a single contact of responsibility.

E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.5 EXTRA MATERIAL

A. Furnish under provisions of Section 26 05 00.

B. Provide two of each air filter.

C. Provide three of each fuse size and type.

D. Spare VFDs: Provide spare variable frequency drives scheduled for the Owner's maintenance stock. Refer to Variable Frequency Drive Schedule for VFD TAG information.

1. VFD TAG: 1Insert Spare Quantity: 1
2. VFD TAG: 2Insert Spare Quantity: 1

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 26 05 00.

B. Accept controllers on site in original packing. Inspect for damage.

C. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

D. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Variable Torque Applications:

1. Toshiba Q9 Series
2. ABB ACH 580 (HVAC) / ACS 580 (other applications) Series
3. Allen Bradley PowerFlex Series

B. The Variable Frequency Drive Schedule and drawings use equipment tags to define the scope of the project. The equipment tag (example: VFD-5) may be representative of multiple similar applications. Additional options and accessories may be required by the specifications and manufacturer recommendations due to the specific application but not represented in the Variable Frequency Drive Schedule. Refer to the Options, Accessories, and minimum performance requirements of this specification for a complete list of requirements (example: output filters and shielded VFD cables).

C. Motor Nameplate (Drive Output) Voltage: Refer to Variable Frequency Drive Schedule and Mechanical Schedules when applicable.

2.2 MINIMUM PERFORMANCE, REQUIRED OPTIONS, AND ACCESSORIES

A. The following minimum performance requirements, options, and accessories supplement the requirements of the Variable Frequency Drive Schedule. In the event of a conflict between the schedule and specification the most stringent requirement will be enforced.

1. Manual Speed Adjustment
2. Electronic Thermal or bi-metal Overloads
3. Control Transformer, Fused, 120 volt. Acceptable Alternative, 120 volt / 24 volt power supply available directly from VFD, 100mA minimum.
4. Hand-off-Auto Door Switch
5. Skip Frequency Capability

B. Forced Ventilation Accessories and Operation: Provide per manufacturer requirements as required for the standard performance of the drive, the application, and environmental conditions.

1. Provide inlet air outlet filter when a fan is provided. Provide an outlet filter if appropriate for the physical construction of the VFD.
2. Field replaceable blower fan sized to maintain VFD at rated operating temperatures for ambient conditions of enclosure location. The VFD manufacturer's air change requirements shall be satisfied or exceeded for enclosed applications.

C. Harmonic Distortion Performance Criteria (PCC defined at VFD): The variable frequency drive shall have the following minimum harmonic distortion performance criteria; reference to the latest edition of IEEE 519. **The Point of Common Coupling PCC shall be considered the input line terminals of the combination VFD, applicable filters, and accessories for the following requirements.**

1. Design Commentary for the benefit of the contractor, vendor, and manufacturer. The IEEE 519 Standard defines harmonic distortion performance based on a "good neighbor" criteria and overlooks good design practice criteria within the end-user's facility. The Harmonic Distortion Performance Criteria associated with this specification exceeds the minimum industry recognized performance criteria by defining the performance at the VFD. The specification defines a combination of acceptable VFD, passive/active filters, and other accessories. The intent is to promote competition while allowing each manufacturer to offer their best value based solution(s) for the benefit of the project. An industry recognized IEEE 519 Harmonic Analysis Report has been listed as a submittal requirement when required for compliance and documentation purposes when required.
2. The minimum configuration represents the minimum acceptable solution to achieve THDv and TDDi performance requirements. Alternative approved solutions have been listed and shall be substituted within the scope of the original bid pricing when the minimum configuration does not satisfy the harmonic performance requirements listed.
3. Equivalent HP rating: When a single VFD is configured to serve multiple smaller motors (example: skid packaged equipment, fan wall systems) the equivalent sum of the motor HPs (VFD HP rating) shall be considered the HP rating for the following criteria.

4. VFD rating 15 HP or less:

    a. Minimum Configuration: 6 Pulse with 3% input reactor. A 3% DC line choke is acceptable in lieu of an input line reactor when coupled with an input harmonic filter.

        1) Voltage Total Harmonic Distortion (THDv) limit: 5 percent
        2) Current Total Demand Distortion (TDDi) limit: 5 percent

    b. Approved Solutions for Minimum THDv and TDDi Performance: The following approved solutions or a combination of the following is acceptable:

        1) Driver Configuration: 6 pulse configuration, 12 pulse configuration, 18 pulse configurations, PWM drives with an Active Front End AFE or "Ultra low harmonic drives" □that do not limit the maximum motor output power at full load.
        2) Passive harmonic filter with a minimum equivalent (3%) impedance when the input line reactor or DC choke is not provided.
        3) Active harmonic filter with minimum three percent (3%) input line reactor on the input line terminals of the VFD; or larger per manufacturer requirements.

5. VFD rating exceeding 15HP to 99HP:

    a. Minimum configuration: 6 Pulse with 3% input reactor. A 3% DC line choke is acceptable in lieu of an input line reactor when coupled with an input harmonic filter.
    b. Minimum Performance Criteria:
        1) Voltage Total Harmonic Distortion (THDv) limit: 5 percent
        2) Current Total Demand Distortion (TDDi) limit: 5 percent

    c. Approved solutions for minimum THDv and TDDi performance: The following approved solutions or a combination of the following is acceptable:

        1) Driver Configuration: 6 pulse configuration, 12 pulse configuration, 18 pulse configurations, PWM drives with an Active Front End AFE or "Ultra low harmonic drives" that do not limit the maximum motor output power at full load.
        2) Passive harmonic filter with a minimum equivalent (3%) impedance when the input line reactor or DC choke is not provided.
        3) Active harmonic filter with minimum three percent (3%) input line reactor on the input line terminals of the VFD; or larger per manufacturer requirements.

6. VFD rating 100HP or larger:

   a. Minimum configuration: 6 Pulse with 3% input reactor. A 3% DC line choke is acceptable in lieu of an input line reactor when coupled with an input harmonic filter.
   b. Minimum Performance Criteria:
      1) Voltage Total Harmonic Distortion (THDv) limit: 5 percent
      2) Current Total Demand Distortion (TDDi) limit: 5 percent
      3) IEEE 519 compliance at the drive/filter input terminals with a voltage imbalance or 3% or larger, operation at unity power factor, and dynamic braking to prevent regeneration to the supply.

   c. Approved solutions for minimum THDv and TDDi performance: The following approved solutions or a combination of the following is acceptable:

      1) Driver Configuration: 6 pulse configuration, 12 pulse configuration, 18 pulse configurations, PWM drives with an Active Front End AFE or "Ultra low harmonic drives" □that do not limit the maximum motor output power at full load.
      2) Passive harmonic filter with a minimum equivalent (3%) impedance when the input line reactor or DC choke is not provided.
      3) Active harmonic filter with minimum three percent (3%) input line reactor on the input line terminals of the VFD; or larger per manufacturer requirements.

D. VFD Output Load Terminals - Minimum Design Requirements:

1. Provide external output line reactors, DV/DT, sine filters, and shielded VFD cable when the manufacturer's recommended maximum distance between the VFD and the motor(s) is exceeded.
2. Provide the following minimum design criteria in addition to manufacturer recommendations:

   a. Output line reactor (3 percent): When recommended by manufacturer.
   b. DV/DT output line reactor: VFD to motor distance exceeds 75 feet (480 volt) or 150 feet (240/208 volt).
   c. Sine Wave Output Line Reactor: VFD to motor distance exceeds 150 feet (480 Volt) or 280 feet (240/208 Volt).
   d. Shielded VFD Motor Cable: Horsepower ratings exceeds 100 HP for any cable length.

2.3 VFD DESCRIPTION, RATINGS, DESIGN

A. Pulse Width Modulated (PWM) Variable Frequency Drives:

1. Converter shall be of a diode bridge design with a sine-weighted PWM inverter section. Converts 60 Hertz input power at voltage specified to a variable AC frequency and voltage for controlling the speed of AC motors. The controller shall be suitable for use with standard inverter duty motors without requiring any modifications to the motor or the drive.
2. Drives shall be capable of use with commercially available Internal Permanent Magnet (IPM) motors up to 12 poles.
3. Main semi-conductors in the inverter section of controller shall be IGBT transistors capable of a carrier switching frequency of up to 8 kHz.

    a. 50HP applications and less: If derating of the inverter is necessary to run at 8kHz, then the unit's derated currents must equal or exceed the motor full load currents listed in NEC Table 430-150.

B. Short Circuit Current Rating SCCR Default: 100 KA. Provide integral circuit breaker or fuse switch with disconnect switch when required to achieve rating.

C. Drive and controller shall be capable of continuous full load operations throughout the following specified environmental operating conditions. Drive shall be capable of operation in the 'forward' and 'reverse' direction.

1. Operating Ambient Temperature: 0°C to 40°C.
2. Minimum Relative Humidity Range: 5% to 90% (non-condensing).
3. Minimum Elevation without Derating: 3300 feet.
4. The VFD shall incorporate a protective coating on the main control board to conform to IEC60721-3-3 class 3C2 levels.

D. Input Voltage Performance: The drive shall provide full rated output from a line voltage range of -15 / +10% nominal voltage.

E. Controller shall have the functional components listed below:

1. Door interlocked input circuit breaker/fused switch.
2. Input rectifier section to supply fixed DC bus voltage.
3. Smoothing reactor or choke for DC bus.
4. DC bus capacitors.
5. Control transformer or switch mode powered from all three phases.
6. Separate terminal blocks for power and control wiring.
7. Terminal block for operator controls.
8. Sine weighted PWM generating inverter section.

F. Enclosure Fabrication:

1. Enclosure: NEMA 250, Type 1, unless otherwise specified.
2. Finish: Manufacturer's standard enamel.
3. Devices shall be factory installed in controller enclosure and functionally tested unless otherwise indicated.

G. Displays: Provide integral digital display to indicate all protection faults and drive status (including overcurrent, overvoltage, undervoltage, ground fault, overtemperature, phase loss, input power ON, output voltage, output frequency, and output current). Include meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

H. Status Indication Door-mounted display shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

I. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

J. Panel-Mounted Operator Station or KeyPad, Start-stop, auto-manual selector switches with manual speed control potentiometer, and elapsed time meter: NEMA ICS 2, heavy-duty type.

K. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

L. Control Relays: Auxiliary and adjustable time-delay relays.

M. Protection:

1. Input transient protection by means of surge suppressors or equivalent protection.
2. Snubber networks to protect against malfunctions due to system transients.
3. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.

4. Power-Interruption Protection: After a power interruption, it prevents the motor from re-energizing until the motor has stopped.
5. Motor thermal overload relay(s) adjustable and capable of NEMA Class 10 motor protection and sized per motor nameplate data. When multiple motors are connected to the VFD output, each motor shall have a manual starter with properly sized overload protection.
6. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination. Skip frequency feature is acceptable.
7. Instantaneous line-to-line and line-to-ground overcurrent trips on input and output.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection (fuses or circuit breaker).
11. Motor overtemperature fault.
12. Loss of load protection.

N. For a fault condition other than an internal fault, an auto restart function shall provide up to 10 programmable restart attempts. The programmable time delay before each restart shall range from 0 to 10 seconds.

O. The deceleration ramp of the controller shall be programmable for normal and fault conditions. Stop modes shall include: DC injection braking, controlled deceleration to stop and coast to stop.

P. Upon loss of the analog speed reference signal the following shall be selectable:

1. The VFD follows the programmed deceleration ramp to a controlled stop.
2. The VFD holds the speed based upon the last good value and trigger a warning alarm.

Q. The VFD operates at a pre-determined frequency (user programmable).

R. STOP key on the keypad shall be functional at all time, drive mode insensitive.

S. The VFD shall be insensitive to input power phase sequence. Input phase loss detection shall be available.

T. The output frequency shall be parameter setting enabled to fold back when the motor is overloaded (stall prevention).

U. For pump applications, the VFD shall incorporate a forward/reverse pump start sub-routine to assist with clogging.

V. An optional real time clock feature shall be available, which must facilitate the time stamping of any drive trip messages.

W. The VFD shall monitor the main circuit capacitors, control circuit capacitor, in-rush suppression circuit, and cooling fan and shall provide a pre-alarm so that maintenance can be scheduled.

X. The VFD shall include an output timer function so that peripheral equipment maintenance can be scheduled.

Y. The VFD shall include parameter selectable input and output phase loss protection.

Z. The VFD basic insulation level shall be tested based upon ANSI/IEEE C62.41-1999.

AA. The VFD shall be rated as a safety VFD (STO) EN ISO 13849-1 PLd/Cat.3, EN61508, and EN61800-5-2 SIL 1 without additional options.

BB. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.

CC. Minimum Efficiency at Full Load: 96 percent.

DD. Overload Capability: 1.1 times the base load current for 60 seconds every 10 minutes; 1.3 times the base load current for 2 seconds every minute.

EE. Starting Torque: 100 percent of rated torque or as indicated.

FF. Speed Regulation: Plus or minus 1 percent with no motor derating.

GG. All drives shall have built-in diagnostic capability with status and fault indicators mounted on enclosure door. Complete operating instructions for diagnostics shall be mounted inside of the enclosure door.

HH. The drive shall provide self-protection when the load is lost or disconnected without damage to the drive.

II. Acceleration Rate Adjustment: 0.5 - 30 seconds.

JJ. Deceleration Rate Adjustment: 1 - 30 seconds.

KK. Minimum Adjustment Range for the Output Frequency shall be: 0 to 90 Hertz.

LL. Minimum Volts/Hertz Range: 3.7 to 8.6 volts/Hertz.

MM. Provide MANUAL-OFF-AUTOMATIC selector switch and manual analog speed control mounted on the front of the enclosure.

NN. Safety Interlocks: Provide terminals for remote contact to inhibit starting under both manual and automatic mode.

OO. Control Interlocks: Provide terminals for remote contact to allow starting in automatic mode.

PP. Provide adjustable skip frequencies on the drive output (minimum of three ranges).

QQ. Automatic Reset/Restart: Attempts up to 10 restarts after controller fault, on return of power after an interruption, or on undervoltage fault, and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load (coasting motor re-start).

RR. Excitation Control will regulate motor output voltage based on torque requirement. Must be able to provide full motor torque when necessary across the operating speed range.

SS. Motor Temperature Compensation at Slow Speeds: Adjustable current fallback based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

TT. Control Transformer: Provide control power transformer for control, 120 volt secondary, fused.

UU. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:

    a. 0 to 10-V dc.
    b. 0-20 or 4-20 mA.
    c. Potentiometer using up/down digital inputs.
    d. Fixed frequencies using digital inputs.
    e. RS485.
    f. Ethernet.
    g. Keypad display for local hand operation.

3. Output Signal Interface:

    a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

        1) Output frequency (Hz).
        2) Output current (load).
        3) DC-link voltage (VDC).
        4) Motor torque (percent).
        5) Motor speed (rpm).
        6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1A) for remote indication of the following:

    a. Motor running.
    b. Set-point speed reached.

c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

5. The control power for the VFD digital inputs and outputs shall be 24Vdc, selectable to sink or source. Optional 120Vac control power for the digital inputs and outputs shall be available.
6. The drive control board shall be capable of operating from an independent 24V dc power supply.
7. All logic connections shall be furnished on a removable terminal strip.
8. External devices shall be able to be connected to the terminal strip for starting/stopping the VFD, speed control and indicating operation status.
9. Speed command input shall be by means of:

a. Keypad.
b. Analog input.
c. Serial communications.
d. Ethernet communications.

VV. Communications: Provide a communications card to interface VFD with Facility Management Control System (FMCS). Coordinate interface requirements with the FMCS provided under Section 23 09 00. Interface shall allow all parameter settings of VFD to be programmed via FMCS control and displayed on FMCS operator workstation. Provide capability for VFD to retain these settings within the nonvolatile memory.

WW. Control:

1. With the "Manual-Off-Auto" switch in the "Manual" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the manual speed potentiometer on the drive door or keypad.
2. With the "Manual-Off-Auto" switch in the "Auto" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the input signal from an external source.
3. If applicable, with the "Drive-Bypass" in the "Bypass" position, regardless the position of the "Manual-Off-Auto" switch, the motor shall be connected across the lines and shall be run at full speed.
4. With the "Manual-Off-Auto" switch in the "Off" position, if applicable, the drive run circuit shall be open and the VFD shall not operate.
5. If applicable, signal from the fire alarm control panel shall shut down VFD and bypass to direct-on-line operation. In this mode the thermal overload relay for the motor must be disabled.

XX. All disconnect switches between VFD and motor(s) shall include an auxiliary contact interlock wired to the VFD fault trip input to shut down the drive upon opening of the disconnect main contacts.

YY. Convertible Auxiliary Contacts (additional): Provide two additional convertible normally open / normally closed contacts.

ZZ. Electronic Thermal Overloads: Provide adjustable electronic type thermal overloads. Size protection per motor nameplate data.

AAA. Multiple Motor Thermal Overloads: Provide manual starter disconnect switch with electronic thermal overloads for each individual motor when the VFD is scheduled to server multiple motors. Size protection per motor nameplate data.

2.4 OPTIONS AND ACCESSORIES - DESCRIPTIONS

A. Active Harmonic Filter: LCL (input line reactor, capacitor, tuned inductor) type sized by manufacturer for application. Provide leading power factor management for when the motor/VFD are not operating. Provide all VFDs coupled with an Active Harmonic Filter with a minimum three percent (3%) input line reactor; or larger per manufacturer requirements.

1. Required:

a. Satisfy Harmonic Distortion Performance Criteria described in Part 2 of this specification.
b. Per VFD schedule.

B. Contactor Manual Bypass:

1. Per VFD schedule.
2. Provide contactors, motor running overload protection, under-voltage and loss of phase protection, and short circuit protection for full voltage, non-reversing operation of the motor. Include isolation switch or third contactor to allow maintenance of inverter during bypass operation.
3. All bypass circuitry shall be located within the same enclosure as the variable frequency drive.
4. All fire alarm and/or smoke control interconnections (e.g., air handling unit shutdown) shall apply regardless of whether control is through VFD or bypass.
5. Provide a Drive-Bypass Selector Switch.
6. When operating in bypass mode, the main power supply to the VFD shall be disconnected and isolated for service.
7. Provide nameplate with instructions for switching from drive to bypass and from bypass to drive. Provide instructions for isolating VFD for maintenance.

C. Shielded VFD Motor Cable:

1. Required:

a. Per VFD schedule.
b. Required by other portions of this specification.
c. Recommended by the manufacturer.

2. Multi-conductor single overall jacket cable, AC motor application controlled by PWM pulse-width modulation VFD applications, minimum 2000 volt rated, copper phase conductor(s) to match motor application and ratings, three copper conductor ground in direct contact with shield, copper tape or braided shield, provide with wire termination kits at VFD and motor, install per manufacturer recommendations.
3. Conduit Raceway: Contractor to size raceway per code and cable cross sectional area provided by manufacturer.
4. Installation: Contractor shall install without cable splices between VFD and motor unless approved by engineer prior to installation.

D. Forced Cooling / Heating Cabinet Enclosure:

1. When required:

a. Per VFD schedule.
b. When VFD is located exterior to the building or specified with a NEMA 3R, 4, 4X, or 12 enclosure.

2. Provide custom VFD enclosure with DX based cooling system, strip heaters, and thermostat temp controller.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Refer to startup and commissioning requirements.

B. The VFD and all associated controller components shall be covered by a supplier parts warranty of 2 years from the time of installation. There shall be an option to extend the warranty to 5 years if initial installation is carried out by a supplier-approved contractor.

3.2 INSTALLATION

A. Install variable frequency drive equipment in accordance with the manufacturer's instructions.

B. Install harmonic filter components in accordance with manufacturer’s instructions. Locate filters above or below VFD to minimize use of available horizontal wall space pending field conditions.

C. Adjust VFD settings per recommendations of the harmonic filter manufacturer’s instructions; example: switching frequency.

D. VFD Output Feeder and Raceway: The contractor shall provide VFD shielded cable for the VFD output feeder when the distance to the motor exceeds manufacturer recommendations or the requirements of this specifications. Contractor to size raceway per code and cable cross sectional area provided by manufacturer.

E. Floor mount VFD on prefabricated or field fabricated supports with controls no higher than 6'-6" and no lower than 3'-0" AFF. Mount supports on 1/2" thick vibration isolation pads set on concrete housekeeping pads.

F. Provide engraved phenolic nameplates under the provisions of Section 26 05 53.

G. Connections: All conduit connections to the VFD shall be by flexible conduit.

H. Input, output, and control wiring shall each be run in separate conduits.

I. All interlocking required by the drive manufacturer shall be the responsibility of the Electrical Contractor.

J. Forced Cooling / Heating Cabinet Enclosure: Coordinate installation with field conditions and manufacturer instructions. Provide additional branch circuit(s) for cooling and heating system per manufacturer requirements.

3.3 STARTUP AND COMMISSIONING

A. The Electrical Contractor shall have a factory service engineer present for the start-up, field calibration, and check-out of each VFD installed. Factory service engineer shall be required to return to the site for recalibration or set-up should unit not function as specified during system commissioning. All costs shall be a part of This Contract. Provide tag with date and signature of factory service Engineer on inside cover of each drive.

B. Verify all settings, parameters, and adjustments with other contractors prior to startup. Make all adjustments and setting to coordinate with controls and equipment.

C. Accelerate the motor to full speed and verify operation. Decelerate the motor to a stop and verify operation. Slowly operate the motor over the speed range and check for resonance.

D. Make all adjustments and settings to coordinate with controls and equipment prior to Substantial Completion. Verify that drive is set for auto restart after power loss and undervoltage fault.

E. Document settings in the Operations and Maintenance manual.

END OF SECTION

SECTION 26 32 13 - PACKAGED ENGINE GENERATOR SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged engine generator system

B. Exhaust silencer and fittings

C. Fuel fittings and day tank

D. Fuel polishing system

E. Remote annunciator panel

F. Battery and charger

G. Weatherproof enclosure

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 22 30 00 - Plumbing Equipment

1.3 REFERENCES

A. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

B. ANSI/NEMA AB 1 - Molded Case Circuit Breakers

C. ANSI/NEMA MG 1 - Motors and Generators

D. NFPA 37 - Installation and Use of Stationary Combustion Engines and Gas Turbines

E. NFPA 70 - National Electrical Code (NEC)

F. CEC California Electrical Code

G. NFPA 110 - Standard for Emergency and Standby Power Systems

H. IEEE 446 - Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications

I. Environmental Protection Agency EPA Emission Standards for Compressed Ignition Engines

J. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at property boundaries due to sound emitted by the generator set, its components and the operation thereof.

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Submit shop drawings showing plan and elevation views with overall and interconnection point dimensions, fuel consumption rate curves at various loads, ventilation and combustion air requirements, and electrical diagrams including schematic and interconnection diagrams.

C. Submit product data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, control panel, battery, battery rack, battery charger, exhaust silencer, vibration isolators, day tank, remote radiator, and remote annunciator.

1. Include work clearance and equipment access information. Clearly identify required equipment access locations for installation, maintenance, testing, and repair.

D. Submit certificates for compliance with EPA Emissions Standards for Compressed Ignition Engines.

E. Submit manufacturer's installation instructions under provisions of Section 26 05 00.

F. Submit complete control and operation sequences for on-board paralleling system.

1.5 EXTRA MATERIALS

A. Submit maintenance materials under provisions of Section 26 05 00.

B. Furnish one set of tools required for preventative maintenance of the engine generator system. Package tools in adequately sized metal toolbox.

C. Provide two additional sets of each fuel, oil, and air filter element required for the engine generator system. Provide additional fuel polishing filters for one year of operation.

D. Provide one fuse for every type and rating used.

E. Provide five (5) extra DC incandescent lamps and five (5) compact fluorescent lamps.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Store and protect products under provisions of Section 26 05 00.

C. Accept packaged engine generator set and accessories on site in crates and verify damage.

D. Protect equipment from dirt and moisture by securely wrapping in heavy plastic.

1.7 SYSTEM DESCRIPTION

A. Engine generator system to provide source of emergency and standby power.

B. System Capacity: 750 KW, 700 KVA, 680 starting KVA at specified voltage dip, at an elevation of 1,000 feet above sea level, and ambient temperature between -20°F and 110°F; continuous rating using engine-mounted radiator.

C. Emergency Power Supply System (EPSS) shall be NFPA 110 Type 10 Class 2 Level 1.

D. Operation: In accordance with ANSI/NFPA 110.

1.8 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 26 05 00 for required generator electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings. Show generator, fuel system components, battery system components, and exhaust system in 1/4" scale plan of room.

1.9 PROJECT RECORD DOCUMENTS

A. Submit record documents under provisions of Section 26 05 00.

B. Accurately record location of engine generator and mechanical and electrical connections.

1.10 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include instructions for normal operation, routine maintenance requirements, service manuals for engine and day tank, oil sampling and analysis for engine wear, and emergency maintenance procedures.

1.11 QUALIFICATIONS

A. Manufacturer: Company specializing in packaged engine generator system with minimum five (5) years documented experience.

B. Manufacturer: Company with minimum five (5) years of documented on-board paralleling system experience.

C. Supplier: Authorized distributor of engine generator manufacturer with service facilities within 50 miles of the project site.

1.12 WARRANTY

A. Provide a five (5) year warranty under provisions of Section 26 05 00.

1.13 MAINTENANCE SERVICE

A. Furnish service and maintenance of packaged engine generator system for one (1) year from Date of Substantial Completion. Maintenance service shall be performed by skilled employees of manufacturer's designated service organization. Include quarterly exercising, and routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Maintenance agreements shall include parts, supplies, and labor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Caterpillar.

B. Cummins Power Generation.

C. Generac.

2.2 PACKAGED ENGINE-GENERATOR SET (GEN-Insert##)

A. Packaged engine-generator set shall be a coordinated assembly of compatible components. Stationary generators shall be listed.

B. Safety Standard: Comply with ASME B15.1 and UL 2200.

C. Nameplates: Each major system component shall be equipped with a nameplate to identify manufacturer's name and address, model and serial number, and component rating in integrated set and as required by the contract documents.

D. Fabricate engine-generator set mounting frame and attachment of components to resist generator-set movement during a seismic event when generator-set mounting frame is anchored to building structure.

E. Mounting Frame: Adequate strength and rigidity to maintain alignment of mounted components without depending on concrete foundation. Mounting frame shall be free from sharp edges and corners and shall have lifting attachments arranged for lifting with slings without damaging components. Provide a rigging diagram permanently attached to the mounting frame to indicate the capacity of each lifting attachment and the generator-set center of gravity.

F. Maximum Dimensions: Insert Insert Insert See plans for dimensions.

2.3 ENGINE

A. Type: Water-cooled in-line or V-type, four-stroke cycle spark-ignition internal combustion engine.

B. Rating: Sufficient to operate at 100 percent load for two hours at specified elevation and ambient limits.

C. Fuel: Appropriate for use of No. 2 fuel oil.

D. Engine Speed: 1800 RPM.

E. Governor: Isochronous type with speed sensing.

F. Safety Devices: Engine shutdown on high water temperature, low oil pressure, overspeed, and engine overcrank. Limits as selected by manufacturer.

G. Frequency Response:

1. Steady State Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
2. Transient Response: Less than 5 percent for a 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady state operating band within 5 seconds.

H. Fuel System:

I. Fuel Supply System:

1. Base-Mounted Fuel Tank: UL 142 listed fuel tank with 12 hour rated (NFPA 110 minimum run time by class) capacity. Integral rupture basin with leak detection. Provide fueling port with an overfill prevention type receptacle and lockable cap for exterior units. The tank shall include structural steel supports for top mounted engine generator set. Furnish complete with flexible fuel line connectors remote cover, and analog level gauge. Furnish complete with float switches to indicate 75%. The footprint of the base-mounted fuel tank shall not exceed the footprint of the generator frame for interior applications or the footprint of the enclosure for exterior installations.

J. Fuel Polishing System:

1. Fuel polishing system capable of removing 99% of emulsified water and particulate down to 3 microns from the fuel. The system shall be sized so the stored fuel capacity shall be polished at least once per week. The system shall include a pump to circulate the fuel from the storage tank through the filter/separator and return it to the tank, A gauge or alarm shall provide notification when a filter is due for change. A timer shall be set to run the pump during off peak hours.

K. Lubrication System: Engine or skid mounted filter and strainer, thermostatic control valve capable of full flow and designed to be fail safe, and crankcase drain arranged for gravity drainage with siphon or pump.

L. Engine Jacket Heater: Thermal circulation type water heater with integral thermostatic control, sized to maintain engine jacket water at 90°F, and suitable for operation on 480-3Ø volts AC. The minimum wattage of the heater shall be  watts or as recommended by the manufacturer.

M. Cooling System: Closed loop, liquid cooled, with and integral engine-driven coolant pump.

1. Fan and Core: Nonferrous-metal construction sized to contain expansion of total system. Blower type fan, sized to maintain safe engine temperature in ambient temperature of 110°F. Radiator Airflow Restriction: 0.5 inches of water, maximum.
2. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anti-corrosive additives.
3. Provide expansion tank with gage glass and petcock, and self-contained, thermostatic-control temperature control valve.

N. Engine Starting: DC starting system with positive engagement, number and voltage of starter motors in accordance with manufacturer's instructions. Include remote starting control circuit, with MANUAL-OFF-REMOTE selector switch on engine-generator control panel. Provide the following accessories:

1. Battery: Voltage to match starter with capacity for three cranking cycles without recharge. Provide with battery cables and acid resistant battery tray.
2. Battery-Charging Alternator: Factory mounted on engine with solid state voltage regulation.
3. Remote Start Circuit Monitoring: Provide continuous monitoring of the generator start circuits. A failure shall initiate visual and audible alarms at the generator, remote annunciators, and start the generator.
4. **BC-##** Battery Charger: Current limiting type designed to float at 2.17 volts per cell and equalize at 2.33 volts per cell. Include overload protection, full wave rectifier, DC voltmeter and ammeter, and 120 volts AC fused input. Provide wall-mounted enclosure to meet ANSI/NEMA 250, Type 1 requirements.
5. Provide two battery strings, two DC power supply/chargers with monitoring, and a best battery selector system. Each shall be sized to provide total starting capacity.
6. DC Power Supply/Charger: Utility grade current limiting type with battery temperature compensation designed to float at 2.17 volts per cell and equalize at 2.33 volts per cell. Include overload protection, full wave filtered rectifier, digital DC voltmeter and ammeter, and 120 volts AC fused input. Provide wall-mounted enclosure to meet ANSI/NEMA 250, Type 1 requirements.
7. Best battery selector system for dual battery single load configuration. Solid-state design must isolate battery strings from each other.

O. Exhaust System: Critical type silencer (85 dBA max at 10 feet), side inlet with muffler companion flanges and flexible stainless steel exhaust fitting, suitable for horizontal orientation, sized in accordance with engine manufacturer's instructions. Silencer shall include a threaded opening for connection of ¾" drain line. Opening shall be flush on inside of silencer.

P. The packaged engine generator shall comply with the current Environmental Protection Agency EPA Emissions standards.

Q. Engine Accessories: Fuel filter, lube oil filter, intake air filter, lube oil cooler, fuel transfer pump, fuel priming pump, gear-driven water pump. Include fuel pressure gauge, water temperature gauge, and lube oil pressure gauge on engine-generator control panel.

R. Mounting: Provide unit with suitable spring-type vibration isolators.

2.4 GENERATOR

A. Generator: ANSI/NEMA MG 1; three phase, re-connectible brushless synchronous generator with brushless exciter and PMG alternator excitation.

B. Rating: As indicated on the drawings, at 0.8 power factor, 60 Hertz at RPM to match engine rating.

C. Insulation: ANSI/NEMA MG 1, Class F.

D. Temperature Rise: 105°C continuous.

E. Enclosure: ANSI/NEMA MG 1; open drip-proof.

F. Voltage Regulation:

1. The maximum instantaneous voltage dip (IVD) shall be 28 percent for building loads and 15 percent for the fire pump.
2. Include solid-state type voltage regulator, separate from exciter to match engine and generator characteristics, with voltage regulation ±1 percent from no load to full load. Include manual controls to adjust voltage drop ±5 percent voltage level, and voltage gain.

G. Subtransient Reactance (X'd): Maximum 15 percent.

H. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

2.5 CONTROLS AND INDICATION

A. Operating and safety indications, protective devices, basic system controls, and engine gauges shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

B. Ground Fault: Provide ground fault sensing at the generator. The sensor shall be located ahead of the generator service disconnect. Provide a ground fault indication on the engine-generator control panel. Provide an instruction nameplate at the control panel.

1. Instruction nameplate: Provide operational instructions for a ground fault indication as approved by the local Authority Having Jurisdiction.

C. **GCP-**Insert**#**; Engine-Generator Control Panel: ANSI/NEMA 250, Type 1 generator mounted control panel enclosure with engine and generator controls and indicators. Include provision for padlock and the following equipment and features:

1. Alarm indication as required by NFPA 110 for a Level 1 system.
2. AC frequency meter.
3. AC output voltmeter with phase selector switch.
4. AC output ammeter with phase selector switch.
5. Output voltage adjustment.
6. DC voltmeter (alternator battery charging).
7. Engine start/stop selector switch.
8. Engine running time meter.
9. Oil pressure gauge.
10. Engine coolant temperature gauge.
11. Shut down devices for overspeed, coolant high-temperature, coolant low-level, and oil low-pressure.
12. Fuel derangement alarm.
13. Generator overload.
14. Auxiliary Relay: 3PDT, operates when engine runs, with contact terminals prewired to terminal strip.
15. Remote Alarm Contacts: Pre-wire SPST contacts to terminal strip for remote alarm functions required by ANSI/NFPA 99.
16. Ground fault indication.
17. Generator control and start signal failure.
18. On-board paralleling controls.
19. 80% load alarm.
20. Key switch, three-position selection switch.

D. **GANN-**Insert**#**; Remote Engine Annunciator Panel: ANSI/NFPA 99 and NFPA 110 for a Level 1 system. Include the listed pre-alarm and alarm points, audible alarm, alarm silencing means, repetitive alarm circuitry, and lamp test switch in a surface mounted panel with brushed stainless steel finish. Provide all interconnecting wiring in conduit per manufacturer's requirements by the Electrical Contractor. The remotely reported alarms shall include the following.

1. Overcrank
2. Low water (engine) temperature
3. High engine temperature pre-alarm
4. High engine temperature
5. Low lube oil pressure pre-alarm
6. Low lube oil pressure
7. Overspeed
8. Low fuel main tank
9. Low coolant level
10. Not in auto
11. Emergency Power Supply (EPS) supplying load
12. High battery voltage
13. Low battery voltage
14. Battery charger failure (includes AC failure)
15. Generator running

16. Normal utility power
17. Emergency stop
18. Rupture basin alarm
19. Emergency Power Off Switch activated (EPO)
20. Alarm for power supply or UPS serving motorized breakers
21. Generator control and start signal failure.
22. On-board paralleling controls.
23. 80% load alarm.

E. Remote Engine Manual Start Control: Two-wire remote start control from fire command center. Provide all interconnecting wiring in conduit per manufacturer's requirements (by the Electrical Contractor).

F. Building Automation System Integration:

1. Provide a terminal block to allow the Facility Monitoring and Control System (FMCS) to report generator alarms. Provide individual terminal points for each of the annunciator alarms and pre-alarms. Provide an additional terminal point to combine all generator alarms under a single terminal point. Provide a permanent label for each terminal point. Each terminal will provide a binary output for the FMCS to read. Refer to Section 23 09 00 for alarms reported by the FMCS.

2.6 ACCESSORIES

A. Generator Circuit Breaker: Molded or insulated case, service-rated electronic trip type; 100% rated breaker complying with NEMA AB1 and UL 489. The disconnect shall simultaneously open all associated ungrounded conductors and be lockable in the open position.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator rating.
3. Shunt Trip: Connected to trip breaker when generator is shut down by other protective devices.
4. Mounting: Provide freestanding enclosure or mount integrally with control and monitoring panel.
5. The disconnecting means shall also shut down the prime mover, disable all start control circuits, and be configured with a mechanical reset.
6. Arc Energy Reduction: Provide and arc energy reduction system to reduce the clearing time of an arc flash event. The arc energy system shall be provided for overcurrent protection devices rated 1,200 amps or larger.

B. **EPO;** Remote Manual Stop Station (Emergency Power Off EPO): Provide a remote manual stop station with weather proof stainless steel or die cast housing, red mushroom button - push to stop operation, breakable cover/lens to access mushroom button, 120-volt rated. The manufacturer shall provide automatic monitoring of the EPO switch. Placing the EPO switch in the "Generator Powered OFF" status shall initiate a visual and audible alarm at each generator annunciator panel.

1. The Remote Manual Stop Station may be located within the generator enclosure when allowed by code. Provide an engraved plastic nameplate "EMERGENCY DISCONNECT - define location", red background, white letters, minimum 4" letters. Provide one nameplate on each side of the generator enclosure with accessible doors.

2.7 OUTDOOR GENERATOR-SET ENCLOSURE

A. Prefabricated or pre-engineered walk-in enclosure with the following features:

1. Construction: Reinforced galvanized steel, metal clad, integral structural steel framed housing anchored to a concrete foundation. Panelized aluminum housing with integral structural framing anchored to a concrete foundation. Construction shall allow access to control panels and service points.
2. Construction: Reinforced galvanized steel, metal clad, integral structural steel framed housing anchored to a concrete foundation. Panelized aluminum housing with integral structural framing anchored to a concrete foundation. Construction shall allow access to control panels and service points. The panels shall enclose all components including intake/exhaust louvers and sound attenuators. Extend the enclosure base frame as required for panels.
3. Structural Design and Anchorage: Wind resistant up to 100 mph.
4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents. Motor operators shall be spring open, power close operating at 24 volts DC. The louvers shall be connected to the generator starting batteries through appropriate control relays. Louvers shall not extend outside main generator enclosure.
5. Hinged doors: Provide a minimum of four doors with padlocking provisions. Single doors shall be 36" wide and 84" high. Double doors shall be 60" wide and 84" high. As standard, doors shall include rain-rail moldings above all door openings, recessed, keyed mortise locks, panic bar door hardware and full weather-stripping. Doors shall be removable.
6. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits as required by engine-generator-set components.
7. Fuel Tank Vent: Provide vent piping from the fuel tank to the exterior of the enclosure.
8. Fuel Fill: Provide fill access on the exterior of the enclosure at an elevation not to exceed 5'-0" above finished grade.
9. The exhaust system silencer shall be installed within the enclosure housing.
10. Electrical:
    a. Provide conduit and wiring for all non-life safety loads: unit heater, engine jacket water heater, battery charger, louver motors, non-life safety lights, receptacles, etc.

11. Acoustical Treatment: Provide acoustical treatment of the generator enclosure including wall panels, intake and exhaust air paths, ventilation openings, and tailpipe exhaust. Maximum sound level horizontally from the generator set shall be 30 dBA at 40 feet in a hemispherical free field in the configuration shown on the drawings. Sound attenuators shall be concealed within the enclosure panels. Panels shall extend from the enclosure base frame to the height of the generator section.

2.8 SITE COORDINATION

A. Generator to property line distance: Insert20 feet

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work and field dimensions are as shown on the drawings.

B. Verify that required utilities are available in proper location and ready for use.

C. Beginning of installation means installer accepts existing conditions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install remote manual stop station in location shown on plans. Provide 120 Volt power and wiring in conduit as required. Coordinate installation with the manufacturer approved shop drawings and wiring diagrams. The remote manual stop station shall shunt trip the generator mounted circuit breaker and signal the engine prime mover to stop.

C. The A-B-C phase rotation of the generator source shall match the A-B-C phase rotation of the utility source. The Contractor shall verify the generator and utility phase rotation match to prevent three phase motors and similar loads from operating backwards while being served by the generator.

3.3 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 05 00 and in compliance with NFPA 110 requirements.

B. Provide portable test bank for full load test. Simulate power failure including operation of transfer switch, automatic starting cycle, and automatic shutdown, and return to normal.

C. Fill fuel tank prior to start of test. Fill tank after test.

D. The on-site installation test shall be conducted as follows:

1. With the prime mover in a "cold start" condition and the emergency load at standard operating level, a primary power failure shall be initiated by opening all switches or breakers supplying the primary power to the building or facility.
2. The test load shall be that load that is served by the Emergency Power Supply System (EPSS).
3. The time delay on start shall be observed and recorded.
4. The cranking time until the prime mover starts and runs shall be observed and recorded.
5. The time taken to reach operating speed shall be observed and recorded.
6. The voltage and frequency overshoot shall be recorded.
7. The time delay on transfer to emergency power for each switch shall be recorded. Life safety and critical branch transfer switches must transfer within 10 seconds.
8. The time taken to achieve a steady-state condition with all switches transferred to the emergency position shall be observed and recorded.
9. The voltage, frequency, and amperes shall be recorded.
10. The prime mover oil pressure and water temperature shall be recorded, where applicable.
11. The battery charge rate shall be recorded at 5-minute intervals for the first 15 minutes and at 15-minute intervals thereafter.
12. When primary power is returned to the building or facility, the time delay on retransfer to primary for each switch with a minimum setting of 5 minutes shall be recorded.
13. The time delay on the prime mover cool down period and shutdown shall be recorded.
14. Allow prime mover to cool for 5 minutes.
15. A load shall be applied for 4 hours total. The building load shall be permitted to serve as part or all of the load, supplemented by a load bank of sufficient size to provide a load equal to 100 percent of the nameplate rating of the Emergency Power Supply (EPS), less applicable derating factors for site conditions. Observe and record load changes and the resultant effect on voltage and frequency.
16. The full load test shall be initiated immediately after the cooling time has expired by any method that starts the prime mover and, immediately upon reaching rated rpm, picks up 100 percent of the nameplate kW rating on one step, less applicable derating factors for site conditions.
17. During test, record the following at 5-minute intervals for the first 15 minutes and every 15 minutes for the rest of the test:

    a. Kilowatts
    b. Amperes
    c. Voltage
    d. Frequency
    e. Coolant temperature
    f. Enclosure temperature (interior)
    g. Oil pressure
    h. Engine exhaust temperature
    i. Engine inlet temperature
    j. Oil Temperature
    k. Battery charge rate

18. Upon completion of the test and after a cool down period, the crank/rest cycle shall be tested.

    a. Any method recommended by the manufacturer for the cycle crank test shall be utilized to prevent the prime mover from running.
    b. The control switch shall be set at "run" to cause the prime mover to crank.
    c. The complete crank/rest cycle shall be observed and recorded.

19. Test alarm and shutdown circuits by simulating conditions.

E. Contractor shall fill fuel tanks upon completion of test.

F. Testing documentation shall be submitted to the Architect/Engineer for review and approval. Reviewed documentation shall be submitted to IDPH as part of the project close-out certification package.

G. Generator testing worksheets are included with this specification section.

3.4 MANUFACTURER'S FIELD SERVICES

A. Prepare, start, test, and adjust systems under provisions of Section 26 05 00.

B. Provide UL field inspection of generator.

3.5 COMMISSIONING: ON-BOARD GENERATOR PARALLELING CONTROL

A. Prepare, start, test, and adjust systems under provisions of Section 26 05 00. The on-board paralleling startup, testing, and commissioning may be conducted with other startup, testing, and commissioning requirements of this specification.

B. Provide on-site manufacturer representative for on-board generator paralleling system startup, testing, and commissioning.

C. Simulate a utility power loss test of the EPSS and on-board generator paralleling control system.

1. Refer to the emergency power system sequence of operation schedule on the drawings.
2. Report and document deviations from the sequence of operation schedule, system adjustments, and deficiencies.
3. Obtain and Submit Authority Having Jurisdiction AHJ observation and certificate of acceptable emergency power system operation when required for facility occupancy certificate.

3.6 ADJUSTING

A. Adjust generator output voltage and engine speed.

3.7 CLEANING

A. Clean work under provisions of Section 26 05 00.

B. Clean engine and generator surfaces. Replace oil and fuel filters.

3.8 DEMONSTRATION

A. Provide systems demonstration. Coordinate the demonstration schedule with the Owner and Architect/Engineer.

B. Describe loads connected to emergency and standby systems and restrictions for future load additions.

C. Simulate power outage by interrupting normal source and demonstrate that system operates to provide emergency and standby power.

END OF SECTION

SECTION 26 36 00 - TRANSFER SWITCH

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Automatic transfer switch with delayed transition ATS-#

B. Manual transfer switch MTS-#

C. Remote annunciator for ATS RA-ATS-#

1.2 RELATED SECTIONS AND WORK

A. Refer to the Transfer Switch Schedule for rating and configuration.

1.3 QUALITY ASSURANCE

A. Manufacturer: Company specializing in automatic transfer equipment with three (3) years documented experience.

1.4 REFERENCES

A. NEMA ICS 1 - General Standards for Industrial Control and Systems

B. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers, and Assemblies

C. NEMA ICS 6 - Enclosures for Industrial Controls and Systems

D. NEMA ICS 10 - Guide to Application of Low-Voltage Automatic Transfer Switch Equipment

E. UL 1008 - Standard for Automatic Transfer Switches

F. NFPA 99 - Health Care Code

G. NFPA 110 - Standard for Emergency and Standby Power Systems

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Submit product data for transfer switches showing overall dimensions, electrical connections, electrical ratings, and environmental requirements.

C. Submit manufacturer's installation instructions under provisions of Section 26 05 00.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include instructions for operating equipment.

C. Include instructions for operating equipment under emergency conditions when engine generator is running.

D. Identify operating limits which may result in hazardous or unsafe conditions.

E. Document ratings of equipment and each major component.

F. Include routine preventive maintenance and lubrication schedule.

G. List special tools, maintenance materials, and replacement parts.

1.7 REGULATORY REQUIREMENTS

A. Conform to applicable code for emergency and standby electrical systems.

PART 2 - PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCH WITH DELAYED TRANSITION

A. Automatic transfer switch, microprocessor controlled, three-position switch mechanism, delayed transition and load shed capable, with local manual operation.

B. Acceptable Manufacturers, Standard Grade:

1. Schneider Electric ASCO 300 Series
2. Siemens Russelectric RMT Series
3. ABB Zenith ZTG Series
4. Generac W Series

C. Description: NEMA ICS 2; automatic transfer switch.

D. Configuration: Electrically-operated, three-position delayed transition / off capable, mechanically-held transfer switch.

E. Control panel shall be micro-processor based.

2.2 MANUAL TRANSFER SWITCH

A. Acceptable Manufacturers:

1. ASCO 300 Series
2. Russelectric RMT Series
3. ABB Zenith ZTG Series
4. Generac W Series

B. Description: NEMA ICS2; manual transfer switch.

C. Configuration: Manually-operated, three-position center-off transfer switch.

D. Engine start switch.

2.3 AUTOMATIC SEQUENCE OF OPERATION

A. Initiate Time Delay to Start Alternate Source Engine Generator: Upon initiation by normal source monitor.

B. Time Delay to Start Alternate Source Engine Generator: 0 to 10 seconds, adjustable.

C. Initiate Transfer Load to Alternate Source: Upon initiation by normal source monitor and permission by alternate source monitor.

D. Time Delay Before Transfer to Alternate Power Source: 0 to 30 seconds, adjustable.

E. Initiate Retransfer Load to Normal Source: Upon permission by normal source monitor.

F. Time Delay Before Transfer to Normal Power: 0 to 30 minutes, adjustable; bypass time delay in event of alternate source failure.

G. Time Delay Before Engine Shut Down: 0 to 30 minutes, adjustable, of unloaded operation.

H. Indicating Lights: Mount in cover of enclosure to indicate NORMAL SOURCE AVAILABLE, ALTERNATE SOURCE AVAILABLE, SWITCH POSITION.

I. Test Switch: Key operated or password protected switch. Mount in cover of enclosure to simulate failure of normal source.

J. Engine Start Signal: Rated 10 amps at 30VDC shall be provided to start the engine generator in the event of a normal source outage.

K. Remote Start Circuit Monitoring: Provide continuous monitoring of the generator start circuits. A failure shall initiate visual and audible alarms at the generator, remote annunciators, and start the generator.

L. Return to Normal Switch: Mount in cover of enclosure to initiate manual transfer from alternate to normal source.

M. Transfer Switch Auxiliary Contacts: 2 normally open; 2 normally closed indicating switch to normal source or emergency source.

N. Normal Source Monitor: Monitor each line of normal source voltage and frequency; initiate transfer when voltage drops below 85 percent or frequency varies more than 3 Hertz from rated nominal value, values shall be field adjustable.

O. Alternate Source Monitor: Monitor each line of alternate source voltage and frequency; inhibit transfer when voltage is below 85 percent or frequency varies more than 3 percent Hertz from rated nominal voltage, values shall be field adjustable.

P. Engine Exerciser: Start engine every 28 days. Run for 30 minutes before shutting down. Each event shall be configurable for Test with Load or Test Without Load. Bypass exerciser control if normal source fails during exercising period.

Q. In-Phase Monitor: Inhibit transfer until source and load are within 30 electrical degrees.

R. Provide 2 N.O. and 2 N.C. isolated contacts to indicate:

1. Normal source available.
2. Emergency source available.
3. Exercise mode in operation.

S. RA-ATS**-#** Remote Annunciator: A remote annunciator shall be provided that shall monitor and control the following functions for each transfer switch:

1. Load Connect to Emergency/Normal Indication
2. Source Available: Emergency/Normal Indication
3. Time Delay Indication and Key Locked Bypass Switch
4. Transfer Test Indication and Key Locked Switch
5. Remote transfer loads between normal and emergency sources with Key Locked Switch
6. Remote generator start with Key Locked Switch
7. Remote generator stop with Key Locked Switch

T. Annunciators shall be located where shown on the drawings, as directed by the Owner. Extend conduit and wire as required by the manufacturer.

U. An adjustable emergency to normal pre-signal signal to elevator controller.

V. Metering Capabilities: The following metered readings shall be available at the local display. The metering information shall also be shared by serial connection to the master control cubicle of the emergency power paralleling equipment.

1. Current, per phase RMS and neutral
2. Current unbalance %
3. Voltage, phase-to-phase and phase-to-neutral
4. Voltage unbalance %
5. Real power (KW), per phase and 3-phase total
6. Apparent power (KVA), per phase and 3-phase total
7. Reactive power (KVAR), per phase and 3-phase total
8. Power factor, 3-phase total & per phase
9. Frequency
10. Accumulated energy, (KWH, KVAH, and KVARH)
11. Demand, (KWH, KVA)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify field measurements are as instructed by the manufacturer.

C. Verify that required utilities are available, in proper location, and ready for use.

D. Beginning of installation means acceptance of existing conditions.

3.2 CONTROL AND SIGNAL CABLING

A. Provide control and signal cabling per manufacturer recommendations for the following systems components:

1. Remote annunciator.
2. Elevator controller. Provide wiring to elevator controller for emergency source mode and emergency to normal pre-signal.
3. Generator start signal. The generator start signal cabling for the following transfer switches shall be fire protected for a minimum of 2 hours using an approved method:

a. Emergency, legally required, optional standby transfer switches
b.
c. Approved Methods:

1) Raceway or cable encased in a minimum of 2 inches of concrete cover.
2) Listed fire resistive raceway / cable system.
3) Raceway / cable is protected by a listed electrical circuit protective system.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION

SECTION 26 43 00 - SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes materials and installation requirements for factory and field wired low voltage surge protection devices (SPD) for the protection of all AC electrical circuits. SPD equipment to be installed at designated service entrance equipment, distribution panels, electronic equipment, elevators, and receptacle devices.

1.2 QUALITY ASSURANCE

A. The specified unit shall be designed, manufactured, tested and installed in compliance with the above references. The unit shall be "Listed by Underwriters Laboratories" to UL 1449.

B. Each unit shall be designed and manufactured by a qualified manufacturer of power conditioning equipment. The qualified manufacturer must have been engaged in the design and manufacturer of such products for a minimum of five years.

1.3 REFERENCES

A. ANSI/IEEE C62.33 - IEEE Guide on Testing of MOV components

B. ANSI/IEEE C62.35 - IEEE Guide on Testing of SAD components

C. ANSI/IEEE C62.41 - IEEE Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits

D. ANSI/IEEE C62.45 - IEEE Guide on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits

E. ANSI/UL 1449 Latest Edition - UL Standard for Safety for Surge Protective Devices

F. CBEMA - Computer Business Equipment Manufacturers Association

G. IEC 664 - International Engineering Consortium, Standard for Clamping Voltage

H. NFPA 70 - National Electrical Code (NEC)

I. CEC California Electrical Code

J. UL 67 - Listed for Internal Panelboard Transient Voltage Surge Suppressors

K. UL 96A - Devices listed as approved for secondary surge arrestors (VZCA)

L. UL 248-1 - Fusing

M. UL 1283 - Electromagnetic Interference Filters, Fifth Edition

1.4 SUBMITTALS

A. Shop Drawings: Should include device dimensions, mounting requirements including wire size and over-current protection device rating, nameplate nomenclature, electrical ratings, short circuit current rating, and test results as indicated below under "Testing, Warranty and Life Expectancy" as provided by an independent test lab or a UL certified test lab for the category(ies) of suppression device(s) specified using the appropriate IEEE test wave. Product data sheets with installation instructions for each size and type of device are required. Shop drawings submitted without the testing data as required by section this section will be rejected.

B. Fuse information: Provide fuse information if required for operation. Include size, manufacturer, time-current chart responses to UL 1449 testing requirements, maximum surge protection capability per mode and phase as limited by the fuse, and verification of repetitive surge protection device operation without system degeneration greater than 10%.

1.5 SPARE PARTS

A. Surge Protection Modules: Furnish 1 replacement module for each type installed.

B. Fuses: Furnish to the Owner 3 spare fuses of each type and rating installed.

1.6 TESTING, WARRANTY AND LIFE EXPECTANCY

A. Manufacturer must provide independent testing on repetitive capability and maximum surge current rating of service entrance suppressor units. This shall be performed at a nationally recognized lab not affiliated with the manufacturer.

1. Single pulse surge current capacity: Single pulse surge current tested in a mode at rated surge currents.
2. Single pulse surge current capacity test: An initial UL 1449 defined 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit's suppression voltage (VPR).
3. A single 8 x 20µs waveform pulse of maximum rated surge current per mode shall then be applied. To complete the test, another UL 1449 surge shall be applied to verify the unit's survival. Survival is achieved if the suppression voltage measured from the two UL1449 surges does not vary by more than 10%.

B. Minimum Repetitive Surge Current Capacity:

1. Service entrance suppressor units should be tested repetitively at an independent lab to verify repetitive capacity.
2. Minimum Repetitive Surge Current Capacity Test:

a. An initial UL 1449 surge defined as 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit's suppression voltage.
b. A repetitive number of ANSI/IEEE C62.41.2-2002 (Category C3) surges, defined as a 1.2 x 50µs 10kV or 20kV open circuit voltage waveform and an 8 x 20µs 10,000A short circuit current waveform, shall then be applied at one-minute intervals.
c. To complete the test, another UL 1449 surge shall be applied to verify the unit's survival.

3. Survival is achieved if the suppression voltage (VPR) does not vary by more than 10%.
4. Proof of such testing shall be the test log generated by the surge generator.

C. Provide UL 1449 classification white sheet pages indicating the VPR (voltage protection rating) for each SPD unit submitted for this product using the 6kV/3kA combination wave surge.

D. Warranty: Ten (10) years. Includes workmanship, installation and programming.

E. No scheduled parts replacement or preventative maintenance shall be required.

## PART 2 - PRODUCTS

### 2.1 DESCRIPTION

A. General: The unit shall provide transient voltage suppression, surge current diversion and high-frequency noise attenuation, when connected in parallel to the facilities distribution system. The unit MCOV shall not be less than 115% of the nominal system voltage. Operating frequency shall be for a 60 Hz system. The unit shall provide protection in all normal modes for "wye" and "delta" systems.

B. Short Circuit Current Rating: Provide factory label for SCCR rating. The short circuit current rating shall be the larger of the listed value on the drawings or as required by the equipment protected.

### 2.2 RATINGS

A. **SPD-#;** Service Entrance Suppressors:

1. For 277/480-volt, 3 phase, 4 wire, type 2, category C3 unit.

a. Surge current capacity: 100,000/200,000 amps per protection mode/phase
b. Nominal Discharge Current: 20 kA.
c. Mounting: Refer to the drawings.
d. Voltage Protection Rating: Refer to requirements below.
e. Components: Minimum component size of 20mm thermally protected metal oxide varistors (MOV).
f. Disconnect: Surge-rated disconnect with 200,000 SCCR.

2. Manufacturers:

    a. Square D Surgelogic EMA Series
    b. Siemens TPS3 Series
    c. Eaton SPD Series
    d. Current Technology Current Guard Plus

B. **SPD-#** Secondary Distribution Suppressors:

1. For 120/208-volt, 3 phase, 4 wire, type 2, category B3/C1 unit.

    a. Surge current capacity: 60,000/120,000 amps per protection mode/phase
    b. Nominal Discharge Current ($I_N$): 20 kA.
    c. Mounting: Refer to the drawings.
    d. Voltage Protection Rating: Refer to requirements below.
    e. Components: Minimum component size of 20mm metal thermally protected oxide varistors (MOV).

2. Manufacturers:

    a. Square D Surgelogic EMA Series
    b. Siemens TPS3 Series
    c. Eaton SPD Series
    d. Current Technology Current Guard Plus

## PART 3 - EXECUTION

### 3.1 INSPECTION

A. Examine equipment for size and type of surge protection device to be used to ensure physical compatibility.

B. Inspect surge protection device for any signs of physical damage due to shipping or handling before installing surge protection device.

### 3.2 INSTALLATION

A. Mounting Location:

1. The unit shall be installed as close as practical to the panel and transformer secondary lugs in accordance with applicable national/Local Electrical Codes and the manufacturer's recommended installation instructions. Connect the unit to the transformer or switchboard or panel using a conduit nipple. Flush mount the unit in the front of the switchboard. Mount unit directly across from the breaker or disconnect serving it.
2. Integral surge protection devices mount between the main and branch circuit breakers.
3. If internal surge protection device is specified, device shall be installed in a barrier compartment isolated from other components.

B. Connections:

1. Conductors from the protected bus to the unit shall not be any longer than necessary avoiding unnecessary bends. The conductor leads shall be twisted together and as short as possible. Connection shall be with mechanical lugs for each phase, neutral, and ground if applicable. Contractor shall provide wire and circuit breakers sized per the approved manufacturer's requirements. Maximum lead length from protected bus to surge protection device shall be per manufacturer's requirements, but no greater than 5'-0".
2. The surge protection unit shall be isolatable from the electrical distribution system via 3 pole circuit breaker mounted in the switchboard/panelboard or be equipped with a factory supplied integral fused switch or circuit breaker. Single phase 120-volt units shall be hardwired without a disconnecting means.
3. Neutral and ground shall not be bonded together at secondary panelboard locations.

C. Additional Locations: Critical Load Protection - Fixed Equipment (120 Vac):

1. Install an A3 hard-wired surge protection device between each of the following equipment items and its power supply conductors.

    a. Fire alarm master panel
    b. Building management system master

D. General:

1. Check unit for proper operation of protection and indication under start-up.
2. Check unit to ensure all MOVs for each mode of protection are operational. Verify integral fuse links are operational and have not melted.
3. Surge suppression devices shall not be installed ahead of the main service disconnect(s).
4. Install fuses in all fuse holders and fused disconnects internal to the surge protection unit. Use fuses recommended by the manufacturer to satisfy repetitive UL 1449 operation of the surge suppression unit. External fusing of the surge protection device is not allowed.
5. Coordinate location of surge protection device to allow adequate clearances for maintenance.
6. Manufacturer service phone number shall be posted on the front of the surge protection device.

END OF SECTION

SECTION 26 51 19 - LED LIGHTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Interior luminaires and accessories

B. Exterior luminaires and accessories

C. Light-emitting diode (LED) luminaire systems

D. LED emergency lighting units

E. Emergency exit signs

1.2 RELATED SECTIONS

A. The lighting system design includes a combination of luminaire sources, lighting control components, programming sequences, and supplementary components for building and energy code compliance. The design uses performance-based specifications for portions of the lighting system to account for the limitation of comparable product solutions available by competitive manufacturers. The Contractor shall reference related specification sections, plans, schedules, and details prior to submitting pricing, submittals, and installation. The Contractor shall coordinate system component compatibility among various manufacturers and suppliers for a turnkey lighting system. Referenced sections include, but are not limited to, the following:

1. 26 09 33 Lighting Control Systems

a. Automatic load control relay (ALCR) (individual luminaire - integral) (ALCR3)

2. 26 52 15 Emergency Lighting Inverter
3. Electrical drawings: Plans, luminaire schedules, lighting control sequence of operations, diagrams, and details.

1.3 REFERENCES

A. ANSI C78.377 - Specifications for the Chromaticity of Solid State Lighting Products

B. ANSI C82.16 - Light-Emitting Diode Drivers - Method of Measurement

C. ANSI C82.77 - Standard for Harmonic Emission Limits and Related Power Quality Requirements for Lighting Equipment

D. NFPA 70E - National Electrical Safety Code

E. NEMA SSL1 - Electronic Drivers for LED Devices, Arrays or System

F. UL 8750 - Light Emitting Diode (LED) Equipment for use in Lighting Products

G. LM-79 - Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products

H. LM-80 - Measuring Luminous Flux and Color Maintenance of LED

I. FS W-L-305 - Light Set, General Illumination (Emergency or Auxiliary)

J. UL 924 - Standard for Emergency Lighting and Power Equipment

K. UL676 Standard for Underwater Luminaires and Submersible Junction Box

L. Project site classification as defined in IESNA RP-33 LZ0.

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Basic Requirements of Submittal:

1. Submit product data sheets for luminaires, LED light engines, drivers and poles. Include complete product model number with all options as specified. Submittal shall be arranged with luminaires listed in ascending order, and with each luminaire's, LED light engine, driver, or pole information following luminaire's product data. Failure to organize submittal in this manner will result in the submittal being rejected.
2. Submit lens product data, dimensions and weights if not included in product data sheet submittal.
3. Include outline drawings, support points, weights, and accessory information for each luminaire.
4. Submit manufacturer origin of LED chipset and driver.

C. LED Lighting - Performance Testing Submittal (when requested by Architect/Engineer):

1. IESNA LM-79: Include photometric report for the latest generation system being furnished. Provide name of independent testing laboratory, report number, date of test, luminaire series/model number, input wattage, and light source specifications.
2. IESNA LM-80: Measuring Lumen Maintenance of LED Light Sources.

D. LED Lighting - Control Compatibility Submittal:

1. Submit lighting control capability data for each LED luminaire. The submittal shall clearly identify device data proposed by the Contractor and approved by the luminaire manufacturer for dimming, switching, addressable, wireless, and similar control characteristics.

E. Submit utility rebate forms where offered at project location. Submit completed rebate forms within 30 days of Substantial Completion.

1.5 EXTRA STOCK

A. Provide extra stock under provisions of Section 26 05 00.

B. LED Light Engines or Modules: 10 percent of quantity installed, minimum one (1) of each size and type of field replaceable light engine or module. Provide field replacement installation instructions.

C. Lenses: Three (3) percent of quantity installed, minimum one (1) of each size and type.

D. LED Drivers: **10** percent of quantity installed, minimum one (1) of each size and type.

E. Exit Signs: Provide **5 a**dditional exit sign luminaires complete with labor, conduit, and wire. Additional exit luminaires shall be located per the Architect/Engineer or provided as attic stock when a location is not defined prior to Owner occupancy. When multiple exit signs are scheduled, the quantity listed above shall represent each type listed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site. Store and protect under provisions of Section 26 05 00.

B. Protect luminaire finishes, lenses, and trims from damage during storage and installation. Do not remove protective films until construction cleanup within each area is complete.

C. Handle site lighting poles carefully to prevent breakage and damage to finish.

1.7 MOCKUP

A. Provide and install luminaires with power and control connections in mockup rooms as identified in Division 1. Approved luminaires in mockup may be reused as part of complete work if in original condition.

1.8 WARRANTY

A. The warranty period begins at the date of Substantial Completion.

B. LED Light Engines and Drivers:
1. LED Drivers and Dimming Drivers: Five (5) years
2. Light Emitting Diode (LED) Light Engines: Five (5) years

C. Emergency Lighting Units and Exit Signs:

1. Emergency Lighting Units: Three (3) year, non-prorated
2. Exit Signs: Three (3) year, non-prorated
3. Emergency Unit and Exit Sign Battery: Sealed lead acid or lead calcium cell, requiring no maintenance or replacement for ten (10) years under normal conditions.

D. Emergency Drivers:

1. Emergency LED Driver: Five (5) years

E. Emergency Inverter for LED Light Engines:

1. Emergency Inverter and Battery: Sealed nickel cadmium five (5) year, non-prorated.

F. Automatic Load Control Relay (ALCR): Five (5) year

G. Pole Finish: Three (3) year warranty of pole color and finish

1.9 REGULATORY REQUIREMENTS

A. Conform to NFPA 101 for installation requirements.

PART 2 - PRODUCTS

2.1 INTERIOR LUMINAIRES AND ACCESSORIES - GENERAL

A. Lensed Troffers: Provide hinged frames with latches and 0.125-inch thick virgin acrylic lenses. Prismatic lenses shall have depth of no less than 0.080", KSH12 or equal. Other lenses as scheduled.

B. Recessed Luminaires: Confirm ceiling and wall type and furnish trim and accessories necessary to permit proper installation in each system. Where fire-rated ceiling or wall assemblies are specified, furnish and install listed enclosures around luminaires that maintain the system rating.

C. Luminaires: Louvers shall be anodized low iridescent specular aluminum with mitered corners and interlocking construction.

D. Suspended Luminaires: Coordinate power feed and suspension canopies with ceiling type and architectural RCP for proper fit and location. Ensure finished installations are plumb and level at elevations specified. Verify suspension length prior to submittal.

E. Painted reflector surfaces shall have a minimum reflectance of 90%.

F. All painted components shall be painted after fabrication.

2.2 EXTERIOR LUMINAIRES AND ACCESSORIES - GENERAL

A. Listed for wet or damp location as scheduled. Provide ingress protection (IP) rating when scheduled.

B. Provide low temperature LED drivers, with reliable starting to -20°F.

C. In-grade luminaires shall have lamp/optic separation to prevent surface temperature from exceeding 115°F. Compartment separation of wire entry and control gear/lamp chamber.

D. Exterior LED luminaires shall contain separate, easily accessible and replaceable Category C surge protection device.

2.3 LIGHT EMITTING DIODE (LED) LUMINAIRE SYSTEMS

A. Light emitting diodes used in interior applications shall have a minimum color rendering index (CRI) of 90. The R9 color rendering value shall be a minimum of 50. Light emitting diodes used in exterior applications shall have a minimum color rendering index (CRI) of 70. Color temperature of the luminaires shall be as noted on the luminaire schedule. Provide light source color consistency by utilizing a binning tolerance within a maximum 3-step McAdam ellipse unless noted otherwise.

B. Refer to the luminaire schedule for color temperature and minimum color rendering index CRI requirements. Provide light source color consistency by utilizing a binning tolerance within a maximum 3-step McAdam ellipse unless noted otherwise.

C. LED chip arrays specified as color changing shall have chip colors as noted on the luminaire schedule.

D. Rated life shall be minimum of 50,000 hours at L70.

E. LED chips shall be wired so that failure of one chip does not prohibit operation of the remainder of the chip array.

F. Luminaire delivered lumens is defined as the absolute lumens per the manufacturers LM-79-08 test report.

G. LED luminaires shall be designed for ease of component replacement including modular replaceable boards or Zhaga sockets. Luminaires that are factory sealed and do not have field replaceable parts shall provide a 10-year warranty.

H. LED light engine shall have a maximum LLD of 0.85 at 50,000 hours at 25°C ambient.

I. LED Driver:

1. Solid state driver with integral heat sink. Driver shall have over-heat, short-circuit and overload protection, power factor 0.90 or above and maximum total harmonic distortion of 10%. Driver shall have a voltage fluctuation tolerance of +/- 10%.
2. Drivers shall have dimming capabilities as outlined in the luminaire schedule for each luminaire type. Dimming shall control light output in a continuous curve from 100% to 10% unless noted otherwise.
3. Driver shall have a minimum of 50,000 hours rated life.

4. Driver shall be tested to ANSI C82-16 for input current inrush, total harmonic distortion (THD), and power factor. Driver start time shall be less than 0.5 seconds to 98% of initial light output. Flicker should be less than 30% throughout the operating range.
5. Driver shall be field replaceable without removal of the luminaire.
6. Class A sound rating; inaudible in a 27 dBA ambient.
7. Demonstrate no visible change in light output with a variation of plus or minus 10 percent change in line-voltage input.

2.4 LED EMERGENCY LIGHTING UNITS

A. Self-Powered Emergency Lighting Units: One-piece, self-contained unit with sealed, maintenance-free nickel cadmium battery, automatic charger and electronic circuitry. Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

B. Battery: Maintenance free lead calcium type, with 120 minute capacity to supply the connected lamp load.

C. Charger: Dual-rate solid state current limiting charger, capable of maintaining the battery in a full-charge state during normal conditions, and capable of recharging discharged battery to full charged within 168 hours. Low voltage disconnect to prevent deep discharge of battery.

D. LED Lamp Wattage: As scheduled on luminaire schedule.

E. Remote Lamps: Match LED lamps on unit.

F. Indicators: Provide lamps to indicate AC ON and RECHARGING. Provide voltmeter.

G. Provide test switch to transfer unit from normal supply to battery supply.

H. Electrical Connection: Knockout for conduit connection.

I. Unit Voltage: Refer to luminaire schedule volts, AC.

J. Self-Diagnostics and Testing:

1. Unit shall be self-diagnostic with continuous monitoring of charger performance and battery voltage. Any malfunction of battery, charger, transfer circuit, or emergency lamps shall be detected and visually indicated.
2. Unit shall be programmed to exercise the battery and test emergency operation by performing a five-minute discharge/diagnostic cycle every six months. A manual test switch shall allow a five-minute discharge/diagnostic test at any time.

2.5 EMERGENCY EXIT SIGNS

A. Exit Signs: Stencil face, 6-inch high letters, directional arrows as indicated, universal mounting type as indicated on the drawings.

B. Self-Powered Exit Signs: Stencil face, 6-inch high letters, directional arrows as indicated, universal mounting type as indicated on the drawings. One-piece, self-contained unit with sealed, maintenance-free nickel cadmium battery, test switch, AC ON pilot light, automatic charger, and electronic circuitry. Power failure relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

C. Directional Indicators: The directional indicator for exit signage shall be of a chevron type meeting all requirements of NFPA 101.

D. Self-Diagnostics and Testing:

1. Unit shall be self-diagnostic with continuous monitoring of charger performance and battery voltage. Any malfunction of battery, charger, transfer circuit, or emergency lamps shall be detected and visually indicated.
2. Unit shall be programmed to exercise the battery and test emergency operation by performing a five-minute discharge/diagnostic cycle every six months. A manual test switch shall allow a five minute discharge/diagnostic test at any time.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Securely fasten luminaires to the listed and labeled ceiling framing member by mechanical means such as bolts, screws, rivets or listed clips identified for use with the type of ceiling framing members. The architectural ceiling framing system may be used in lieu of independent support with prior written approval by the ceiling system manufacturer and Authority Having Jurisdiction (AHJ). Luminaires and wiring installed in fire-rated ceiling assemblies shall be independently supported for all applications.

1. Install recessed flanged luminaires to permit removal from below. Use manufacturer-supplied plaster frames and swing gate supports. Provide independent support as follows:

a. Luminaires less than 56 lbs: Provide a minimum of two (2) #12 gauge suspended ceiling support wires located on diagonal corners of the luminaires.
b. Luminaires 56 lbs or greater: Provide a minimum of four (4) #12 gauge suspended ceiling support wires located on diagonal corners of the luminaires. Support luminaire independent of the ceiling system.
c. Luminaires larger than eight square feet (8 ft2): Support luminaire independent of the ceiling system.

B. Do not fasten luminaire supports to piping, ductwork, mechanical equipment, or conduit, unless otherwise noted. Support wires shall be tightly wrapped (minimum of three turns within 3 inches of the connection) and sharply bend to prevent vertical movement.

C. Support suspended or pendant mounted luminaires independent of ceiling grid with adjustable stainless steel aircraft cables or per luminaire schedule mounting requirements. Suspension assembly and anchors shall be capable of supporting 300 pounds dead load at each suspension point.

D. Support wire used to independently support luminaires, raceways, and wiring systems shall be distinguishable from ceiling support systems by color (field paint), tagging or equivalent means.

E. Provide seismic bracing of luminaires per IBC Chapter 16. Design pendant luminaires on a component seismic coefficient (Cc) of 0.67. Design vertical supports with a factor of safety of 4.0. Contractor shall verify the Seismic Hazard Exposure Group and Performance Criteria Factor.

F. Install lamps in lamp holders of luminaires.

G. Adjust aimable luminaires to obtain lighting levels on objects and areas as directed to obtain desired lighting levels.

H. Recessed luminaires and other optical accessories shall remain in protective wraps or films until construction in area is complete and area has been cleaned.

I. Industrial Pendant Luminaires: Use power hook hangers rated 500 pounds minimum or provide safety chain between driver and structure. Provide safety chain between reflector and driver.

J. Luminaire Pole Bases: Sized and constructed as indicated on the drawings. Project anchor bolts 2 inches minimum above base. Install poles plumb with double nuts for adjustment. Grout around pole anchor base.

K. Embedded Luminaire Poles: Depth as indicated. Install plumb.

L. Use belt slings or non-chafing ropes to raise and set pre-finished luminaire poles.

3.2 CONSTRUCTION USE OF PROJECT LUMINAIRES

A. The Contractor shall provide temporary construction lighting per the requirements of Division 1.

B. The project luminaires shown on the construction documents shall not be used for temporary construction purposes without providing a plan for Owner approval that addresses energy and luminaire operating hours.

3.3 AUTOMATIC LOAD CONTROL RELAYS

A. Factory or field installation per manufacturer requirements.

B. Remote Test Switch: Provide connection to remote test switch.

C. Fire Alarm Override: Provide connection to addressable fire alarm relay.

3.4 EMERGENCY LIGHTING UNITS AND EXIT SIGNS

A. Install units plumb and level.

B. Aim directional lamp heads as directed.

C. Test emergency lighting equipment for 60 minutes to determine proper operation, prior to Substantial Completion. Provide electronic copy of periodic test log form to Owner's Representative. Explain and instruct Owner's Representative of requirements for testing and maintenance. Refer to latest adopted NFPA 101 for testing and logging requirements.

3.5 RELAMPING

A. Replace failed LED light engine modules or arrays at completion of work.

3.6 ADJUSTING AND CLEANING

A. Align luminaires and clean lenses and diffusers at completion of work. Clean paint splatters, dirt, and debris from installed luminaires.

B. Touch up luminaire and pole finish at completion of work.

3.7 OWNER TRAINING

A. Test emergency lighting equipment for 60 minutes to determine proper operation, prior to Substantial Completion, with the Owner's Representative.

B. Provide electronic copy of periodic test log form to Owner's Representative. Explain and instruct Owner's Representative of requirements for testing and maintenance. Refer to latest adopted NFPA 101 for testing and logging requirements.

3.8 LUMINAIRE SCHEDULE

A. As shown on the drawings.

END OF SECTION

SECTION 27 05 00 - BASIC COMMUNICATIONS SYSTEMS REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Basic Communications Systems Requirements specifically applicable to Division 27 sections, in addition to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 REFERENCES

A. CCR California Code of Regulation

B. CBC California Building Code

C. CFC California Fire Code

D. CEC California Electric Code

E. CMC California Mechanical Code

F. CPC California Plumbing Code

G. California Title 24 - Building Energy Efficiency Standards

H. SCAQMD Southern California Air Quality Management Division

1.3 SCOPE OF WORK

A. This Specification and the associated drawings govern furnishing, installing, testing and placing into satisfactory operation the Communications Systems.

B. The Contractor shall furnish and install all new materials as indicated on the drawings, and/or in these specifications, and all items required to make the portion of the Communications Work a finished and working system.

C. All work will be awarded under a single General Contract. The division of work listed below is for the Contractor's convenience and lists normal breakdown of the work.

D. Description of Systems include, but are not limited to, the following:

1. Complete Structured Cabling System including, but not limited to:

a. Voice and data backbone cabling and terminations.
b. Voice and data horizontal cabling and terminations.
c. Information outlets (IOs) including faceplates, jacks and labeling.
d. Equipment racks, cabinets, cable management and equipment.

e. Telecommunication Room equipment including patch panels, optical distribution cabinets, and termination blocks.
f. Cabling pathways.
g. Grounding and Bonding
h. Testing

2. Complete Audio/Visual Systems.
3. Complete Paging Systems.
4. Mounting and patching of wireless access points provided by others.
5. Low Voltage Communications Wiring (less than +120VAC) as specified and required for proper system control and communications.
6. All associated electrical backboxes, conduit, miscellaneous cabling, and power supplies required for proper system installation and operation as defined in the "Suggested Matrix of Scope Responsibility".
7. Firestopping of penetrations as described in Section 27 05 03.
8. Seismic requirements as described in Section 26 05 48 "Seismic Requirements for Equipment and Supports".

1.4 DIVISION OF WORK BETWEEN ELECTRICAL AND COMMUNICATIONS CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described in the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described in the contract documents. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Electrical Contractor" as referred to herein refers to the Contractors listed in Division 26 of this Specification.
2. "Electrical Contractor" shall also refer to the Contractor listed in Division 27 of this specification when the "Suggested Matrix of Scope Responsibility" indicates the work shall be provided by the EC. Refer to the Contract Documents for the "Suggested Matrix of Scope Responsibility".
3. "Technology Contractor" as referred to herein refers to the Contractors listed in Division 27 of this Specification.
4. Low Voltage Technology Wiring: The wiring (less than 120VAC) associated with the Technology Systems, used for analog and/or digital signals between equipment.
5. Telecommunications/Technology Rough-in: Relates specifically to the backboxes, necessary plaster rings and other miscellaneous hardware required for the installation and mounting of the telecommunications/technology outlet. Rough-in shall include conduit from the information outlet backbox to above the lay-in ceiling. Where surface mounted backboxes are required, conduit shall be routed to above the lay-in ceiling.

C. General:

1. The purpose of these specifications is to outline typical Electrical and Technology Contractor's work responsibilities as related to technology systems including telecommunications rough-in, audio/visual systems rough-in, conduit, power wiring, and low voltage communications and technology wiring. The prime contractor is responsible for all divisions of work.
2. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals are approved. Therefore, only known wiring, conduits, raceways, and electrical power as related to such items, is shown on the technology drawings. Other wiring, conduits, raceways, junction boxes, and electrical power not shown on the technology drawings but required for the successful operation of the systems shall be the responsibility of the Technology Contractor and included in the Contractor's bid.
3. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of technology systems, the final installation shall not begin until a coordination meeting between the Electrical Contractor and the Technology Contractor has convened to determine the exact location and requirements of the installation.
4. This Contractor shall establish electrical and technology utility elevations prior to fabrication and installation. The Technology Contractor shall cooperate with the Electrical Contractor and the determined elevations in accordance with the guidelines below. This Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

    a. Lighting Fixtures
    b. Gravity Flow Piping, including Steam and Condensate
    c. Sheet Metal
    d. Electrical Busduct
    e. Sprinkler Piping and other Piping
    f. Conduit and Wireway
    g. Open Cabling

D. Electrical Contractor's Responsibility:

1. Assumes all responsibility for all required conduit and power connections when shown on the "Suggested Matrix of Scope Responsibility" to be provided by the Electrical Contractor.
2. Responsible for Communications Systems grounding and bonding.
3. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Technology Contractor's Responsibility:

1. Assumes all responsibility for the low voltage technology wiring of all systems, including cable support where open cable is specified.
2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being provided by the Electrical Contractor on the "Suggested Matrix of Scope Responsibility."
3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined herein).
4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of technology equipment which is required to be bonded to the technology bonding system.
5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.5 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

    a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.
    b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
    c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
    d. Maintenance clearances and code-required dedicated space shall be included.
    e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. Spaces with open/cloud ceiling architecture shall indicate the overhead utilities and locate equipment as required to maintain clearance above lights. The intent for the installation is to maintain a maximum allowable vertical clearance and an organized/clean manner in the horizontal. Notify Architect/Engineer of the maximum clearance which can be maintained. Failure to comply will result in modifications with no cost to Owner.

3. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.
2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

    a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of applicable drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

    a. Scale of drawings:

        1) General plans: 1/4 Inch = 1 '-0" (minimum).
        2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).
        3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).
        4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).
        5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.
3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.
4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.
2. A plotted set of coordination drawings shall be available at the project site.
3. Coordination drawings are not shop drawings and shall not be submitted as such.
4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.
5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.
6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.
7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.
8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.
9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

    a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.
    b. Potential layout changes shall be made to avoid additional access panels.
    c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.
    d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.
    e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain signoff of the drawings by all contractors prior to installing any of the components.
11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.
12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.6 QUALITY ASSURANCE

A. Telecommunications Structured Cabling System Standards:

1. All work and equipment shall conform to the most current ratified version of the following published standards unless otherwise indicated that draft standards are to be followed:

a. ANSI/NECA/BICSI 568 - Standard for Installing Commercial Building Telecommunications Cabling
b. ANSI/TIA-568-C.0 - Generic Telecommunications Cabling for Customer Premises

1) C.1 - Commercial Building Telecommunications Standard
2) C.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standard
3) C.3 - Optical Fiber Cabling Components Standard
4) C.4 - Broadband Coaxial Cabling and Components Standard

c. ANSI/TIA-569-C - Telecommunications Pathways and Spaces
d. ANSI/TIA-606-B - Administration Standard for Commercial Telecommunications Infrastructure
e. ANSI/TIA-607-B - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
f. ANSI/TIA-758-B - Customer-Owned Outside Plant Telecommunications Standard
g. ANSI/TIA-1152 - Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
h. ANSI/TIA/EIA-598-C - Optical Fiber Cable Color Coding
i. NFPA 70 (NEC) - National Electrical Code (Current Edition)
j. UL 444 - Standard for Safety for Communications Cable
k. California Electrical Code Article 725

B. Refer to individual sections for additional Quality Assurance requirements.

C. Qualifications:

1. Only products of reputable manufacturers as determined by the Architect/Engineer will be acceptable.
2. The installing Contractor shall be certified by the manufacturer of the structured cabling system. Certification of Contractor shall have been in place for a minimum of one (1) year prior to bidding this project. Documentation of certification is required at the time of bid. Shop drawings will not be approved until proof of certification is submitted. Refer to the end of this specification section for certification documentation requirements.
3. Each Contractor and their subcontractors shall employ only workers who are skilled in their respective trades and fully trained. All workers involved in the termination of cabling shall be individually certified by the manufacturer.

4. The Contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.
5. The Contractor shall own and maintain tools and equipment necessary for successful installation and testing of optical and copper structured cabling systems and have personnel adequately trained in the use of such tools and equipment.
6. The Contractor shall obtain the services of a BICSI RCDD (Registered Communications Distribution Designer) or CNet CNIDP (Certified Network Infrastructure Design Professional) for the project. The RCDD or CNIDP shall perform the following tasks on the project:

    a. Review contractor's submittals and stamp the submittals stating the submittals compliance with the contract documents.
    b. Provide written and dated confirmation of an observation of the contractor's installation activities no less than every month during the construction period.
    c. Provide a final written and dated confirmation of a final construction review prior to testing.
    d. Review final testing of system and indication that the documented results or transmittal of the results stating the test results compliance with the contract documents.

7. The Contractor shall have certified BICSI installation technicians or CNet CNIT (Certified Network Infrastructure Technician) on staff to perform the following tasks on the project:

    a. Act as the field superintendent or job foreman with the responsibility of monitoring the daily work of each technician.
    b. Oversee all testing and termination of cabling.

8. A resume of qualification shall be submitted with the Contractor's bid indicating the following:

    a. Documentation of certification of This Contractor by the proposed structured cabling system manufacturer as required at the end of this specification section.
    b. A list of test equipment proposed for use in verifying the installed integrity of copper and fiber optic systems on the project.
    c. Resume and certification of the RCDD or CNIDP for the project as required by the form at the end of this specification section.
    d. Resume and certification of the BICSI installation technician or CNet CNIT for the project.

D. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the State of California Codes, Laws, Ordinances and other regulations having jurisdiction.
2. Conform to all published standards of San Bernardino County.
3. In the event there are no local codes having jurisdiction over this job, the current issue of the National Electrical Code shall be followed.
4. If there is a discrepancy between the codes and regulations having jurisdiction over this installation, and these specifications, Architect/Engineer shall determine the method or equipment used.
5. If the Contractor notes, at the time of bidding, any parts of the drawings and specifications which are not in accordance with the applicable codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time to follow this procedure, he shall submit with the proposal, a separate price required to make the system shown on the drawings comply with the codes and regulations.
6. Verify the installation environment prior to purchasing or installing any cable. Cable installed in a plenum environment shall be appropriately rated. Bring all discrepancies between the contract documents and installation conditions to the attention of the Architect/Engineer prior to purchase or installation.
7. All changes to the system made after the letting of the contract, in order to comply with the applicable codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.

E. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.
2. Abide by all applicable laws, regulations, ordinances, and other rules of the State or Political Subdivision wherein the work is done, or as required by any duly constituted public authority.
3. Pay all applicable charges for such permits or licenses that may be required.
4. Pay all applicable fees and taxes imposed by the State, Municipal and/or other regulatory bodies.
5. Pay all charges arising out of required inspections due to codes, permits, licenses or as otherwise may be required by an authorized body.
6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized independent agency/consultant.
7. Pay any charges by the service provider related to the service or change in service to the project.
8. All equipment and materials shall be as approved or listed by the following (unless approval or listing is not applicable to an item by all acceptable manufacturers):

    a. Factory Mutual
    b. Underwriters' Laboratories, Inc.

F. Service Provider Requirements:

1. Secure from the telecommunications service provider all applicable requirements.
2. Comply with all service provider requirements.
3. The Owner shall make application for and pay for new telecommunications service equipment and installation. The Contractor shall coordinate schedule and requirements with the Owner and service provider.

G. Examination of Drawings:

1. The drawings for the technology systems work are diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment etc., and the approximate sizes of equipment.
2. Contractor shall determine the exact locations of equipment and the exact routing of cabling to best fit the layout of the job. Scaling of the drawings will not be sufficient or accurate for determining this layout. Where a specific route is required, such route will be indicated on the drawings.
3. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.
4. If an item is either shown on the drawings, called for in the specifications or required for proper operation of the system, it shall be considered sufficient for including same in this contract.
5. The determination of quantities of material and equipment required shall be made by the Contractor from the drawings. Schedules on the drawings and in the specifications are completed as an aid to the Contractor but where discrepancies arise, the greater number shall govern.
6. Where words "provide", "install", or "furnish" are used on the drawings or in the specifications, it shall be taken to mean, to furnish, install and terminate completely ready for operation, the items mentioned.

H. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.
2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.
3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by IMEG. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
4. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
5. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

6. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.
7. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

I. Field Measurements:

1. Before ordering any materials, this Contractor shall verify all pertinent dimensions at the job site and be responsible for their accuracy.
2. Field conditions that will result in telecommunications drops that exceed the length limitations identified in the contract documents shall be brought to the attention of the Architect/Engineer prior to installation. The cost of reworking cabling that is too long, that was not brought to the written attention of the Architect/Engineer will be borne entirely by the Contractor.
3. This Contractor shall provide the Architect/Engineer with written documentation of any cabling drops that will not be able to use the cable tray (where cable tray is available) due to the resulting cabling lengths. This documentation shall be submitted prior to installation and installation shall not commence until approved by the Architect/Engineer.

1.7 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

| Referenced Specification Section | Submittal Item | Coordination Drawings |
|---|---|---|
| 27 05 03 | Through Penetration Firestopping | |
| 27 05 26 | Communications Bonding | |
| 27 05 28 | Interior Communications Pathways | Yes |
| 27 05 43 | Exterior Communications Pathways | Yes |
| 27 05 53 | Identification and Administration | |
| 27 11 00 | Communication Equipment Rooms | Yes |
| 27 13 00 | Backbone Cabling Requirements | |
| 27 15 00 | Horizontal Cabling Requirements | |
| 27 17 10 | Testing | |
| 27 41 00 | Professional Audio Video System | Yes |
| 27 51 13 | Paging Systems | Yes |

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

    a. Date
    b. Project title and number
    c. Contractor's name and address
    d. Description of items submitted and relevant specification number
    e. Notations of deviations from the contract documents
    f. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

    a. Date
    b. Project title and number
    c. Architect/Engineer
    d. Contractor and subcontractors' names and addresses
    e. Supplier and manufacturer's names and addresses
    f. Description of item submitted (using project nomenclature) and relevant specification number
    g. Notations of deviations from the contract documents
    h. Other pertinent data
    i. Provide space for Contractor's review stamps

3. Composition:

    a. Submittals shall be submitted using specification sections and the project nomenclature for each item.
    b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).
    c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

5. Contractor's Approval Stamp:

    a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.
    b. Unstamped submittals will be rejected.
    c. The Contractor shall provide proof of RCDD or CNIDP review on the submittal.
    d. The Contractor's review shall include, but not be limited to, verification of the following:

        1) Only approved manufacturers are used.
        2) Addenda items have been incorporated.
        3) Catalog numbers and options match those specified.
        4) Performance data matches that specified.
        5) Electrical characteristics and loads match those specified.
        6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
        7) Dimensions and service clearances are suitable for the intended location.
        8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
        9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

    e. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.
    f. The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.

6. Submittal Identification and Markings:

    a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.
    b. The Contractor shall clearly indicate the size, finish, material, etc.
    c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.
    d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.
8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.
9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.
11. Submittals not required by the contract documents may be returned without review.
12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.
13. Submittals shall be reviewed and approved by the Architect/Engineer before releasing any equipment for manufacture or shipment.
14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.
15. Schedule shall allow for adequate time to perform orderly and proper review of submittals, including time for consultants and Owner if required, and resubmittals by Contractor if necessary, and to cause no delay in Work or in activities of Owner or other contractors.

    a. Allow at least two weeks for Architect's/Engineer's review and processing of each submittal.

16. Architect/Engineer reserves the right to withhold action on a submittal which, in the Architect/Engineer's opinion, requires coordination with other submittals until related submittals are received. The Architect/Engineer will notify the Contractor, in writing, when they exercise this right.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. Submittal file name: 27 XX XX.description.YYYYMMDD
    b. Transmittal file name: 27 XX XX.description.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.

1.8 CHANGE ORDERS

A. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders shall be broken down by sheet or associated individual line item indicated in the change associated narrative, whichever provides the most detailed breakdown. Change orders with inadequate breakdown will be rejected.

B. Itemized pricing with unit cost shall be provided from all distributors and associated subcontractors.

C. Change order work shall not proceed until authorized.

1.9 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to prevent damage to fixtures, equipment and materials.

B. Store materials on the site to prevent damage.

C. Keep fixtures, equipment and materials clean, dry and free from deleterious conditions.

1.10 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.11 WARRANTY

A. At a minimum, provide a one (1) year warranty for all equipment, materials, and workmanship. Individual specifications sections within Division 27 may require additional warranty requirements for specific equipment or systems.

B. The warranty period for the entire installation described in this Division of the specifications shall commence on the date of substantial completion unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner or their representative.

C. Warranty requirements shall extend to correction, without cost to the final user, of all work and/or equipment found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from such defects or nonconformance with contract documents exclusive of repairs required as a result of improper maintenance or operation, or of normal wear as determined by the Architect/Engineer.

1.12 INSURANCE

A. Contractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.13 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the first named manufacturer constitutes the basis for job design and establishes the equipment quality required.

B. Equivalent equipment manufactured by the other named manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meets all requirements of the drawings and specifications and fits in the allocated space. When using other listed manufacturers, the Contractor shall assume responsibility for any and all modifications necessary (including, but not limited to structural supports, electrical connections and rough-in, and regulatory agency approval, etc.) and coordinate such with other contractors. The Architect/Engineer shall make the final determination of whether a product is equivalent.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer via addendum. The Contractor bears full responsibility for the unnamed manufacturers equipment adequately meeting the intent of design. The Architect/Engineer may reject manufacturer at time of shop drawing submittal. The Contractor assumes all costs incurred by other trades on the project as a result of changes necessary to accommodate the offered material, equipment or installation method.

D. Should this Contractor be unable to secure approval from the Architect/Engineer for other unnamed manufacturers as outlined above, this Contractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder. Should a voluntary alternate material be accepted, This Contractor shall assume all costs that may be incurred as a result of using the offered material, article or equipment necessitating extra expense on This Contractor or on the part of other Contractors whose work is affected.

PART 2 - PRODUCTS

2.1 CABLE JACKET RATING

A. This project does not require all cable jackets to carry a plenum rating.

2.2 Refer to individual sections.

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employees and subconsultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Installation of all conduit and cabling shall comply with Sections 26 05 33 and 26 05 13. Additional conduit requirements described within this Division shall be supplemental to the requirement described in Section 26 05 33. Should conflicts exist between the two Divisions the more stringent (more expensive material and labor) condition shall prevail until bidding addendum or construction clarification or RFI can be submitted and responded to. In no case shall the Contractor carry the least stringent condition in the pricing.

B. It is the Contractor's responsibility to survey the site and include all necessary costs to perform the installation as specified.

C. The Contractor shall be responsible for identifying and reporting to the Architect/Engineer any existing conditions including but not limited to damage to walls, flooring, ceiling and furnishings prior to start of work. All damage to interior spaces caused by this Contractor shall be repaired at this Contractor's expense to pre-existing conditions, including final colors and finishes.

D. All cables and devices installed in damp or wet locations, including any underground or underslab location, shall be listed as suitable for use in such environments. Follow manufacturer's recommended installation practices for installing cables and devices in damp or wet locations. Any cable or device that fails as a result of being installed in a damp or wet location shall be replaced at the Contractor's expense.

3.3 FIELD QUALITY CONTROL

A. General:

1. Refer to specific Division 27 sections for further requirements.
2. The Contractor shall conduct all tests required and applicable to the work both during and after construction of the work.
3. The necessary instruments and materials required to conduct or make the tests shall be supplied by the Contractor who shall also supply competent personnel for making the tests who has been schooled in the proper testing techniques.
4. In the event the results obtained in the tests are not satisfactory, This Contractor shall make such adjustments, replacements and changes as are necessary and shall then repeat the test or tests which disclose faulty or defective work or equipment, and shall make such additional tests as the Architect/Engineer or code enforcing agency deems necessary.
5. All communications cable tests that fail, including those due to excessive cabling lengths, shall be remedied by the Contractor without cost to the project.

B. Protection of cable from foreign materials:

1. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.
2. Application of foreign materials of any kind on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

3.4 PROJECT CLOSEOUT

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. The Architect/Engineer will not perform a final jobsite observation until the project is ready. This is not dictated by schedule, but rather by completeness of the project.
2. Refer to the end of this specification section for a "STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION."
3. The Contractor shall sign this form and return it to the Architect/Engineer so that the final observation can commence.

C. Before final payment will be authorized, this Contractor must have completed the following:

1. Submitted operation and maintenance manuals to the Architect/Engineer for review.
2. Submitted bound copies of approved shop drawings.
3. Record documents including edited drawings and specifications accurately reflecting field conditions, inclusive of all project revisions, change orders, and modifications.
4. Submitted a report stating the instructions given to the Owner's representative complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representative as having received the instructions.
5. Submitted testing reports for all systems requiring final testing as described herein.
6. Submitted start-up reports on all equipment requiring a factory installation inspection and/or start.
7. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site; submit receipt to Architect/Engineer prior to final payment being approved.
8. Provide System Assurance Warranty certificate for the telecommunications system.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.
2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. O&M file name: O&M.div27.contractor.YYYYMMDD
    b. Transmittal file name: O&Mtransmittal.div27.contractor.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.
6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.
7. All text shall be searchable.
8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.
2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.
3. Copies of all final approved shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.
4. Copy of final approved test and balance reports.
5. Copies of all factory inspections and/or equipment startup reports.
6. Copies of warranties.
7. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
8. Dimensional drawings of equipment.
9. Capacities and utility consumption of equipment.
10. Detailed parts lists with lists of suppliers.

11. Operating procedures for each system.
12. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
13. Repair procedures for major components.
14. List of lubricants in all equipment and recommended frequency of lubrication.
15. Instruction books, cards, and manuals furnished with the equipment.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. Adequately instruct the Owner's designated representative or representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representative or representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The Architect/Engineer shall be notified of the time and place for the verbal instructions to be given to the Owner's representative so that their representative can be present if desirable.

E. Refer to the individual specification sections for minimum hours of instruction time for each system.

F. Operating Instructions:

1. The Contractor is responsible for all instructions to the Owner and/or Owner's operating staff on the Communications Systems.
2. If the Contractor does not have Engineers and/or Technicians on staff who can adequately provide the required instructions on system operation, performance, troubleshooting, care and maintenance, they shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 SYSTEM STARTING AND ADJUSTING

A. The Communications Systems included in the construction documents are to be complete and operating systems. The Architect/Engineer will make periodic job site observations during the construction period. The system start-up, testing, configuration, and satisfactory system performance is the responsibility of the Contractor. This shall include all calibration and adjustments of electrical equipment controls, equipment settings, software configuration, troubleshooting and verification of software, and final adjustments that may be required.

B. All operating conditions and control sequences shall be simulated and tested during the start-up period.

C. The Contractor, subcontractors, and equipment suppliers are expected to have skilled technicians to ensure that the system performs as designed. If the Architect/Engineer is requested to visit the job site for the purpose of trouble shooting, assisting in the satisfactory start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period through no fault of the design; the Contractor shall reimburse the Owner on a time and material basis for services rendered at the Architect/Engineer's standard hourly rates in effect at the time the services are requested. The Contractor shall be responsible for making payment to the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.8 RECORD DOCUMENTS

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Mark specifications to indicate approved substitutions, change orders, and actual equipment and materials used.

C. This Contractor shall maintain at the job site, a separate and complete set of technology drawings which shall be clearly and permanently marked and noted in complete detail any changes made to the location and arrangement of equipment or made to the Technology Systems and wiring as a result of building construction conditions or as a result of instructions from the Architect or Engineer. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable. Should This Contractor fail to complete Record Documents as required by this contract, This Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer's hourly rates in effect at the time of work.

D. Record actual routing of all conduits sized 2" or larger.

E. The above record of changes shall be made available for the Architect and Engineer's examination during any regular work time.

F. Upon completion of the job, and before final payment is made, This Contractor shall give the marked-up drawings to the Architect/Engineer.

3.9 ADJUST AND CLEAN

A. Contractor shall thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Contractor shall clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from equipment.

C. Contractor shall remove all rubbish, debris, etc., accumulated during the Contractor's operations from the premises.

3.10 SPECIAL REQUIREMENTS

A. Adhesives and Sealants: All sealers, adhesives, and sealants shall comply with the low emitting material limits of the following standards: CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions VOC from Indoor Sources Using Environmental Chambers Version 1.1.
   1. South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications. All adhesives and sealants wet-applied on site shall comply with the applicable chemical content requirements of SCAQMD Rule 1168.

B. South Coast Air Quality Management District Rule SCAQMD 1113 - Wet Applied Paints and Coatings. All paints and coatings wet-applied on site must meet the applicable VOC limits of SCAQMD Rule 1113.

STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION

To assist the contractor in a timely close-out of the project, it is crucial that the final jobsite observation is not conducted prior to the project being ready. The contractor is required to review the completion status of the project at the time the observation is scheduled. This review, and the subsequent submittal of this form to the Architect/Engineer, shall indicate the contractor's agreement that the area of the project being requested for final observation is ready as defined below. The following list represents the degree of completeness required prior to requesting a final observation:

1. All cabling pathways (cable tray, ladder rack, conduit sleeves, etc.) are installed and all cabling has been pulled through them.
2. All mechanical firestop products are installed and all other penetrations have been sealed.
3. All telecommunications jacks are installed in the faceplates.
4. All telecommunications cabling is pulled and at least 75% of all jacks have been terminated at the jack and at the telecom room.
5. Telecommunications testing is in progress and at least 25% of testing has been completed.
6. Telecommunications labeling has been provided on at least 25% of each type of component requiring a label.
7. All telecommunications related grounding is complete.
8. All Audio/Visual components, cabling and control systems are installed, programmed and operational.
9. All overhead or integrated paging systems, including speakers, back boxes, cabling, and power supplies, and all headend equipment is installed, programmed and operational.

Prime Contractor: _____ By: _____

Requested Observation Date _____ Today's Date: _____

Contractor shall sign this readiness statement and transmit to Architect/Engineer at least 10 days prior to the requested date of observation.

It is understood that if the Architect/Engineer finds that the project is not complete as defined above and that the final jobsite observation cannot be completed on the requested date, the Architect/Engineer will return to the site at a later date. All additional visits to the site for the purposes of completing the final observation will be billed T&M to the Contractor at our standard hourly rates, including travel expenses or the contractor's retainage may be deducted for the same amount.

TELECOMMUNICATIONS - PROOF OF CERTIFICATION

There are specific Contractor qualification requirements for this project as defined in Section 27 05 00, which may include Manufacturer Certification and RCDD or CNIDP credentials. This Proof of Certification document, and the supporting documentation require herein, is required to be submitted at the time of bid to show compliance with the requirements of 27 05 00.

Statement of Compliance:
The named Contractor's base bid is a structured cabling solution from the connectivity manufacturer _____. Named Contractor is trained and certified, under the named manufacturer's formal certification program to provide and install all materials and

work required by this project. Further, said Contractor is authorized, by the named manufacturer, to offer all product, labor and system assurance warranties required for this project by these contract documents.

The certification of this named manufacturer is valid, current and in effect as of the bid day of this project, the _____ day of _____, 20____.

The named Contractor is not employing any other sub-contractor on the telecommunications portion of this project that does not also meet this certification requirement.

Contractor Company Name:
_____

Authorized Representative: (print)
_____

Date: _____
Manufacturer Certification Number (if any): _____

If this project requires RCDD certification, complete the following:

RCDD or CNIDP Name: _____
RCDD #: _____ Expiration: _____

Submit the following with the bid:
This form.
Proof of Manufacturer Certification indicated above.
Proof of RCDD or CNIDP status.

END OF SECTION

SECTION 27 05 03 - THROUGH PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this Section.

B. Installer: Individuals performing work shall be certified by the manufacturer of the system selected for installation.

1.2 REFERENCES

A. UL 263 - Fire Tests of Building Construction and Materials

B. UL 723 - Surface Burning Characteristics of Building Materials

C. ANSI/UL 1479 - Fire Tests of Through Penetration Firestops

D. UL 2079 - Tests for Fire Resistance of Building Joint Systems

E. UL Fire Resistance Directory Through Penetration Firestop Systems (XHEZ)

F. Intertek / Warnock Hersey - Directory of Listed Products

G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials

H. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Firestops

I. CBC California Building Code

J. The Building Officials and Code Administrators National Building Code

K. 1997 Uniform Building Code

L. 2021 International Building Code

M. NFPA 5000 – Building Construction Safety Code

1.3 SUBMITTALS

A. Submit under provisions of Section 27 05 00.

B. Submit Firestopping Installers Certification for all installers on the project.

C. Shop Drawings: Submit for each condition requiring firestopping. Include descriptions of the specific penetrating item, actual wall/floor construction, manufacturer's installation instructions, and UL or Intertek / Warnock Hersey Assembly number.

D. Through-Penetration Firestop System Schedule: Indicate locations of each through-penetration firestop system, along with the following information:

1. Types of penetrating items.
2. Types of constructions penetrated, including fire-resistance ratings and, where applicable, thicknesses of construction penetrated.
3. Through-penetration firestop systems for each location identified by firestop design designation of qualified testing and inspecting agency.
4. F ratings for each firestop system.

E. Maintain a notebook on the job site at all times that contains copies of approved submittals for all through penetration firestopping to be installed. Notebook shall be made available to the Authority Having Jurisdiction at their request and turned over to the Owner at the end of construction as part of the O&M Manuals.

F. Submit VOC rating of firestopping material in g/L (less water) with documentation that it meets the limits set forth in SCAQMD Rule 1168.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store, protect and handle products on site. Accept material on site in factory containers and packing. Inspect for damage. Protect from deterioration or damage due to moisture, temperature changes, contaminants, or other causes. Follow manufacturer's instructions for storage.

B. Install material prior to expiration of product shelf life.

1.5 PERFORMANCE REQUIREMENTS

A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

1. Fire-resistance-rated walls including fire partitions, fire barriers, and smoke barriers.
2. Fire-resistance-rated horizontal assemblies including floors, floor/ceiling assemblies, and ceiling membranes of roof/ceiling assemblies.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per UL 1479:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.

C. For through-penetration firestop systems exposed to light, traffic, moisture, or physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

E. For through-penetration firestop systems in air plenums, provide products with flame-spread and smoke-developed indexes of less than 25 and 50, respectively, as determined per ASTM E 84.

1. Adhesives and Sealants: All sealers, adhesives, and sealants shall comply with the low emitting material limits of the following standards: CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions VOC from Indoor Sources Using Environmental Chambers Version 1.1.
2. South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications. All adhesives and sealants wet-applied on site shall comply with the applicable chemical content requirements of SCAQMD Rule 1168.
3. South Coast Air Quality Management District Rule SCAQMD 1113 - Wet Applied Paints and Coatings. All paints and coatings wet-applied on site must meet the applicable VOC limits of SCAQMD Rule 1113.

1.6 MEETINGS

A. Pre-installation meeting: A pre-installation meeting shall be scheduled and shall include the General Contractor, all Subcontractors associated with the installation of systems penetrating fire barriers, Firestopping Manufacturer's Representative, and the Owner.

1. Review foreseeable methods related to firestopping work.
2. Tour representative areas where firestopping is to be installed; inspect and discuss each type of condition and each type of substrate that will be encountered, and preparation to be performed by other trades.

1.7 WARRANTY

A. Provide one year warranty on parts and labor.

B. Warranty shall cover repair or replacement of firestop systems which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability, or appear to deteriorate in any manner not clearly specified by the manufacturer as an inherent quality of the material.

PART 2 - PRODUCTS

2.1 THROUGH PENETRATION FIRESTOP SYSTEMS

A. Provide materials and systems classified by or listed by Intertek / Warnock Hersey to provide firestopping equal to time rating of construction being penetrated.

B. All firestopping materials shall be free of asbestos, lead, PCB's, and other materials that would require hazardous waste removal.

C. Firestopping shall be flexible to allow for normal penetrating item movement due to expansion and contraction.

D. Provide firestopping systems capable of supporting floor loads where systems are exposed to possible floor loading or traffic.

E. Provide firestopping systems allowing continuous insulation for all insulated pipes.

F. Provide firestopping systems classified by UL or listed by Intertek / Warnock Hersey for penetrations through all fire rated construction. Firestopping systems shall be selected from the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory Category XHEZ based on substrate construction and penetrating item size and material and shall fall within the range of numbers listed.

G. Any opening in walls or floors shall be coordinated with the firestopping manufacturer.

H. Any openings in floors or walls not described in the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory or outlined in manufacturer's information shall be sealed in a manner agreed upon by the Firestopping Manufacturer, Owner, and the Authority Having Jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Ensure all surfaces that contact seal materials are free of dirt, dust, grease, oil, rust, or loose materials. Clean and repair surfaces as required. Remove laitance and form-release agents from concrete.

B. Ensure substrate and penetrating items have been permanently installed prior to installing firestopping systems. Ensure penetrating items have been properly spaced and have proper clearance prior to installing firestopping systems.

C. Surfaces to which sealing materials are to be installed must meet the selected UL or Intertek / Warnock Hersey system substrate criteria.

D. Prime substrates where recommended in writing by through-penetration firestop system manufacturer. Confine primer to area of bond.

3.2 INSTALLATION

A. Install penetration seal materials in accordance with printed instructions of the UL or Intertek / Warnock Hersey Fire Resistance Directory and with the manufacturer's printed application instructions.

B. Install dams as required to properly contain firestopping materials within openings and as required to achieve required fire resistance rating. Remove combustible damming after appropriate curing.

3.3 CLEANING AND PROTECTING

A. Clean excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not cause damage.

B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

3.4 INSPECTION

A. All penetrations shall be inspected by the manufacturer's representative to ensure proper installation.

B. Access to firestop systems shall be maintained for examination by the Authority Having Jurisdiction at their request.

C. Proceed with enclosing through-penetration firestop system with other construction only after inspection reports are issued and firestop installations comply with requirements.

D. The contractor shall allow for visual destructive review of 5% of installed firestop systems (minimum of one) to prove compliance with specifications and manufacturer's instructions and details. Destructive system removal shall be performed by the contractor and witnessed by the Architect/Engineer and manufacturer's factory representative. The Architect/Engineer shall have sole discretion of which firestop system installations will be reviewed. The contractor is responsible for all costs associated with this requirement including labor and material for removing and replacing the installed firestop system. If any firestop system is found to not be installed per manufacturer's specific instructions and details, all firestop systems are subject to destructive review and replacement at the Architect/Engineer's discretion and the contractor's expense.

END OF SECTION

SECTION 27 05 26 - COMMUNICATIONS BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bonding Conductors

B. Bonding Connectors

C. Grounding Busbar (PBB and SBB)

D. Rack-mount Telecommunications Grounding Busbar

1.2 RELATED WORK

A. Section 26 05 33 - Conduit and Boxes

B. Section 26 05 13 - Wire and Cable

C. Section 26 05 26 - Grounding and Bonding

D. Section 27 05 00 - Basic Communications Systems Requirements

E. Section 27 05 03 - Through Penetration Firestopping

F. Section 27 11 00 - Communication Equipment Rooms

G. Section 27 05 28 - Interior Communication Pathways

H. Section 27 05 53 - Identification and Administration

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

B. Communications bonding system component, device, equipment, and material manufacturer(s) shall have a minimum of five (5) years documented experience in the manufacture of communications bonding products.

C. The entire installation shall comply with all applicable electrical codes, safety codes, and standards. All applicable components, devices, equipment, and material shall be listed by Underwriters' Laboratories, Inc.

1.4 REFERENCES

A. ANSI/IEEE 1100 - Recommended Practice for Power and Grounding Sensitive Electronic Equipment in Industrial and Commercial Power Systems

B. ANSI/TIA 568-C - Commercial Building Telecommunications Cabling Standard

C. ANSI/TIA 569-A - Commercial Building Standard for Telecommunications Pathways and Spaces

D. ANSI/TIA 606 - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

E. ANSI/TIA 758 - Customer Owned Outside Plant

F. ANSI/TIA-607-D - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

G. IEEE 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements

H. IEEE 837 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding

I. NFPA 70 - National Electrical Code

J. NFPA 780 - Standard for the Installation of Lightning Protection Systems

K. UL 96 - Lightning Protection Components

L. UL 96A - Installation Requirements for Lightning Protection Systems

M. UL 467 - Grounding and Bonding Equipment

1.5 SUBMITTALS

A. Submit product data and shop drawings under provisions of Section 27 05 00 and Division 1.

B. Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

1. Compliance with each requirement of these documents. The submittal shall acknowledge each requirement of this section, item-by-item, including construction, materials, ratings, and all other parameters identified in Part 2 - Products.
2. Manufacturer's installation instructions indicating application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

C. Provide CAD-generated, project-specific system shop drawings as follows:

1. Provide a system block diagram indicating system configuration, system components, interconnection between components, and conductor routing. The diagram shall clearly indicate all wiring and connections required in the system. When multiple devices or pieces of equipment are required in the exact same configuration (e.g., multiple identical equipment racks or sections of ladder tray), the diagram may show one device and refer to the others as "typical" of the device shown. The diagram shall list room numbers where system equipment will be located.
2. Installation details for all system components.

D. Provide system checkout test procedure to be performed at acceptance.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under the provisions of Section 27 05 00.

B. Store and protect products under the provisions of Section 27 05 00.

C. Contractor shall exercise care to prevent corrosion of any products prior to installation. Corroded products shall not be acceptable for use on this project.

1.7 SYSTEM DESCRIPTION

A. This section describes the requirements for the furnishing, installation, adjusting, and testing of a complete turnkey communications bonding system, including connection to the electrical ground grid.

B. Performance Statement: This specification section and the accompanying drawings are performance based, describing the minimum material quality, required features, operational requirements, and performance of the system. These documents do not convey every wire that must be installed, every equipment connection that must be made, or every feature and function that must be configured. Based on the equipment constraints described and the performance required of the system as presented in these documents, the Contractor is solely responsible for determining all components, devices, equipment, wiring, connections, and terminations required for a complete and operational system that provides the required performance.

C. This document describes the major components of the system. All additional hardware, subassemblies, supporting equipment, and other miscellaneous equipment required for complete, proper system installation and operation shall be provided by the Contractor.

D. Basic System Requirements:

1. A complete communications bonding infrastructure is required for this project. Refer to the drawings and the requirements of ANSI-J-STD-607-D and NFPA 70 for complete information.
2. The bonding system shall include, but not be limited to, the following major components:

a. Telecommunications Bonding Conductor (TBC)
b. Primary Bonding Busbar (PBB)
c. Telecommunications Bonding Backbone (TBB)
d. Secondary Bonding Busbar(s) (SBB)
e. Rack mount Telecommunications Grounding Busbar(s)
f. Bonding Conductor(s) (BC)
g. Bonding Connectors
h. Bonding system labeling and administration as defined in Section 27 05 53.

1.8 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 27 05 00.

B. Provide final system block diagram showing any deviations from approved shop drawing submittal.

C. Provide floor plans that document the following:

1. Actual locations of system components, devices, and equipment.
2. Actual conductor routing.
3. Actual system component, device, equipment, and conductor labels.

D. Provide statement that system checkout test, as outlined in the approved shop drawing submittal, is complete and test results were satisfactory.

E. Complete all operation and maintenance manuals as described below.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 27 05 00.

B. Submitted data shall include:

1. Approved shop drawings.
2. Descriptions of recommended system maintenance procedures, including:

a. Inspection
b. Periodic preventive maintenance
c. Fault diagnosis
d. Repair or replacement of defective components

PART 2 - PRODUCTS

2.1 BONDING CONDUCTORS

A. Bare Copper:

1. Annealed uncoated stranded conductor.
2. Minimum size 6 AWG.

B. Insulated Copper:

1. Annealed uncoated stranded conductor.
2. Insulation:

   a. PVC insulation with nylon outer jacket.
   b. Rated at 600 volts.
   c. Green.

3. Minimum size 6 AWG.

C. All bonding conductors shall be listed and recognized by a nationally recognized testing laboratory as being suitable for the intended purpose and for installation in the space in which they are installed.

D. Bonding Conductor Sizing:

1. All communications bonding system conductors shall be sized by length as follows:

| Length<br>Linear ft (m) | Size<br>(AWG) |
|---|---|
| Less than 13 (4) | 6 |
| 14 - 20 (4 - 6) | 4 |
| 21 - 26 (6 - 8) | 3 |
| 27 - 33 (8 - 10) | 2 |
| 34 - 41 (10 - 13) | 1 |
| 42 - 52 (13 - 16) | 1/0 |
| 53 - 66 (16 - 20) | 2/0 |
| 67 - 84 (20 - 26) | 3/0 |
| 85 - 105 (26 - 32) | 4/0 |
| 106 - 125 (32 - 38) | 250 kcmil |
| 126 - 150 (38 - 46) | 300 kcmil |
| 151 - 175 (46 - 53) | 350 kcmil |
| 176 - 250 (53 - 76) | 500 kcmil |
| 251 - 300 (76 - 91) | 600 kcmil |
| Greater than 301 (91) | 750 kcmil |

2. The TBC shall be the same size as the TBB or larger.

2.2 BONDING CONNECTORS

A. Acceptable Types:

1. Two-hole compression lug
2. Exothermic weld
3. Irreversible compression

B. Connectors shall be provided in kit form and selected per manufacturer's written instructions.

C. Connectors shall comply with IEEE 837 and UL 467 and be listed for use for specific types, sizes, and combinations of conductors and connected items.

2.3 GROUNDING BUSBAR (PBB AND SBB)

A. Features:

1. Wall-mount configuration.
2. Listed and recognized by a nationally recognized testing laboratory as being suitable for intended purpose.
3. Hole patterns compliant with BICSI recommendations and ANSI-J-STD-607-D standards.
4. Predrilled holes.
5. Integral insulators.
6. Stainless steel offset mounting brackets.

B. Specifications:

1. Material: Electrolytic tough pitch copper bar with tin plating.
2. Refer to drawings for grounding busbar size(s).

a. Minimum Dimensions: Refer to drawings.
b. Increase dimensions and/or quantity furnished and installed as required to accommodate all terminations required by the project, plus 20% spare capacity.
c. Hole patterns on busbars accommodate two-hole lugs per the recommendation of ANSI/BICSI N3-20 and ANSI/TIA-607 standards.

2.4 RACK-MOUNT TELECOMMUNICATIONS GROUNDING BUSBAR

A. Features:

1. Listed and recognized by a nationally recognized testing laboratory as being suitable for intended purpose.
2. Predrilled holes.
3. Mounts in a standard 19" equipment rack.

B. Specifications:

1. Material: Electrolytic tough pitch copper bar with tin plating.
2. Minimum Dimensions: 3/16" thick x 3/4" high x 19" long.

    a. Increase dimensions and/or quantity furnished and installed as required to accommodate all terminations required by the project, plus 20% spare capacity.

3. Hole pattern shall include:

    a. A minimum of eight (8) 6-32 tapped lug mounting holes on 1" centers.
    b. A minimum of two (2) pairs of 5/16" diameter holes spaced 3/4" apart.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Bonding Requirements:

1. The communications bonding system shall be a complete system. Contractor shall furnish and install all necessary miscellaneous components, devices, equipment, material, and hardware, including, but not limited to, lock washers, paint-piercing washers, hex nuts, compression lugs, insulators, mounting screws, lugs, etc., to provide a complete system.
2. A licensed electrician shall perform all bonding.
3. Comply with the manufacturer's instructions and recommendations for installation of all products.

B. Main Cross Connect and Service Entrance Room Bonding Requirements:

1. Locate the PBB in the service entrance room unless otherwise noted on the drawings.
2. The location of the PBB shall be the shortest practical distance from the telecommunications primary lightning protection devices.
3. Bond the telecommunications primary protectors to the PBB. Maintain a minimum 1 foot separation of the bonding conductor from all DC power cables, switchboard cable, and high frequency cable.

C. Where the service entrance cable contains a shield, the shield(s) shall be bonded to the PBB using manufacturer-approved hardware.

D. Primary Bonding Busbar (PBB) Requirements:

1. Install PBB such that it is insulated from its support with a minimum 2" standoff.
2. Bond the PBB to the electrical service ground via the TBC.

    a. A minimum of 1 foot separation shall be maintained between the TBC and any DC power cables, switchboard cable, or high frequency cables.

3. Where backbone or horizontal cabling contains a shield, the shield(s) shall be bonded to the PBB.
4. PBB shall be bonded to all electrical panels located in the same room or space as the PBB. PBB shall be bonded to all electrical panels providing electrical power to communications equipment located in the same room or space as the PBB.
5. PBB shall be bonded to accessible metallic building structure located within the same room or space as the PBB.
6. All metallic continuous cable pathways, including, but not limited to, cable trays, basket trays, ladder racks, raceways, conduits, conduit sleeves, and fire-rated cable pathway devices, located within the same room or space as the PBB, shall be bonded to the PBB.
7. All metallic communications equipment, including, but not limited to, cable pair protectors, surge suppressors, cross-connect frames, patch panels, equipment cabinets, etc., located within the same room or space as the PBB, shall be bonded to the PBB.

E. Secondary Bonding Busbar (SBB) Requirements:

1. Provide a SBB in each telecommunications equipment room.
2. Install SBB such that it is insulated from its support with a minimum 2" standoff.
3. Bond each SBB to the PBB via the TBB.

    a. A minimum of 1 foot separation shall be maintained between the TBB and any DC power cables, switchboard cable, or high frequency cables.
    b. The TBB may be routed from PBB to SBB or as a radial feed to each SBB as the layout requires.

4. If more than one (1) SBB is provided within the same room or space, they shall all be bonded together via a BC the same size as the TBB.
5. Where horizontal cabling contains a shield, the shield(s) shall be bonded to the SBB.
6. SBBs shall be bonded to accessible metallic building structure located within the same room or space as the SBBs.
7. SBBs shall be bonded to all electrical panels located in the same room or space as the SBB. SBBs shall be bonded to all electrical panels providing electrical power to communications equipment located in the same room or space as the SBB.
8. All metallic continuous cable pathways, including, but not limited to, cable trays, basket trays, ladder racks, raceways, conduits, conduit sleeves, and fire-rated cable pathway devices, located within the same room or space as the SBB, shall be bonded to the SBB.
9. All metallic communications equipment, including, but not limited to, cable pair protectors, surge suppressors, cross-connect frames, patch panels, equipment cabinets, etc., located within the same room or space as the SBB, shall be bonded to the SBB.

F. Rack Bonding Busbar Requirements (RBB):

1. Provide a rack-mount telecommunications ground bar in each equipment rack and equipment rack enclosure.
2. Install RBB such that it is electrically bonded to the rack. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond between RBB and equipment rack.
3. Bond each RBB to the PBB/SBB via a telecommunications equipment bonding conductor (TEBC).
4. If more than one (1) RBB is provided within the same room or space, they shall all be bonded together via a TEBC.
5. Where horizontal cabling containing a shield is terminated on rack-mounted termination hardware, the shield(s) shall be bonded to the RBB.
6. All contractor-furnished and/or contractor-installed metallic communications equipment, including, but not limited to patch panels, fiber optic distribution enclosures, splice enclosures, active electronics, uninterruptible power supplies, etc., mounted within the same equipment rack as the RBB, shall be bonded to the RBB. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond between equipment rack and installed metallic communications equipment. Active electronics and uninterruptible power supplies shall be bonded to the RBB via a dedicated unit bonding conductor (UBC) for each device.

G. Metallic Interior Communication Pathway Bonding Requirements:

1. All metallic interior continuous communication cable pathways, including, but not limited to, conduit, conduit sleeves, fire-rated cable pathway devices, cable tray, basket tray, and ladder rack, shall be bonded to the communications bonding system.

H. Bonding Conductor Requirements:

1. Bonding conductors shall be green or marked with a distinctive green color.
2. Bonding conductors shall be routed parallel and perpendicular to building structure along shortest and straightest paths possible. Number of bends and changes in direction should be minimized. Install and secure conductors in a manner that protects the conductors from impact and from physical or mechanical strain or damage.
3. Bonding conductors shall not be installed in metallic conduit.

4. All conductors, including, but not limited to, the TBC, TBB, BBC, and TEBC(s), shall be installed splice-free. If the Contractor believes that site conditions do not allow a splice-free installation, the Contractor may request permission from the Architect/Engineer to splice a specific communications bonding system conductor.

    a. Where documented permission to splice a conductor is granted:

        1) The number of splices shall be limited to as few as possible.
        2) Splices shall be made using exothermic welding or irreversible compression-type connections only. Splice hardware shall be listed for grounding and bonding. Solder is not an acceptable means of splicing conductors.
        3) Splices shall be made in telecommunications spaces in accessible locations to facilitate future inspection and maintenance.
        4) Splices shall be adequately supported and protected from impact and from physical or mechanical strain or damage.

5. All bonding conductors shall be labeled in accordance with the requirements of Section 27 05 53. In addition to the requirements of Section 27 05 53:

    a. Labels shall be nonmetallic.
    b. Labels shall be printer-generated.
    c. Labels shall be located on conductors as close as is practical to their point of termination in a readable position.
    d. Additionally, conductors shall be labeled as follows:

        1) "IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER."

6. Interior water piping is not acceptable for use as a communications bonding system bonding conductor.
7. Metallic cable shields are not acceptable for use as communications bonding system bonding conductors.

I. Bonding Connection Requirements:

1. Make all connections in accessible locations to facilitate future inspection and maintenance.
2. Communications bonding system connections shall be made using exothermic welding, two-hole compression lugs, or other irreversible compression-type connections. The use of 1-hole lugs is prohibited, except for connections to a rack-mount telecommunications ground bar. Connection hardware shall be listed for grounding and bonding. Sheet metal screws shall not be used to make communications bonding system connections.
3. Thoroughly clean conductors before installing lugs and connectors.

4. Install and tighten all connectors in accordance with manufacturer's instructions, using the appropriate purpose-designed tool(s) recommended by the manufacturer for that purpose. Exercise care not to tighten connectors beyond manufacturer's recommendations.
5. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond at all connections.
6. All bonding connections shall be coated in anti-oxidant joint compound that is purpose-designed and purpose-manufactured for that use. Anti-oxidant joint compound shall be applied in accordance with manufacturer's recommendations and instructions.
7. All installed connectors on conductors installed in damp locations shall be sealed with dielectric grease and then covered with heat shrink tubing to protect against moisture ingress. Applied heat shrink tubing shall overlap conductor's outer jacket a minimum of four (4) inches past connector and be installed in accordance with manufacturer's recommendations and instructions.

3.2 FIELD QUALITY CONTROL

A. Field inspection and testing shall be performed under provisions of Section 27 05 00.

B. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product from a reputable manufacturer that meets the requirements of the specifications.

C. Periodic observations will be performed during construction to verify compliance with the requirements of the specifications. These services do not relieve the Contractor of responsibility for compliance with the contract documents.

3.3 ADJUSTING

A. Adjust work under provisions of Section 27 05 00.

B. Contractor shall make any and all adjustments to the communications bonding system necessary to ensure that the installed system meets all requirements listed herein. Modifications necessary to comply with listed requirements or to provide specified performance shall be completed by the Contractor at no additional cost to the Owner.

3.4 TESTING

A. Measure and document resistance to ground at PBB, each SBB, each RBB, and each electrical distribution panel bonded to the PBB or a SBB.

1. Measurements shall be made not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage, and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the fall-of-potential method according to IEEE 81.
2. The preferred measured resistance to ground for the grounding electrode system is 5 ohms or less. Refer to Division 26 for exact project requirements.

3. Under no circumstances shall any point in the communications bonding system have a lower resistance to ground than that of nearby electrical distribution system components that it is bonded to.

B. Two-point Ground/Continuity Test:

1. Two-point ground continuity test shall be performed per TIA-607D standards.
2. Contractor shall use an earth ground resistance tester to confirm a resistance of less than 100 milliohms between the building's electrical grounding electrode system and any other point in the telecommunications bonding system.
3. At a minimum, perform tests in the following areas:

    a. PBB to the electrical ground in distributors
    b. Each SBB to the electrical ground in distributors
    c. PBB/SBB to the structural metal (if present)
    d. PBB to SBB(s)
    e. Structural metal (if present) to the electrical ground

4. Complete testing prior to installation of Owner-provided equipment.

C. Measure and document voltage between screen of installed and terminated ScTP, FTP, and/or SSTP horizontal cables and electrical ground of electrical outlet(s) serving the information outlet location area.

D. Include measurement documentation in test data submitted at completion of project under provisions of Section 27 17 10.

3.5 SYSTEM TRAINING

A. All labor and materials required for on-site system training shall be provided. Training shall be conducted at the project site using the project equipment.

1. Provide two weeks' advanced notice of training to the Owner and Architect/Engineer.
2. The Architect/Engineer shall be presented with the option to attend the training.
3. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

B. At a minimum, the following training shall be conducted:

1. A course detailing the system functions and operations that a technical user will encounter. Provide training on all aspects of using the system, including making new bonding connections to the PBB, SBB, or RBB. Provide training on all recommended inspection, maintenance, and repair procedures for the system.

C. Minimum on-site training times shall be:

1. Technical user: Four hours.

END OF SECTION

SECTION 27 05 28 - INTERIOR COMMUNICATION PATHWAYS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 33 - Conduit and Boxes

B. Section 27 05 00 - Basic Communications Systems Requirements

C. Section 27 05 26 - Communications Bonding

1.2 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for requirements.

1.3 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.
2. Manufacturer's installation instructions.

B. Coordination Drawings:

1. Include conduit sleeve layout in composite electronic coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

1.5 DRAWINGS

A. The drawings, which constitute a part of these specifications, indicate the general route of conduit, sleeves, etc. Data presented on these drawings is as accurate as preliminary surveys and planning can determine until final equipment selection is made. Accuracy is not guaranteed and field verification of all dimensions, routing, etc., is required.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Refer to Section 26 05 33 for conduit requirements for this project.

2.2 CABLE HANGERS AND SUPPORTS

A. Provide a non-continuous cable support system suitable for use with open cable.

B. Cable Hooks:

1. Construction: Flat bottom design with a minimum cable bearing surface of 1-5/8". Hooks shall have 90-degree radius edges.
2. All cable hook mounting hardware shall be recessed to prevent damage to cable during installation. Installed cabling shall be secured using a cable latch retainer that shall be removable and reusable.
3. Finish: Pre-galvanized steel, ASTM A653 suitable for general duty use.

C. Cable Hangers:

1. Adjustable, non-continuous cable support slings for use with low voltage cabling.
2. Steel and woven laminate construction, rated for indoor non-corrosive use. Laminate material shall be suitable for use in plenum environments.
3. Sling length shall be adjustable to a capacity of 425 4-pair UTP cables.
4. Cabling hanger load limit shall be 100 lbs per foot.
5. Manufacturer:

a. Erico Caddy
b. CableCat CAT425
c. Arlington Fittings TI Series
d. Or approved equal.

2.3 INNERDUCT - CORRUGATED

A. Fabricated from self-extinguishing high-impact polyvinyl chloride (PVC), orange in color.

B. Fittings and accessories fabricated from same material as conduit and usable with rigid nonmetallic conduit.

C. Solvent-cement type joints as recommended by manufacturer.

D. Inside diameter not less than that of rigid steel conduit.

E. Dielectric strength a minimum of 400 volts per mil.

F. Corrugated wall construction.

G. Pull rope pre-installed by manufacturer.

H. Innerduct installed within buildings (not including riser paths) or utility tunnels shall meet all the above General requirements plus:

1. Be fabricated of flame-retardant materials (plenum rated) suitable for installation in such environments.
2. Meet or exceed all requirements for flame resistant duct as required by Bellcore TR-NWT-000356 (Section 4.33).

I. Innerduct installed within building riser shafts shall meet all the above general requirements plus:

1. Be fabricated of flame-retardant materials suitable for installation in such environment.

J. Meet or exceed all requirements for flame propagation as specified by test method UL-1666 and referenced by the National Electrical Code (NEC) Section 770-53 for listed optical fiber raceways being installed in vertical runs in a shaft between floors.

## PART 3 - EXECUTION

### 3.1 INNER DUCT INSTALLATION REQUIREMENTS

A. Inner duct shall be riser or plenum rated as required by the installation environment. At minimum, inner duct should extend to the ladder rack above the termination enclosure at system endpoints. Where not installed in a continuous length, inner duct segments should be spliced using couplings designed for that purpose.

B. All exposed inner duct is to be labeled at 35-foot intervals with tags indicating ownership, the cable type (e.g., "Fiber Optic Cable") and the cables it contains (e.g., MA-CS or FS-CS).

C. Where exposed, fiber optic cable shall be installed in protective inner duct.

D. Contractor shall determine optimum size and quantity to satisfy the requirements of the installation and to ensure that the mechanical limitations, including minimum bend radius of the cable, are considered.

E. The inner duct should extend into the termination enclosure at system endpoints.

F. Where not installed in a continuous length, inner duct segments should be spliced using couplings designed for that purpose.

### 3.2 CABLE HOOK SUPPORT SYSTEM

A. In areas where cabling is not supported by ladder rack, enclosed wireway or installed in conduit, such cabling shall be supported by an approved cable hook support system.

B. Refer to manufacturer's requirements for allowable fill capacity for selected cable hook. In no case shall a 40% fill capacity be exceeded.

C. Cable hooks shall be securely mounted per manufacturer's instructions. In no case shall the side-to-side travel of any cable hook exceed 6".

D. Cable hooks shall be selected based on the contractor's cable routing. Hooks shall be capable of supporting a minimum of 30 pounds with a safety factor of 3.

E. J-hook support spans shall be based on the smaller of the manufacturer's load ratings and code requirements. In no case shall horizontal spans exceed 5 feet and vertical spans exceed 4 feet.

F. The resting and supporting of cabling on structural members shall not meet the requirements for cabling support specified herein.

G. The use of tie-wraps or hook and loop type fasteners is specifically prohibited as a substitute for cable hooks specified herein.

3.3 CONDUIT AND CABLE ROUTING

A. Refer to Section 26 05 33 for additional requirements.

B. All conduits shall be reamed and shall be installed with a nylon bushing.

C. Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of less than 2", maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter 2" or greater, maintain a bend radius of at least 10 times the internal diameter.

D. No conduit or sleeve containing more than two (2) cables shall exceed 40% fill ratio, regardless of length.

E. Any conduit exceeding 90' in length or containing more than two (2) 90-degree bends shall contain a pull box sized per ANSI/TIA/EIA 569 requirements.

1. A separate pull box is required for each 90' (or greater) length section.
2. A separate pull box is required after any two (2) consecutive 90-degree bends.
3. Pull box shall be located in an area that maintains accessibility of box, including the ability to remove box lid without removal or relocation of any other materials.

F. Any conduit with bends totaling 90 degrees or more shall have the fill capacity derated by 15% for each 90 degrees of cumulative bend.

G. Cables installed in any conduits that do not meet the above requirements shall be replaced at the Contractor's expense, after the conduit condition has been remedied.

3.4 ATTACHMENT TO METAL DECKING

A. Where supports for cable trays and cable hook systems attach to metal roof decking, excluding concrete on metal decking, do not exceed 25 lbs. per hangar and a minimum spacing of 2'-0" on center. This 25-lb. load and 2'-0" spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

END OF SECTION

SECTION 27 05 43 - EXTERIOR COMMUNICATION PATHWAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements relating to furnishing and installing exterior racks, ladders, conduits, sleeves, innerduct, etc. for an exterior cabling plant.

1.2 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

1.3 REFERENCES

A. Section 27 05 00 - Basic Communications Systems Requirements.

B. ANSI/ASTM A153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

C. ASTM A123 - Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strips.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.
2. Manufacturer's installation instructions.

B. Submit shop drawings and product data under provisions of Section 27 05 00.

C. Submit manufacturer's installation instructions under provisions of Section 27 05 00.

D. Coordination Drawings:

1. Include hand holes and conduits 1.5" and larger in coordination files. Include all in-floor and underfloor conduit in coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

1.5 REGULATORY REQUIREMENTS

A. Equipment and material shall be UL (Underwriters Laboratory) listed and labeled.

PART 2 - PRODUCTS

2.1 OUTSIDE PLANT CONDUIT

A. Rigid Metallic Conduit (RMC) and Fittings:

1. Rigid steel conduit hot-dipped galvanized inside and out with threaded ends meeting ANSI C80.1.
2. Fittings and Conduit Bodies:

a. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.
b. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.
c. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete tight.
d. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. High impact phenolic threaded type bushings are not acceptable.
e. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

3. Manufacturers:

a. Allied
b. LTV
c. Steelduct
d. Wheatland Tube Co
e. O-Z Gedney
f. Or pre-approved equal

B. Rigid Non-Metallic Conduit (RNC) and Fittings:

1. UL listed, NEMA TC2 and TC6 Schedule 40 or 80 rigid polyvinyl chloride (PVC) approved for direct burial without concrete encasement.
2. Fittings: NEMA TC3 and TC9, sleeve type suitable for and manufactured especially for use with the conduit by the conduit manufacturer.
3. Plastic cement for joining conduit and fittings shall be provided as recommended by the manufacturer.
4. Manufacturers:

a. Carlon (Lamson & Sessions) Type 40
b. Cantex
c. J.M. Mfg.
d. or pre-approved equal

C. High-Density Polyethylene (HDPE) Conduit:

1. Minimum Size: 2 inches, unless noted otherwise.
2. Acceptable Manufacturers:

    a. Carlon
    b. Chevron Phillips Chemical Company
    c. or pre-approved equal.

3. Materials used for the manufacture of polyethylene pipe and fittings shall be extra high molecular weight, high-density polyethylene resin. The material shall be listed by PPI (Plastic Pipe Institute) and shall meet the following resin properties:

| ASTM Test | Description | Values HDPE |
|---|---|---|
| D-1505 | Density g/CM 3 | Less than 0.941 |
| D-1238 | Melt Index, g/10 min Condition E | Greater than 0.55 grams/10 min. |
| D-638 | Tensile Strength at yield (psi) | 3000 min. |
| D-1693 | Environmental Stress Crack Resistance Condition B, F 20 | 96 hrs. |
| D-790 | Flexural Modulus, MPa (psi) | Less than 80,000 |
| D-746 | Brittleness Temperature | -75°C Max |

4. The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same raw material, including both the base resin and coextruded resin. The pipe shall be homogeneous throughout and free of visible cracks, holes, voids, foreign inclusions, or other defects that may affect the wall's integrity.
5. Fitting and Conduit Bodies:
    a. Directional Bore and Plow Type Installation: Electrofusion or universal aluminum threaded couplings. Tensile strength of coupled pipe must be greater than 2,000 lbs.
    b. For All Other Types of Installation: Coupler must provide a watertight connection. The tensile strength of coupled pipe must be greater than 1,000 lbs.
    c. E-loc type couplings are not acceptable in any situation.
    d. Acceptable Manufacturers:

        1) ARCON
        2) Carlon
        3) or approved equal.

D. Fittings:

1. Sweeps: Factory manufactured RMC wrapped with 4 mil vinyl tape with a bend radius as follows:

   a. Conduit internal diameter of 2" or less is 6 times the internal conduit diameter.
   b. Conduit internal diameter of more than 2" is 10 times the internal conduit diameter.

2. End Caps (Plugs): Pre-manufactured and watertight. Tape is not an acceptable end cap or cover.

2.2 HAND-HOLES

A. Type:

1. Polymer concrete

B. Dimensions:

1. As indicated on the drawings.

C. Requirements:

1. Includes polymer concrete cover.

D. Acceptable Manufacturers

1. Quazite
2. Old Castle Precast Christy®®
3. New Basis.

2.3 TEXTILE INNERDUCT

A. Contractor shall provide and install innerduct in each conduit identified to have copper and fiber optic cable installed.

B. Innerduct shall have an 18-gauge solid copper core tracer wire installed into each cell to allow for detection by industry standard toning equipment.

C. Each innerduct cell shall have a pull tape installed.

D. Acceptable Manufacturers:

1. Maxcell
2. or pre-approved equal.

2.4 UNDERGROUND WARNING TAPE

A. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, compounded for direct-burial service.

B. Overall Thickness: 5 mils.

C. Foil Core Thickness: 0.35 mil.

D. Orange colored tape 3-wide with 1-inch-high black letters permanently imprinted with "CAUTION "" BURIED COMMUNICATIONS LINE BELOW". Printing on tape shall be permanent and shall not be damaged by burial operations.

E. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

F. Comply with ANSI Z535.1 through ANSI Z535.5.

PART 3 - EXECUTION

3.1 INSTALLATION - DUCTBANK

A. Make duct bank installations and penetrations through foundation walls watertight.

B. Top of duct banks shall be a minimum of 24 inches below grade, unless otherwise indicated on drawings.

C. Assemble duct banks using non-magnetic saddles, spacers and separators. Position separators to provide 3-inch minimum separation between the outer surfaces of the ducts.

D. Transition from non-metallic to galvanized rigid steel conduit where duct banks enter buildings, manholes, and hand-holes.

E. Where ducts enter structures such as hand-holes, pullboxes and buildings, terminate the ducts in suitable end bells.

F. Slope duct runs for drainage toward manholes and away from buildings with a slope of approximately 3-inches per 100 feet.

G. After completion of the duct bank and prior to pulling cable, pull a mandrel, not less than 12 inches long and with a cross section approximately 1/4 inch less than the inside cross section of the duct, through each duct. Then pull a rag swab or sponge through to make certain that no particles of earth, sand, or gravel have been left in the duct.

H. Plug and seal empty spare ducts entering buildings and structures. Seal watertight all ducts in use entering buildings and structures.

3.2 INSTALLATION - HAND-HOLES

A. Install gravel drainage bed a minimum of 6" depth below hand-hole using a minimum gravel size of 1 inch.

B. Provide units and/or extensions as required by conduit depth for hand-hole cover to be flush with finished grade.

C. Slope grade away from cover with a slope of approximately 1 inch in 3 feet.

D. Conduit entry penetrations shall not exceed 25% of side wall area.

3.3 INSTALLATION - TEXTILE INNERDUCT

A. Provide two (2) 3-cell innerducts per 4" conduit or as recommended by the manufacturer.

B. Install innerduct per manufacturer's guidelines.

C. Cut and tie off innerduct and pull tape inside each communications vault or Entrance Room.

3.4 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. The Contractor shall do all necessary excavating, securing, filling, backfilling, compacting, and restoration in connection with their work.

B. Excavation:

1. Excavations for trenches shall be excavated to proper dimensions to permit installation and inspection of work.
2. Where excavations are carried in error below indicated levels, thoroughly compacted sand-gravel fill, shall be placed in such excess excavations.
3. Excavations shall be protected against frost action and freezing.
4. Care shall be exercised in excavating so as to not damage surrounding structures, equipment, and buried utilities. In no case shall any major structural footing or foundation be undermined.
5. Excavation shall be performed in all ground characteristics, including rock, if encountered. Each bidder shall visit the premises and determine, by actual observations, borings, or other means, the nature of the soil conditions. The cost of all such inspections, borings, etc., shall be borne by the bidder.
6. In the case where the trench is excavated in rock, a compacted bed with a depth of 3" (minimum) of sand and gravel shall be used to support the conduit unless masonry cradles or encasements are used.
7. Where satisfactory bearing soil is not found at the indicated levels, the Architect/Engineer or their representative shall be notified immediately and no further work shall be done until further instructions are given.

8. Mechanical excavation of the trench to line and grade of the conduit, unless otherwise indicated on the drawings.

C. Dewatering:

1. The Contractor shall be responsible for the furnishing, installation, operation and removal of all dewatering pumps and lines necessary to keep the excavation free of water at all times.

D. Underground Obstructions:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found by calling 811. The Contractor is responsible for obtaining all utility locates for all trades on the project to determine obstructions indicated. The Contractor shall use great care in installing in the vicinity of underground obstruction.

E. Fill and Backfilling:

1. No rubbish or waste material shall be permitted in excavations for trench fill and backfill.
2. The Contractor shall provide the necessary sand for backfilling.
3. Dispose of the excess excavated earth as directed.
4. Soils for backfill shall be suitable for required stability and compaction, clean and free from perishable materials, frozen earth, debris or earth with an exceptionally high void content, and free from stones greater than 4 inches in diameter. Under no circumstances shall water be permitted to rise in unbackfilled trenches after installation has been placed.
5. All trenches shall be backfilled immediately after installation of conduit, unless other protection is directed.
6. All conduit shall be laid on a compacted bed of sand at least 3" deep. Backfill around the conduit with sand, spread in 6" layers, then compact each layer.
7. Use sand for backfill up to grade for all conduit located under building slabs or paved areas. Native soil materials may be used as backfill if approved by the Geotechnical Engineer. All other conduit shall have sand backfill to 6" above the top of the conduit.
8. The backfilling above the sand shall be placed in uniform layers not exceeding 6" in depth. Each layer shall be placed, then carefully and uniformly tamped, so as to eliminate the possibility of lateral or vertical displacement.
9. Install a warning tape approximately 12 inches below finished grade over all underground duct banks. The identifying warning tape shall be as specified above.
10. Where the fill and backfilling will ultimately be under a building, floor or paving, each layer of fill shall be compacted to 95% of the maximum density as determined by AASHTO Designation T-99 or ASTM Designation D-698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content as determined by AASHTO T-99 or ASTM D-698 test.

11. After backfilling of trenches, no superficial loads shall be placed on the exposed surface of the backfill until a period of 48 hours has elapsed.

3.5 RESTORATION REQUIREMENTS

A. Where soil and sod has been removed, it shall be replaced as soon as possible after backfilling is completed. All areas disturbed by work shall be restored to their original condition. The restoration shall include any necessary topsoiling, fertilizing, liming, seeding, or mulching,

END OF SECTION

SECTION 27 05 53 - IDENTIFICATION FOR COMMUNICATION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the identification requirements relating to the structured cabling system and its termination components and related subsystems.

B. Identification and labeling.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

B. Perform all work in accordance with San Bernardino County standard.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Documentation of labeling scheme.

PART 2 - PRODUCTS

2.1 LABELING

A. Adhesive labels shall meet the requirements of UL 969 (Ref D-16) for legibility, defacement and adhesion. Exposure requirements of UL 969 for indoor and outdoor (as applicable) use shall be met.

B. Insert labels shall meet the requirements of UL 969 for legibility, defacement and general exposure.

C. Labeling shall be consistent for all common elements in the project. This consistency shall include label size, color, typeface and attachment method.

D. Labels incorporating bar codes shall be either Code 39 conforming to USS-39 or Code 128 conforming to USS-128.

1. All Code 39 bar codes shall have a ratio between 2.5:1 and 3.0:1. Provide a minimum "quite zone" of 0.25" on each side of the bar code.
2. A descriptive label for reading by personnel shall be provided with any bar code. Bar codes by themselves are not acceptable.

E. Color Code: Observe the following requirements for color coding:

1. Labels on each end of a cable shall be the same color for each termination.
2. Labels for cross-connects shall be two different colors at each termination field, representative of the color of that field.
3. Orange (Pantone 15C) shall be used for the demarcation point.
4. Green (Pantone 353C) shall be used for the termination point of network connection on the facility side of the demarc.
5. Purple (Pantone 264C) shall be used to identify the termination of cables from common equipment (PBX, computers, LANS, etc.)
6. White shall be used to identify the first-level backbone termination in the main cross-connect.
7. Gray (Pantone 422C) shall be used to identify the second-level backbone termination in the main cross-connect.
8. Blue (Pantone 291C) shall be used to identify the termination of station cabling at the telecommunications closet and/or equipment room end of the cable.
9. Brown (Pantone 465C) shall be used to identify the termination of the interbuilding backbone cable terminations.
10. Yellow (Pantone 101C) shall be used to identify the termination of auxiliary circuits, alarms, maintenance, security, etc.
11. Red (Pantone 184C) shall be used to identify the termination of key telephone systems.
12. In facilities that do not contain a main cross-connect, the color white may be used to identify second-level backbone terminations.

F. Tag all CAT 3, CAT 5E, CAT 6, and optical fiber cables at both the Communications Equipment Room and the information outlets using the following alphanumeric labeling system:

1. (Room Number) - (Outlet Number) - (Jack Number) - (Use).
2. "Outlet Number" shall start with 1 in each room, with additional outlets in each room numbered sequentially.
3. "Jack Number" shall start with 1 for the upper left jack in each outlet, increasing sequentially from left to right and top to bottom across the outlet face.
4. "Use" shall be designated by the following:

    a. "V" for voice (RJ-45)
    b. "D" for data (RJ-45)
    c. "C" for video (coax)
    d. "M" for multimedia retrieval (coax)
    e. "S" for speaker (RCA)

5. Example #1: "106-1-1-V" indicates the top left voice jack in outlet #1 in Room 106.
6. Example #2: "109-3-4-D" indicates the bottom right data jack (assuming a 4-port faceplate) in outlet #3 in Room 109.

2.2 DOCUMENTATION/AS-BUILTS/RECORDS

A. General:

1. Upon completion of the installation, the Contractor shall submit as-builts per the requirements of Section 27 05 00 and Division 1. Documentation shall include the items detailed in the subsections below.
2. All documentation, including hard copy and electronic forms shall become the property of the Owner.

B. Record Drawings:

1. The drawings are to include cable routes and outlet locations. Outlet locations shall be identified by their sequential number as defined elsewhere in this document. Numbering, icons and drawing conventions used shall be consistent throughout all documentation provided.

PART 3 - EXECUTION

3.1 IDENTIFICATION AND LABELING

A. Cable Labeling:

1. Horizontal cables shall be labeled at each end.

a. Cables that differ only by performance class shall have a suitable marking or label to indicate the higher performance class. For example, station cabling utilizing the blue color may include blue with a white stripe to indicate the higher performance class station cabling.

2. Backbone cables shall be labeled at each end.

a. Provide additional cable labeling at each manhole and pull box.
b. Cables that are routed through multiple pathway segments shall contain reference to all pathway segments in the pathway linkage field.
c. Cables that differ only by performance class shall have a suitable marking or label to indicate the higher performance class. For example, station cabling utilizing the blue color, may include blue with a white stripe to indicate the higher performance class station cabling.

B. Information Outlet Labeling: Tag all voice and data jacks as defined herein.

END OF SECTION

SECTION 27 11 00 - COMMUNICATION EQUIPMENT ROOMS (CER)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements related to furnishing and installing equipment for communication equipment rooms.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements

B. Section 27 05 26 - Communications Bonding

C. Section 27 05 28 - Interior Communication Pathways

D. Section 27 15 00 - Horizontal Cabling Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for applicable standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.
2. Manufacturer's installation instructions.

B. Coordination Drawings:

1. Include ladder racking, equipment racks and conduit sleeve layout in composite electronic coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

PART 2 - PRODUCTS

2.1 EQUIPMENT GROUNDING

A. Refer to specification section 27 05 26 for grounding requirements.

B. All equipment required to be grounded shall be provided with a grounding lug suitable for termination of the specified size electrode conductor.

## 2.2 EQUIPMENT RACKS AND CABINETS

A. Where identified on the drawings in Communication Equipment Rooms, equipment racks and/or equipment cabinets shall be furnished and installed by the Contractor to house cable termination components (e.g., copper, optical fiber, coax) and network electronics.

B. The equipment rack shall conform to the following requirements:

1. Standard TIA/EIA 19" Floor Rack:

    a. Equipment rack shall be 84" in height, self-supporting and provide a usable mounting height of 45 rack units (RU) (1 RU = 1 3/4").
    b. Channel uprights shall be spaced to accommodate industry standard 19" mounting.
    c. Equipment rack shall be double side drilled and tapped to accept 12-24 screws. Uprights shall also be drilled on back to accept cable brackets, clamps, power strip(s), etc. Hole pattern on rack front shall be per TIA/EIA specifications (5/8"-5/8"-1/2"). Hole pattern on the rear shall be at 3" intervals to accept cable brackets.
    d. Equipment racks shall be provided with a supply of spare screws (minimum of 24).
    e. Equipment racks shall be provided with a ground bar and #6 AWG ground lug.
    f. Provide all mounting hardware and accessories as required for complete installation.

2. Swing Gate TIA/EIA 19" Wall Rack:

    a. Equipment rack shall be 48" in height and provide a usable mounting height of 26 RU. Rack shall be a minimum of 18" deep.
    b. Wall-mounted equipment racks shall be provided with a swing-gate assembly to allow rear access of rack-mounted equipment.
    c. Equipment rack shall support up to 300 lbs. when securely mounted to a wall or backboard.
    d. Provide all mounting hardware and accessories as required for complete installation.

## 2.3 CABLE MANAGEMENT - VERTICAL AND HORIZONTAL

A. Equipment Racks:

1. Equipment racks shall be equipped with vertical and horizontal cable management hardware in the form of rings and guides. Racks shall incorporate vertical and horizontal covers, to allow an orderly, hidden, routing of copper, optical fiber, and coax jumpers from the modular patch panels and/or 110-type termination blocks to the customer provided network electronics. Vertical and horizontal cable management hardware shall be as follows:

    a. Horizontal cable management hardware shall be 16 gauge cold rolled steel construction with six (6) pass-thru holes and seven (7) front-mounted 3.5" steel rod D-rings. Provide with cover designed to conceal and protect cable.
    b. At a minimum, horizontal cable management hardware shall be positioned above and below (a) each grouping of two rows of jacks on modular patch panels, and (b) above and below each optical fiber patch panel and (c) each grouping of two rows of F-type connectors on coax patch panels.
    c. Vertical cable management hardware shall provide for cable routing on front and rear of each rack and be 14" deep x 6" wide (minimum). Where multiple equipment racks are to be installed, this hardware shall be mounted between the uprights of adjacent equipment racks. Equipment rack uprights and the spacers shall be secured together per manufacturer's recommendations. Provide with cover designed to conceal and protect cable.

2. Each equipment rack shall be supplied with a minimum of 12 releasable (e.g., "hook and loop") cable support ties.
3. Where cable termination hardware is wall-mounted, the Contractor shall be responsible for establishing a cable pathway for jumpers routed from the equipment rack(s) to the wall. This shall be in the form of slotted ducts or troughs. Routing of jumpers via the overhead cable tray or ladder rack system is NOT acceptable. The proposed method shall be included in the submittals required by this document and shall be approved by the Architect/Engineer prior to installation.

B. Equipment Cabinets

1. Equipment cabinets shall be equipped with vertical and horizontal cable management hardware, in the form of rings and guides, to allow an orderly routing of optical fiber and copper jumpers from the modular patch panel and/or 110-type termination blocks to the customer provided network electronics. At a minimum, one such horizontal cable management panel shall be provided with each equipment cabinet. Horizontal cable management panels shall be 3.5" in height and have a minimum of five (5) jumper distribution rings.

2.4 PATCH PANELS

A. Where identified on the drawings in Communication Equipment Rooms, modular patch panels shall be furnished and installed by the Contractor for termination of copper cable.

B. Copper cabling shall be terminated in Communication Equipment Rooms on modular patch panels consisting of a modular connector system incorporating modular jacks meeting the specifications for the jacks detailed in Section 27 15 00.

C. The largest single modular patch panel configuration shall not exceed 48-Ports. Modular patch panels shall be fully populated (all ports occupied by jacks) and be provided in increments of no less than 12 jacks. High-density modular patch panels will not be accepted.

D. The modular patch panel blocks shall have the ability to seat and cut eight (8) conductors (4 pairs) at a time and shall have the ability of terminating 22- through 26-gauge plastic insulated, solid and stranded copper conductors. Modular patch panel blocks shall be designed to maintain the cables' pair twists as closely as possible to the point of mechanical termination.

E. Modular patch panels shall incorporate cable support and/or strain relief mechanisms to secure the horizontal cables at the termination block and to ensure that all manufacturers minimum bend radius specifications are adhered to.

2.5 OPTICAL FIBER PANELS

A. All terminated optical fibers shall be mated to simplex LC-type couplings mounted on enclosed fiber distribution cabinets. Couplings shall be mounted on a panel that, in turn, snaps into the enclosure. The proposed enclosure shall be designed to accommodate a changing variety of connector types including SC, ST, Fixed Shroud Duplex (e.g., "FDDI Connector"), Biconic, FC, and MT-RJ by changing panels on which connector couplings are mounted.

B. The fiber distribution cabinet shall be sized to accommodate the total fiber count to be installed at each location as defined in the specifications and drawings, including those not terminated (if applicable). Connector panels and connector couplings (sleeves, bulkheads, etc.) adequate to accommodate the number of fibers to be terminated shall be furnished and installed by the Contractor.

C. The fiber distribution cabinet shall be an enclosed assembly affording protection to the cable subassemblies and to the terminated ends. The enclosures shall incorporate a hinged or retractable front cover designed to conceal and protect the optical fiber couplings, connectors, and cable.

D. Access to the inside of the fiber distribution cabinet's enclosure during installation shall be from the front and/or rear. Panels that require any disassembly of the fiber distribution cabinet to gain entry will not be accepted.

E. The fiber distribution cabinet's enclosure shall provide for strain relief of incoming optical fiber cables and shall incorporate radius control mechanisms to limit bending of the optical fiber to the manufacturer's recommended minimums or ½½", whichever is larger.

F. All fiber distribution cabinets shall provide protection to both the "facilities" and "user" side of the coupling. The fiber distribution cabinet's enclosure shall be configured to require front access only when patching. The incoming optical fiber cables (e.g., backbone, riser, horizontal, etc.) shall not be accessible from the patching area of the panel. The fiber distribution cabinet's enclosure shall provide a physical barrier to access such optical fiber cables.

G. Where "Loose Buffered" cables are installed, the 250 µµm coated optical fibers contained in these cables may be terminated either by (1) splicing of factory-terminated cable assemblies ("pigtails") or (2) the use of a "fan-out" kit. In the latter approach, individual fibers are to be secured in a protective covering, an Aramid (e.g., Kevlar¢¢) reinforced tube for example, with connectors mated to the resulting assembly. In both instances, the proposed termination hardware shall incorporate a mechanism by which cable and subassemblies are secured to prevent damage. Splicing shall be by the "fusion" method. Individual splice loss shall not exceed 0.3 dB for multi-mode fibers. Direct termination of 250 µµm coated optical fibers shall not be permitted.

2.6 OPTICAL FIBER COUPLERS/ADAPTERS

A. Optical Fiber Couplings (LCtype) (Multimode/Singlemode):

1. LC-type optical fiber couplings shall be used to terminate optical fiber backbone cable on fiber distribution cabinet panels in communication equipment rooms. Horizontal optical fiber cables shall also be terminated using optical fiber couplings at their designated work area locations on information outlet faceplates for "fiber to the desk."
2. LC-type optical fiber couplings shall be snap-type with locking washer and nut.
3. LC-type optical fiber couplings shall incorporate domed zirconia ferrule and shall utilize a PC polish to ensure fiber-to-fiber physical contact for low loss and reflections.
4. LC-type optical fiber couplings shall accept 125-micron outside diameter multimode fiber.
5. The attenuation per mated pair shall not exceed 0.7 dB (individual) and 0.5 dB (average). Connectors shall sustain a minimum of 200 mating cycles per TIA/EIA-455-21 without violating specifications.
6. LC-type optical fiber couplings shall meet the following performance criteria:

| Test Procedure | Maximum Attenuation Change |
|---|---|
| Cable Retention (FOTP-6) | 0.2 dB |
| Durability (FOTP-21) | 0.2 dB |
| Impact (FOTP-2) | 0.2 dB |
| Thermal Shock (FOTP-3) | 0.2 dB |
| Humidity (FOTP-5) | 0.2 dB |

7. Performance Requirements:

    a. Length: 2 inches
    b. Operating Temperature: -40 to 85 degrees C

8. Basis of Design:

    a. Hubbell

2.7 LADDER RACK

A. Provide complete ladder rack system including metallic ladder rack, splice connectors, fastening hardware and other miscellaneous materials as required for a complete installation per manufacturer's recommendations.

B. Tubing Style Ladder Rack:

1. Rolled steel siderail stringer, minimum 1.5" stringer height, 9" spaced welded rungs.
2. Steel shall meet the requirements of ASTM A1011 SS Grade 33.
3. Loading limits shall be 185 lbs/ft for 4 ft spans.

C. Ladder rack finish shall be flat black powder coat.

2.8 D-RINGS

A. Rounded edge D-rings for support of cabling in vertical and horizontal configurations.

B. EIA 310D compliant, manufactured from materials meeting UL94-V0 specifications.

C. Provide 1/4" screw holes for wall mounting.

2.9 POWER STRIPS

A. Provide power strips on all equipment racks, unless noted otherwise. These power strips shall have the following characteristics:

1. Standard Rack Mount:

    a. TIA/EIA 19" equipment rack mountable.
    b. Compliant with UL-1449 Third Edition and UL-497A.
    c. Provide transient suppression to 12,000-A. Protection shall be in all three modes (line-neutral, line-ground and neutral-ground).
    d. Shall meet or exceed ANSI C62 Category A3 requirements.
    e. Provide high-frequency noise suppression as follows:

        1) Greater than 20-dB @ 50 kHz
        2) Greater than 40-dB @ 150 kHz
        3) Greater than 80-dB @ 1 MHz
        4) Greater than 30-dB @ 6 to 1000 MHz

f. Protection Modes and UL 1449 Clamping Voltage: 475-volt L-N, L-G, and N-G.
g. Components: Nonmodular units composed of 20mm metal oxide varistors (MOV). Series inductors, SAD, or selenium cells may be used in addition to MOVs.
h. Be equipped with a 10-foot power cord.

2.10 COPPER PATCH CORDS

A. Modular Patch Panel:

1. Provide Category 6 and Category 6A copper patch cords for 50% of all assigned ports on the modular patch panel. Of these cords, 60% shall be 3' in length and 40% shall be 5' in length. These patch cords shall be the cross-connect between the network electronics and the horizontal RJ-45 modular patch panel. Copper patch cords shall be equipped with a 4-pair RJ-45 connector on each end.
2. Refer to Section 27 15 00 for cable and connector performance requirements.
3. Patch cords shall not be made-up in the field.
4. Basis of Design (Refer to 27 17 20 for Acceptable Manufacturers):

a. Hubbell HC Series

2.11 FIBER PATCH CORDS

A. Optical Fiber Patch Cords (Multimode):

1. Provide 50/125 mm multimode (MM) optical fiber utilizing tight buffer construction for 50% of all assigned ports on the fiber distribution cabinet. These patch cords shall be the cross-connect between the backbone fiber distribution cabinet and the Owner's network electronics (hub/switch). Optical fiber patch cords shall be equipped with a ceramic tipped LC-type connector on each end and shall be a minimum of 5 feet in length. Connector body shall be of materials similar to that used in the proposed couplings. Provide required lengths as determined on the plans.
2. Channels shall be of equal length.
3. Refer to Section 27 15 00 for cable and connector performance requirements.
4. Basis of Design (Refer to 27 17 20 for Acceptable Manufacturers):

a. Hubbell DFPC Series

2.12 DEMARCATION REQUIREMENTS

A. Contractor shall coordinate all requirements for the demarcation point with the Owner's selected service provider.

B. The Contractor shall not proceed with any installation without written communication with the Architect/Engineer should the service provider's requirements differ from the work shown on the contract documents.

C. Refer to the drawings for further requirements.

PART 3 - EXECUTION

3.1 EQUIPMENT RACKS

A. Equipment racks shall be furnished and installed as shown on the drawings.

B. The Contractor shall bolt the rack to the floor as recommended by the manufacturer. Multiple racks shall be joined and the ground made common on each. The rack shall be stabilized by extending a brace to the wall. Alternately, overhead ladder rack by which the cabling accesses the equipment rack(s) may provide this function.

C. A space between the rack upright and the wall (approximately 4") should be provided to allow for cabling in that area. The rear of the rack should be approximately 40" from the wall to allow for access by maintenance personnel. In all cases, a minimum of 40" workspace in front of the rack is also required. Locations where these guidelines cannot be followed should be brought to the attention of the Architect/Engineer for resolution prior to installation.

D. All hardware and equipment are to be mounted between 18" and 79" above floor level. This is to afford easy access and, in the case of the lower limit, prevent damage to the components. Positioning of hardware should be reviewed and approved by the Architect/Engineer and Site Coordinator(s) prior to installation.

E. Equipment racks shall be equipped with cable management hardware as to allow an orderly and secure routing of optical fiber and/or copper cabling to the optical fiber distribution cabinets and/or modular patch panels. At minimum, one such horizontal jumper management panel shall be placed below each optical fiber distribution cabinet installed by the Contractor. Additional Jumper Management panels may be required pending installation of other cable types on the equipment rack.

F. Each rack shall be grounded to the Telecommunications Ground Bar (GND) using a #6 AWG (or larger) insulated stranded copper conductor (GREEN jacket) directly or via an adjacent grounded equipment rack. Refer to grounding requirements below.

3.2 LADDER RACK

A. Provide support for ladder rack on 4 ft centers.

B. Maintain a 1.5 safety factor on all load limits specified herein.

C. Ladder rack support shall be by 5/8" diameter threaded rod when ceiling mounted. Ladder rack requiring wall mounting shall utilize accessories supplied by the ladder rack manufacturer specifically for the purpose of wall mounting ladder rack.

3.3 D-RINGS

A. Provide D-rings for cable routing and management in all areas where open cabling is routed along the wall in an Equipment Room.

B. Locate D-rings on 24" centers vertically and horizontally.

C. Securely attach D-rings to the wall as required by the manufacturer.

3.4 GROUNDING

A. Provide a complete grounding system in accordance with the requirements of Section 27 05 26.

3.5 CROSS CONNECT INSTALLATION

A. Bend radius of cable shall not exceed 4 times the outside cable diameter or manufacturer's recommendation, whichever is less.

B. Cables shall be neatly bundled and dressed to their respective panels and/or blocks. Each shall be fed by an individual bundle separated and dressed to the point of cable entrance into the rack and/or frame.

C. The cable jacket shall be maintained as close as possible to the termination point.

D. Each cable shall be clearly labeled on the cable jacket behind the patch panel at a location that is visible without removing the bundle support.

3.6 OPTICAL FIBER TERMINATION

A. All fiber slack shall be neatly coiled within fiber splice enclosures or splice trays. No slack loops shall be allowed external to the enclosure.

B. Each cable shall be individually attached to the respective fiber enclosure by mechanical means. The cable strength member shall be securely attached to the cable strain relief bracket in the enclosure.

C. Each cable shall be clearly labeled at the entrance to all enclosures.

D. A maximum of 12 strands shall be spliced in any tray.

3.7 CONDUITS AND CABLE ROUTING

A. Refer to Section 26 05 33 for additional requirements.

B. Where conduits enter a telecommunications room, conduits shall be terminated on the wall where shown on the contract documents. Conduits entering the room from the floor shall extend 3" above the floor slab.

C. Where cabling rises vertically in a telecommunications rooms, provide vertical cable management to support the cabling from floor to ceiling level.

D. All conduits shall be reamed and shall be installed with a nylon bushing.

E. Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of 2" or less, maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter greater than 2", maintain a bend radius of at least 10 times the internal diameter.

END OF SECTION

SECTION 27 13 00 - BACKBONE CABLING REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements relating to furnishing and installing backbone communications cabling and termination components and related subsystems as part of a cabling plant. The cabling plant consists of both optical fiber and/or copper cabling.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Technology Systems Requirements.

B. Section 27 15 00 - Horizontal Cabling Requirements.

C. Section 27 17 20 - Structured Cabling System Warranty.

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.
2. Manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 GENERAL

A. The basis of design is listed herein. Refer to Section 27 17 20 for additional acceptable manufacturers.

2.2 OPTICAL FIBER BACKBONE - INSIDE PLANT

A. Multimode (MM)/Singlemode (SM):

1. This optical fiber backbone cable shall be suitable for installation in building riser systems, in conduit and in innerduct.
2. Optical fiber cable materials shall be all dielectric (no conductive material).
3. Optical fiber cable shall carry an OFNR (optical fiber non-conductive riser) or OFNP (optical fiber non-conductive plenum) rating. Refer to Section 27 05 00 for project requirements.
4. Outer Sheath: The outer sheath shall be marked with the manufacturer's name, date of manufacture, fiber type, flame rating, UL symbol, and sequential length markings every two feet.
5. Temperature Range:

    a. Storage: -40°°C to +70°°C (no irreversible change in attenuation).
    b. Operating: -40°°C to +70°°C.

6. Humidity Range: 0% to 100%.
7. Maximum Tensile Strength (å? 12 fibers):

    a. During Installation: 1332 N (300 lb. force) (no irreversible change in attenuation).
    b. Long-Term: 600 N (135 lb. force).

8. Maximum Tensile Strength (ä? 6 fibers):

    a. During Installation: 1000 N (225 lb. force) (no irreversible change in attenuation).
    b. Long-Term: 100 N (67 lb. force).

9. Bending Radius:

    a. During Installation: 20 times cable diameter.
    b. No Load: 10 times cable diameter.

B. Optical fiber cables suitable for installation in multiple environments (e.g., underground duct and building risers) may be used at the Contractor's option. Such optical fiber cables shall meet all specifications noted above for cables designated for each environment through which the optical fiber cable shall pass.

C. Basis of Design (OM3 Multimode):

1. Hubbell OM3 (HFCD15xxx series).
2. Additional acceptable manufacturers.

    a. Corning

2.3 OPTICAL FIBER BACKBONE - OUTSIDE PLANT

A. Exterior Conduit (Multimode/Singlemode):

1. This optical fiber cable shall be suitable for installation in underground duct and in innerduct.
2. Optical fiber cable materials shall be all dielectric (no conductive materials).
3. Optical fiber cable shall be filled with a water-blocking material.
4. Outer Sheath: Polyethylene (PE). The outer sheath shall be marked with the manufacturer's name, words identifying the cable type (e.g., "Optical Fiber Cable" or "Fiber Optic Cable"), year of manufacture, and sequential length markings. The actual length of the optical fiber cable shall be within -0/+1% of the length markings. The marking shall be in a contrasting color to the cable jacket.
5. Temperature Range:

    a. Storage: -40°C to +70°C (no irreversible change in attenuation).
    b. Operating: -40°C to +70°C.

6. Humidity Range: 0% to 100%.
7. Maximum Tensile Strength:

    a. During Installation: 2700 Newton (600 lb. force) (no irreversible change in attenuation).
    b. Long Term: 890 N (200 lb. force).

8. Bending Radius:

    a. During Installation: 20 times cable diameter.
    b. No Load: 10 times cable diameter.

9. Basis of Design (Multimode):

    a. Corning (XXX).
    b. Additional acceptable manufacturers:

        1) Hubbell
        2) Mohawk
        3) Berk-Tek
        4) Superior Essex

2.4 OPTICAL FIBER CONNECTORS

A. Optical Fiber Pigtails (Multimode):

1. Single-fiber fiber optic pigtails shall be constructed from 50/125 µm multimode (MM) optical fiber of the same grade as the multimode fiber optic backbone cable utilizing tight buffer construction.
2. Fiber optic pigtails shall be factory terminated with a ceramic tipped LC-type connector on one end and shall be a minimum of 5 feet (1.5m) in length or as indicated on the drawings. Channels shall be of equal length.
3. Connector body shall be of materials similar to that used in the proposed couplings. Refer to Section 27 15 00 for connector performance requirements.
4. Provide in quantity to terminate all backbone fiber optic cable strands on each end.
5. Basis of Design:

    a. Multimode Optical Fiber Pigtails shall be from the same manufacturer as used for the fiber optic termination equipment.

2.5 OPTICAL FIBER BACKBONE PERFORMANCE

A. OM3 Multimode (MM):

1. Fiber Type: Multimode; doped silica core surrounded by a concentric glass cladding.
2. Index Profile: Graded Index.
3. Transmission Windows: 850-nm and 1300-nm.
4. Core Diameter (nom): 50-èm (microns) ±± 2.5.
5. Cladding Diameter: 125-èm ±± 1.
6. Core-clad Concentricity: ä? 1.0-èm.
7. Cladding Non-circularity: ä? 1.0%.
8. Fiber Coating Diameter:

    a. 245-èm ±± 10 (primary coating).
    b. 900-èm (nominal) secondary coating (tight buffer)
    c. All coatings shall be mechanically strippable without damaging the optical fiber.

9. Attenuation (maximum @ 23 ±± 5°°C; backbone):

    a. @ 850-nm: 3.0 dB/km.
    b. @ 1300-nm: 1.0 dB/km.
    c. @ 1300-nm thru 1380-nm: 1.0dB/km

        1) When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components," the average change in attenuation over the rated temperature range of the optical cable shall not exceed 0.50 dB/km with 80% of the measured fibers not exceeding 0.25 dB/km.

10. Bandwidth (minimum):

    a. @ 850-nm: 2000 MHz*km.
    b. @ 1300-nm: 500 MHz*km.

11. No optical fiber shall show a point discontinuity greater than 0.2 dB at the specified wavelengths. Such a discontinuity or any discontinuity showing a reflection at that point shall be cause for rejection of that optical fiber by the Owner.

## PART 3 - EXECUTION

### 3.1 CABLE INSTALLATION REQUIREMENTS

A. Cable slack shall be provided in each backbone fiber optic cable. This slack is exclusive of the length of fiber that is required to accommodate termination requirements and is intended to provide for cable repair and/or equipment relocation. The cable slack shall be stored in a fashion as to protect it from damage and be secured in the termination enclosure or a separate enclosure designed for this purpose. Multiple cables may share a common enclosure.

B. A minimum of 5 meters (approximately 15 feet) of slack cable (each cable if applicable) shall be coiled and secured at both ends located in the entrance room, Telecommunications Room or main equipment room, for backbone and intra-building cable.

C. Where exposed, all backbone fiber optic cable shall be installed in protective inner duct. This includes areas where the cable is routed in cable tray and where making a transition between paths (e.g., between conduit and cable tray or into equipment racks). The inner duct should extend into the termination and/or storage enclosure(s) at system endpoints.

3.2 CROSS-CONNECTS

A. The Owner will be responsible for all cross-connects between the data backbone cabling and network electronics and between the data network electronics and horizontal cabling.

B. This Contractor shall not be responsible for cross-connects between the cabling terminations at the Entrance Room and the telephone utility network point-of-presence. It shall be the responsibility of the Contractor, to work with the Owner and provide the necessary assistance to allow Owner and/or telephone company personnel to make the necessary connections to establish service on the new cable system. These activities include, but are not limited to cross-connect documentation, general wiring overview and cable pair identification.

END OF SECTION

SECTION 27 15 00 - HORIZONTAL CABLING REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements relating to furnishing and installing horizontal communications cabling and termination components and related subsystems as part of a cabling plant. The cabling plant consists of copper cabling.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements

B. Section 27 17 20 - Structured Cabling System Warranty

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards and plenum or non-plenum cable requirements.

B. The channel shall be required to meet the performance requirements indicated herein. The manufacturer shall warranty the performance of their system to the required performance (and not just to the Standard, should the required performance exceed the Standard).

C. Specific components of the channel shall be required, at a minimum, to meet the Standard component requirements for that particular component.

D. The installing contractor must be certified by the manufacturer of the structured cabling system.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.
2. Manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLE

| Electrical Value (1 - 250 MHz) | Minimum Margin |
|---|---|
| Insertion Loss: | 14.0% |
| NEXT: | 7.0 dB |
| PS NEXT: | 8.0 dB |
| ACR-F (ELFEXT): | 8.0 dB |
| PS ACR-F (PS ELFEXT): | 8.0 dB |
| Return Loss: | 4.0 dB |

A. CAT 6 Cable:

1. The horizontal cable requirements must be met, as well as the following channel requirements.
2. CAT 6 cable shall terminate on rack-mounted modular patch panels in their respective communication equipment room as indicated on the drawings.
3. Performance tests shall be conducted using swept frequency testing through 250 MHz for the channel. All numbers given are for a 4-connection channel. Discrete frequency testing results at 250 MHz is not acceptable.
4. Performance data shall be characterized as "Guaranteed Headroom" and shall be guaranteed by the manufacturer to perform at guaranteed margins over ANSI/TIA/EIA-568-C.2. Performance data that is not warranted by the manufacturer will not be considered.
5. The structured cabling and connectivity must be provided by the same company. For the purpose of this specification that shall mean that the cabling and connectivity must be marketed, branded, supported, warranted, and distributed by the same company. Specifically, ally or partnerships between cabling manufacturers and connectivity manufacturers do not meet this requirement unless otherwise listed in Section 27 17 20 as an acceptable manufacturer. Specifically, products made by others through an OEM relationship are acceptable if the products are marketed, branded, supported, warranted, and distributed by the same company.

6. The 4-connector channel performance margins in the table below shall be guaranteed margins above ANSI/TIA/EIA-568-C.2:

| Electrical Value (1 - 250 MHz) | Minimum Margin |
|---|---|
| Insertion Loss: | 5% |
| NEXT: | 3.0 dB |
| PS NEXT: | 5.0 dB |
| ACR-F (ELFEXT): | 4.0 dB |
| PS ACR-F (PS ELFEXT): | 5.0 dB |
| Return Loss: | 2 dB |

7. The jacket color for CAT 6 cable shall be blue for all applications.
8. Basis of Design:

    a. Hubbell HC6R Series
    b. Additional acceptable manufacturers:

        1) Belden
        2) Berk-Tek
        3) Commscope/Uniprise
        4) Panduit
        5) Siemon
        6) Superior Essex

B. CAT 6A Cable:

1. The horizontal cable requirements must be met, as well as the following channel requirements.
2. CAT 6A cable shall terminate on rack-mounted modular patch panels in their respective communication equipment room as indicated on the drawings.
3. Cable shall exceed transmission requirements listed in ANSI/TIA/EIA-568-C.2. Performance tests shall be conducted using swept frequency testing through 500 MHz for the channel. All numbers given are for a 4-connection channel. Discrete frequency testing results at 500 MHz is not acceptable.
4. Performance tests shall be conducted using swept frequency testing through 500 MHz for the channel. All numbers given are for a 4-connection channel. Discrete frequency testing results at 500 MHz is not acceptable.
5. Performance data shall be provided by third-party independent testing laboratories only. Testing data shall be submitted on the third-party testing laboratory letterhead. Test data will only be accepted if it displays testing as a channel. Electrical characteristics of the performance of the cable itself will not satisfy this requirement.

6. The structured cabling and connectivity may be provided by the same company. For the purpose of this specification that shall mean that the cabling and connectivity must be marketed, branded, supported, warranted, and distributed by the same company. Specifically, ally or partnerships between cabling manufacturers and connectivity manufacturers do not meet this requirement unless otherwise listed in Section 27 17 20 as an acceptable manufacturer. Specifically, products made by others through an OEM relationship are acceptable if the products are marketed, branded, supported, warranted, and distributed by the same company.
7. The 4-connector channel performance margins in the table below shall be guaranteed margins above ANSI/TIA/EIA-568-C.2:

| Electrical Value (1 - 500 MHz) | Minimum Margin |
|---|---|
| Insertion Loss: | 3% |
| NEXT: | 2 dB |
| PS NEXT: | 3 dB |
| PSA NEXT: | 3 dB |
| PSA NEXT (Average): | |
| ACR-F: | 2 dB |
| PS ACR-F: | 3 dB |
| PSA ACR-F: | 3 dB |
| PSA ACR-F (Average): | 3 dB |
| Return Loss: | 2 dB |

8. The jacket color for CAT 6A cable shall be blue for WAP applications.
9. Basis of Design:

    a. Hubbell C6ASP Series
    b. Additional acceptable manufacturers:

        1) Belden
        2) Berk-Tek
        3) General Cable
        4) Panduit
        5) Siemon
        6) Superior Essex

2.2 FACEPLATES/JACKS

A. CAT 6 Jacks:

1. CAT 6 horizontal cable shall each be terminated at their designated work area location on RJ-45 modular jacks. These modular jack assemblies shall snap into a modular mounting frame. The combined modular jack assembly is referred to as an information outlet.
2. The same orientation and positioning of modular jacks shall be utilized throughout the installation. Prior to installation, the Contractor shall submit the proposed configuration for each information outlet type for review by the Architect/Engineer.
3. Information outlet faceplates shall incorporate recessed designation strips at the top and bottom of the frame for identifying labels. Designation strips shall be fitted with clear plastic covers.
4. Where standalone CAT 6 only modular jacks are identified, the information outlet faceplate shall be configured as to allow for the addition of one (1) additional modular jack (CAT 3, CAT 5E, or CAT 6) to be installed to supplement each such modular jack as defined by this project. The installation of these supplemental modular jacks is NOT part of this project.
5. Any unused modular jack positions on an information outlet faceplate shall be fitted with a removable blank inserted into the opening.
6. The information outlet faceplate shall be constructed of high impact plastic (except where noted otherwise). The information outlet faceplate color shall:

    a. Match the receptacle color used for other utilities in the building, or
    b. When installed in surface raceway (if applicable), match the color of that raceway.

7. Different faceplate and frame designs for locations, which include optical fiber cabling relative to those, that terminate only copper cabling are acceptable. Information outlets that incorporate optical fiber shall be compliant with the above requirements plus:

    a. Be a low-profile assembly.
    b. Incorporate a mechanism for storage of cable and fiber slack needed for termination.
    c. Position the optical fiber couplings to face downward or at a downward angle to prevent contamination.
    d. Incorporate a shroud that protects the optical fiber couplings from impact damage.

8. All information outlets and the associated modular jacks shall be of the same manufacturer throughout the project.
9. The CAT 6 modular jacks shall be non-keyed 8-pin modular jacks.
10. The interface between the modular jack and the horizontal cable shall be a 110-type termination block or insulation displacement type contact. Termination components shall be designed to maintain the horizontal cable's pair twists as closely as possible to the point of mechanical termination.
11. CAT 6 modular jacks shall be pinned per T-568B.

12. CAT 6 termination hardware shall, as a minimum, meet all the mechanical and electrical performance requirements of the following standards:

    a. ANSI/TIA/EIA-568-A-5
    b. ANSI/TIA/EIA-568A
    c. ISO/IEC 11801
    d. IEC 603-7
    e. FCC PART 68 SUBPART F

13. The color for CAT 6 jacks shall be blue for all applications. Alternately, a color-coded bezel or icon may be used to identify the CAT 6 modular jack.

B. Cat 6A Jacks:

1. CAT 6A horizontal cable shall each be terminated at its designated work area location on RJ-45 modular jacks. These modular jack assemblies shall snap into a modular mounting frame. The combined modular jack assembly is referred to as an information outlet.
2. The same orientation and positioning of modular jacks shall be utilized throughout the installation. Prior to installation, the Contractor shall submit the proposed configuration for each information outlet type for review by the Architect/Engineer.
3. Information outlet faceplates shall incorporate recessed designation strips at the top and bottom of the frame for identifying labels. Designation strips shall be fitted with clear plastic covers.
4. Where standalone CAT 6A only modular jacks are identified, the information outlet faceplate shall be configured as to allow for the addition of one (1) additional modular jack (CAT 3, CAT 5E, or CAT 6) to be installed to supplement each such modular jack as defined by this project. The installation of these supplemental modular jacks is NOT part of this project.
5. Any unused modular jack positions on an information outlet faceplate shall be fitted with a removable blank inserted into the opening.
6. The information outlet faceplate shall be constructed of high impact plastic (except where noted otherwise). The information outlet faceplate color shall:

    a. Match the receptacle color used for other utilities in the building, or
    b. When installed in surface raceway (if applicable), match the color of that raceway.

7. Different faceplate and frame designs for locations, which include optical fiber cabling relative to those, that terminate only copper cabling are acceptable. Information outlets that incorporate optical fiber shall be compliant with the above requirements plus:

    a. Be a low-profile assembly.
    b. Incorporate a mechanism for storage of cable and fiber slack needed for termination.
    c. Position the optical fiber couplings to face downward or at a downward angle to prevent contamination.
    d. Incorporate a shroud that protects the optical fiber couplings from impact damage.

8. All information outlets and the associated modular jacks shall be of the same manufacturer throughout the project.
9. The CAT 6A modular jacks shall be non-keyed 8-pin modular jacks.
10. The interface between the modular jack and the horizontal cable shall be an angled insulation displacement type contact and shall provide separation for ANEXT suppression. Termination components shall be designed to maintain the horizontal cable's pair twists as closely as possible to the point of mechanical termination.
11. CAT 6A modular jacks shall be pinned per T-568B.
12. CAT 6A termination hardware shall, as a minimum, meet all the mechanical and electrical performance requirements of the following standards:

    a. ANSI/TIA/EIA-568-B.2-10
    b. IEEE 802.af (PoE)
    c. IEEE 802.an 10GBASE-T
    d. ISO/IEC 60603-7
    e. ISO 11801 Class E Compliant
    f. FCC PART 68.5 SUBPART F

13. The color for CAT 6A jacks shall be orange for WAP applications. Alternately, a color-coded bezel or icon may be used to identify the CAT 6A modular jack.

## 2.3 COPPER WORK AREA CORDS

A. RJ-45:

1. Provide the same quantity of Category 6 and Category 6A copper work area cords as copper patch panel cords specified in Section 27 11 00. Copper work area cords shall be equipped with an 8-pin modular RJ-45 connector on each end.
2. Work area cords shall be 10' in length.
3. Manufacturer of copper patch cable shall be the same as the manufacturer of the horizontal copper cable.

PART 3 - EXECUTION

3.1 CABLE INSTALLATION REQUIREMENTS

A. Horizontal Cabling:

1. The maximum horizontal cable drop length for Data UTP shall not exceed 295 feet (90 meters) in order to meet data communications performance specifications. This length is measured from the termination panel in the wiring closet to the outlet and must include any slack required for the installation and termination. The Contractor is responsible for installing horizontal cabling in a fashion so as to avoid unnecessarily long runs. Any area that cannot be reached within the above constraints should be identified and reported to the Architect/Engineer prior to installation. Changes to the contract documents shall be approved by the Architect/Engineer.
2. All cable shall be free of tension at both ends. In cases where the cable must bear some stress, Kellum grips may be used to spread the strain over a longer length of cable.
3. Manufacturer's minimum bend radius specifications shall be observed in all instances.
4. Horizontal cabling installed as open cabling shall be supported at a maximum of 5' between supports. Refer to the specifications for required cable supports.
5. Horizontal cabling installed as open cable or in cable tray shall be bundled at not less than 10' intervals with hook-and-loop tie wraps. The use of plastic cable ties is strictly prohibited.
6. The maximum conduit fill for horizontal cabling shall not exceed 40% regardless of conduit length.
7. Cable sheaths shall be protected from damage from sharp edges. Where a cable passes over a sharp edge, a bushing or grommet shall be used to protect the cable.

B. A coil of 3 feet in each cable shall be placed in the ceiling at the last support (e.g., J-hook, bridle ring, etc.) before the cables enter a fishable wall, conduit, surface raceway or box. At any location where cables are installed into movable partition walls or modular furniture via a service pole, approximately 15-feet of slack shall be left in each horizontal cable under 250 feet in length to allow for change in the office layout without re-cabling. These "service loops" shall be secured at the last cable support before the cable leaves the ceiling and shall be coiled from 100% to 200% of the cable recommended minimum bend radius.

1. Category 6A cables shall not be mixed with any other category cable in any bundle. Bundles of Category 6A cable shall maintain a 0.5" separation from bundles of cables containing different categories (e.g., Cat 6, Cat 5E).
2. To reduce or eliminate EMI, the following minimum separation distances from 480V power lines shall be adhered to:

    a. Twelve (12) inches from power lines of less than 5-kVa.
    b. Eighteen (18) inches from high-voltage lighting (including fluorescent).
    c. Thirty-nine (39) inches from power lines of 5-kVa or greater.
    d. Thirty-nine (39) inches from transformers and motors.

3. Information outlets shown on floor plans with the subscript "W" are intended to be used for wall mounted telephones. Back boxes for wall mounted telephones shall not be located within 12" vertically, or horizontally, from any light switches, power receptacles, nurse call devices, thermostats, or any other architectural element that would otherwise prevent the installation of a wall mounted telephone on the mating lugs.

3.2 CABLE TERMINATION REQUIREMENTS

A. Cable Termination - CAT 3 Voice Horizontal Cabling:

B. Cable Terminations - Data UTP:

1. Modular patch panels shall be designed and installed in a fashion as to allow future horizontal cabling to be terminated on the panel without disruption to existing connections.
2. If the "last" patch (per rack) is greater than 50% utilized, one additional patch panel shall be provided for future use.
3. At information outlets and modular patch panels, the Contractor shall ensure that the twists in each cable pair are preserved to within 0.5-inch of the termination for data cables. The cable jacket shall be removed only to the extent required to make the termination.

END OF SECTION

SECTION 27 17 10 - TESTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the testing requirements relating to the structured cabling system and its termination components and related subsystems.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work, the Contractor shall submit:

1. Complete information on testing procedure as described herein.
2. Test plan summary for each cable type to be tested including equipment to be used, setup, test frequencies or wavelengths, results format, etc.

PART 2 - PRODUCTS

2.1 TESTING COPPER

A. General Requirements:

1. Perform acceptance tests as indicated below for each sub-system (e.g., backbone, horizontal, etc.) as it is completed.
2. Supply all equipment and personnel necessary to conduct the acceptance tests. The method of testing shall be approved by the Architect/Engineer.
3. Visually inspect all cabling and termination points to ensure that they are complete and conform to the wiring pattern defined herein. Provide the Architect/Engineer with a written certification that this inspection has been made.
4. Conduct acceptance testing according to a schedule coordinated with the Owner/Architect/Engineer. Representatives of the Owner may be in attendance to witness the test procedures. Provide a minimum of one (1) week's advance notice to the Architect/Engineer to allow for such participation. The notification shall include a written description of the proposed conduct of the tests, including copies of blank test result sheets to be used.
5. Tests related to connected equipment of others shall only be done with the permission and presence of the Contractor involved. The Contractor shall ascertain that testing only is required to prove the wiring connections are correct.

6. Provide test results and describe the conduct of the tests including the date of the tests, the equipment used, and the procedures followed. At the request of the Architect/Engineer, provide copies of the original test results in their native format.
7. All cabling shall be 100% fault-free unless noted otherwise. If any cable is found to be outside the specification defined herein, that cable and the associated termination(s) shall be replaced at the expense of the Contractor. The applicable tests shall then be repeated.
8. Should it be found by the Architect/Engineer that the materials or any portion thereof furnished and installed under this Contract fail to comply with the specifications and drawings with respect or regard to the quality, amount, or value of materials, appliances, or labor used in the work, it shall be rejected and replaced by the Contractor and all work disturbed by changes necessitated in consequence of said defects or imperfections shall be made good at the Contractor's expense.

    a. CAT 6 Cable:

        1) Testing shall be from the modular jack at the information outlet to the modular patch panel in the communication equipment room.
        2) Horizontal cable shall be free of shorts within the pairs, and be verified for continuity, pair validity and polarity, and conductor position on the modular jack (e.g., wire map). Any defective, split, or mis-positioned pairs must be identified and corrected.
        3) CAT 6 horizontal cable shall be tested to 250 MHz as defined by TIA/EIA-568-C.2. Measurements shall be of the "Channel Link", including patch cords, cabling and modular jacks at the information outlet and modular patch panel. Parameters to be tested must include:

            a) Wire Map
            b) Length
            c) NEXT Loss (Pair-to-Pair)
            d) NEXT (Power Sum)
            e) ELFEXT (Pair-to-Pair)
            f) ELFEXT (Power Sum)
            g) Return Loss
            h) Attenuation
            i) Propagation Delay
            j) Delay Skew

        4) The maximum length of horizontal cable shall not exceed 295 feet, which allows 33 feet for technology equipment and modular patch cords.

5) To establish testing baselines, cable samples of known length and of the cable type and lot installed shall be tested. The cable may be terminated with an eight-position CAT 6 modular connector (8-pin) to facilitate testing. Nominal Velocity of Propagation (NVP) and nominal attenuation values shall be calculated based on this test and be utilized during the testing of the installed cable plant. This requirement can be waived if NVP and nominal attenuation data is available from the cable manufacturer for the exact cable type under test.

6) CAT 6 horizontal cable testing shall be performed using a test instrument designed for testing to 250 MHz or higher. Test records shall verify, "PASS" on each cable and display the specified parameters, comparing test values with standards based "templates" integral to the unit. Test records that report a PASS*, FAIL*, or FAIL result for any of the parameters will not be accepted.

7) In the event results of the tests are not satisfactory, the Contractor shall make adjustments, replacements, and changes as necessary and shall then repeat the test or tests that disclosed faulty or defective material, equipment, or installation methods, and shall make additional tests as the Architect/Engineer deems necessary at no additional expense to the project or user agency.

b. CAT 6A Cable:

1) Testing shall be from the modular jack at the information outlet to the modular patch panel in the communication equipment room.

2) Horizontal cable shall be free of shorts within the pairs and be verified for continuity, pair validity and polarity, and conductor position on the modular jack (e.g., wire map). Any defective, split, or mis-positioned pairs must be identified and corrected.

3) CAT 6A horizontal cable shall be tested to 500 MHz as defined by TIA/EIA-568-C.2. Measurements shall be of the "Channel Link", including patch cords, cabling and modular jacks at the information outlet and modular patch panel. Parameters to be tested must include:

a) Wire Map
b) Length
c) NEXT Loss (Pair-to-Pair)
d) NEXT (Power Sum)
e) ELFEXT (Pair-to-Pair)
f) ELFEXT (Power Sum)
g) Return Loss
h) Attenuation
i) Propagation Delay
j) Delay Skew

4) The maximum length of horizontal cable shall not exceed 295 feet, which allows 33 feet for technology equipment and modular patch cords.

5) To establish testing baselines, cable samples of known length and of the cable type and lot installed shall be tested. The cable may be terminated with an eight-position CAT 6A modular connector (8-pin) to facilitate testing. Nominal Velocity of Propagation (NVP) and nominal attenuation values shall be calculated based on this test and be used during the testing of the installed cable plant. This requirement can be waived if NVP and nominal attenuation data is available from the cable manufacturer for the exact cable type under test.

6) CAT 6A horizontal cable testing shall be performed using a test instrument designed for testing to 500 MHz or higher. Test records shall verify "PASS" on each cable and display the specified parameters, comparing test values with standards based "templates" integral to the unit. Test records that report a PASS*, FAIL*, or FAIL result for any of the parameters will not be accepted.

7) In the event results of the tests are not satisfactory, the Contractor shall make adjustments, replacements, and changes as necessary and shall then repeat the test or tests that disclosed faulty or defective material, equipment, or installation methods, and shall make additional tests as the Architect/Engineer deems necessary at no additional expense to the project or user agency.

2.2 TESTING FIBER

A. General Requirements:

1. Perform acceptance tests as indicated below for each optical fiber sub-system (e.g., backbone, horizontal, etc.) as it is completed.
2. Supply all equipment and personnel necessary to conduct the acceptance tests. The method of testing shall be approved by the Architect/Engineer.
3. Visually inspect all optical fiber cabling and termination points to ensure that they are complete and conform to the standards defined herein. Provide the Architect/Engineer with a written certification that this inspection has been made.
4. Conduct acceptance testing according to a schedule coordinated with the Owner/Architect/Engineer. Representatives of the Owner may be in attendance to witness the test procedures. Provide a minimum of one (1) week's advance notice to the Architect/Engineer to allow for such participation. The notification shall include a written description of the proposed conduct of the tests, including copies of blank test result sheets to be used.
5. Tests related to connected equipment of others shall only be done with the permission and presence of the Contractor involved. The Contractor shall ascertain that testing only is required to prove that the optical fiber connections are correct.
6. Provide test results and describe the conduct of the tests including the date of the tests, the equipment used and the procedures followed. At the request of the Architect/Engineer, provide copies of the original test results.
7. All optical fiber cabling shall be 100% fault-free unless noted otherwise. If any optical fiber cable is found to be outside the specification defined herein, that optical fiber cable and the associated connector(s) shall be replaced at the expense of the Contractor. The applicable tests shall then be repeated.

8. Should it be found by the Architect/Engineer that the materials or any portion thereof furnished and installed under this Contract fail to comply with the specifications and drawings with respect or regard to the quality, amount, or value of materials, appliances, or labor used in the work, it shall be rejected and replaced by the Contractor and all work disturbed by changes necessitated in consequence of said defects or imperfections shall be made good at the Contractor's expense.
9. The optical fibers utilized in the installed cable shall be traceable to the manufacturer. Upon request by the Owner, provide cable manufacturer's test report for each reel of cable provided. These test reports shall include manufacturer's on-reel attenuation test results at 850-nm and 1300-nm for each optical fiber of each reel prior to shipment from the manufacturer.

    a. On-the-reel bandwidth performance as tested at the factory. Factory data shall be provided upon request.
    b. The testing noted for optical fiber cabling utilizes an Optical Time Domain Reflectometer (OTDR). However, the Contractor may submit to the Architect/Engineer for pre-approval of alternate fiber optic testing equipment.

B. Tests Prior to Installation: The Contractor, at their discretion and at no cost to the Owner, may perform an attenuation test with an OTDR at 850-nm or 1300-nm on each optical fiber of each cable reel prior to installation. Supply this test data to the Architect/Engineer prior to installation.

C. Tests After Installation: Upon completion of cable installation and termination, the optical fiber cabling shall be tested to include:

1. Optical Attenuation ("Insertion Loss" Method):

    a. Optical Attenuation shall be measured on all terminated optical fibers in one direction of transmission using the "Insertion Loss" method measurement in accordance with the TIA/EIA 526-14, Method B, and be inclusive of the optical connectors and couplings installed at the system endpoints. Access jumpers shall be used at both the transmit and receive ends to ensure that an accurate measurement of connector losses is made. Multimode optical fibers shall be tested at 850 ±± 30 nm. Singlemode optical fibers (if applicable) shall be tested at 1300 ±± 20 nm.
    b. Attenuation of optical fibers shall not exceed the values calculated as follows:

        1) Attenuation (max.) = 2*C+L*F+S dB.
        2) Where C is the maximum allowable Connector Loss (in dB), L is the length of the run (in kilometers), and F is the maximum allowable optical fiber loss (in dB/km). S is the total splice loss (# of splices * maximum attenuation per splice).

2. Verification of Link Integrity (OTDR):

a. All optical fibers shall be documented in one direction of transmission using an Optical Time Domain Reflectometer (OTDR). Multimode optical fibers shall be tested at 850-nm and 1300-nm (nominal). Singlemode optical fibers (if applicable) shall be tested at 1310-nm and 1550-nm (nominal). The OTDR(s) shall incorporate high-resolution optics optimized for viewing of short cable sections. Access jumpers of adequate length to allow viewing of the entire length of the cable, including the connectors at the launch and receive end, shall be used. Access jumpers used for testing shall match the type and core diameter of the fiber optic strand under test.

b. Set OTDR's test variables to the manufacturer's published backscatter coefficient and velocity of propagation figure for the specific strand of fiber under test. OTDR's range should be set to approximately 1.5 times the length of the strand under test, pulse width should be optimized for the length of the fiber optic strand under test, and number of averages should be adjusted to approximately 120 seconds per wavelength.

c. OTDR traces revealing a point discontinuity greater than 0.2 dB in a multimode optical fiber or 0.1 dB in a singlemode optical fiber (if applicable) at any of the tested wavelengths or any discontinuity showing a reflection at that point shall be a valid basis for rejection of that optical fiber by the Owner. The installation of that optical fiber cable shall be reviewed in an effort to remove any external stress that may be causing the fault. If such efforts do not remove the fault, that optical fiber cable and the associated terminations shall be replaced at the expense of the Contractor.

## 2.3 DOCUMENTATION/AS-BUILTS/RECORDS

A. General:

1. Upon completion of the installation, submit as-builts per the requirements of Section 27 05 00 and Division 1. Documentation shall include the items detailed in the subsections below.
2. All documentation, including hard copy and electronic forms, shall become the property of the Owner.
3. The Architect/Engineer may request that a 10% random field retest be conducted on the cable system at no additional cost to verify documented findings. Tests shall be a repeat of those defined above. If findings contradict the documentation submitted by the Contractor, additional testing can be requested to the extent determined necessary by the Architect/Engineer, including a 100% retest. This retest shall be at no additional cost to the Owner.

B. Copper Media Test Data:

1. Test results shall include a record of test frequencies, cable type, conductor pair and cable (or Outlet) I.D., measurement direction, test equipment type, model and serial number, date, reference setup, and crew member name(s).
2. Printouts generated for each cable by the wire test instrument shall be submitted as part of the documentation package. The Contractor shall furnish this information in electronic form (USB thumb drive). The thumb drive shall contain the electronic equivalent of the test results as defined by the bid specification and be in the tester's native format as well as summaries of each test in pdf format. Provide a licensed copy of the software required to view and print the data that is provided in a proprietary format. Furnish one (1) copy of the data and display (if applicable) software.

C. Optical Fiber Media Test Data:

1. Test results shall include a record of test wavelengths, cable type, fiber and cable (or Outlet) I.D., measurement direction, test equipment type, model and serial number, date, reference setup, and crew member name(s).
2. OTDR traces of individual optical fiber "signatures" obtained as specified above shall be provided to the Architect/Engineer in electronic form for review. Trace files shall be so named as to identify each individual optical fiber by location in the cable system and optical fiber number or color. Where traces are provided in electronic form, provide along with the above documentation, one (1) licensed copy of software that will allow for the display of OTDR traces provided. The software shall run on a Microsoft Windows-based personal computer.

D. Record Drawings:

1. The drawings are to include cable routes and outlet locations. Outlet locations shall be identified by their sequential number as defined elsewhere in this document. Numbering, icons, and drawing conventions used shall be consistent throughout all documentation provided.

PART 3 - EXECUTION (Not Used)

END OF SECTION

SECTION 27 41 00 - PROFESSIONAL AUDIO/VIDEO SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. System Components

B. Audio Cabling

C. Digital Video Cabling

D. Control Cabling

E. Horizontal Copper and Fiber Cabling and Connectors

1.2 RELATED WORK

A. Section 26 05 33 - Conduit

B. Section 26 05 13 - Wire and Cable

C. Section 27 05 00 - Basic Communications Requirements

D. Section 27 05 26 - Communications Bonding

E. Section 27 05 03 - Through Penetration Firestopping

F. Section 27 11 00 - Communication Equipment Rooms

G. Section 27 05 28 - Interior Communications Pathway

H. Section 27 15 00 - Horizontal Cabling Requirements

1.3 QUALITY ASSURANCE

A. Manufacturer: The manufacturer of equipment shall have a complete service organization for all products in the manufacturer's line.

B. Integrator/Dealer: The Contractor shall be a factory-authorized and certified integrator/dealer specializing in each selected manufacturer's products, with demonstrated prior experience with the selected manufacturer's system installation and programming.

C. Control System Dealer: The media control system shall be provided, terminated, installed, and programmed by a factory-authorized and certified dealer and integrator in good standing with the manufacturer. The dealer shall have direct purchasing and support authority. These services shall not be subcontracted.

D. Control System Programmer: The media control system shall be programmed by a factory-trained and certified programmer.

1. The Contractor shall have all certifications required by the manufacturer(s) for the installed system components on staff for the appropriate duties and responsibilities required by the manufacturer.

a. The control system programmer shall have all refresher courses completed for the latest features of the control platform prior to bidding the project to ensure that the Contractor is up to date with the latest software features.

E. Audio System Programmer: All digital sound processing equipment (DSP) used on the project shall be setup, programmed and calibrated by a factory-trained and certified technician. The audio system programmer shall have the following complementary certifications:

1. Associated manufacturer certifications
2. Dante Level III

F. Video System Programmer: All video distribution and processing used on the project shall be setup, programmed and calibrated by a factory-trained and certified technician.

G. The Contractor shall have acquired and maintained all certifications for a minimum of one (1) month prior to the posted bid date of this project.

H. Servicing Contractor: The installer must be factory certified to provide service on the installed manufacturer's equipment and must have local service representatives within a 100 mile radius of the project site.

1.4 REFERENCES

A. ADA - Americans with Disabilities Act

B. ADAAG - Americans with Disability Accessibility Guidelines

C. ANSI - American National Standards Institute

D. AVIXA - Audiovisual and Integrated Experience Association (Formerly InfoComm)

E. ANSI/InfoComm A102.01:2017 - Audio Coverage Uniformity

F. ANSI/InfoComm 2M-2010 - Standard Guide for Audiovisual Systems Design and Coordination Processes

G. ANSI/InfoComm F501.01:2015 - Cable Labeling for Audiovisual Systems

H. ANSI/InfoComm 10:2013 - Audiovisual Systems Performance Verification

I. ANSI/AVIXA V202.01:2016 - Display Image Size for 2D Content in Audiovisual Systems

J. ANSI/InfoComm 4:2012 - Audio Visual Systems Energy Management

K. ANSI/InfoComm 3M-2011 - Projected Image System Contrast Ratio

L. IBC - International Building Code

M. IEC - International Electrotechnical Commission

N. NFPA 70 - National Electrical Code (NEC)

O. UL 813 - Commercial Audio Equipment

P. UL 1419 - Professional Video and Audio Equipment

Q. UL 1480 - Speakers for Fire Alarm, Emergency, and Commercial and Professional Use

R. UL 1492 - Audio/Video Products and Accessories

S. CBC - California Building Code (Current Version)

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 27 05 00.

B. General Requirements:

1. Submittals will be submitted in multiple passes over the course of construction. Each pass will be a dedicated single submission for review as outlined in the general submittal requirements outlined in section 27 05 00.
2. Upon acceptance of an item in the submittal, the Contractor shall remove them from future resubmittals of the same submittal "pass".
3. Should the Contractor not provide shop drawings in a timely fashion, not complete requirements, or extend the time of any resubmittals so as to jeopardize schedules, cause delay, or limit access for field work, the Contractor bears responsibility for impact and delay that may occur. This includes access or lift to overhead positions and associated protection of work already in place.

C. First Pass Submittals: To be submitted after the project is awarded but before equipment is submitted, purchased and installed.

1. Contractor(s) resume of qualifications.
2. All certifications shall be current and valid. Any certificate with expired dates will not be accepted.
3. All certifications outlined in the qualifications shall be included in this submittal. Refer to the qualifications section for additional information. Certifications include, but are not limited to:

    a. All installed manufacturer certifications required by the manufacturer.
    b. Control system authorized dealer certification.
    c. Control system certified programmer certification(s).
    d. Audio system DSP dealer certification.
    e. Audio system DSP programmer certification.
    f. Professional audio components dealer certification(s).
    g. Video system dealer certification(s).
    h. All other applicable dealer, installation and programming certifications.

4. If an alternate manufacturer(s) is submitted, the equivalent certifications to the basis of design manufacturer(s) shall be required and submitted.

D. Second Pass Submittals: To be submitted after all initial submittals have been approved but before equipment is purchased, installed, configured, and programmed. This can be submitted with the first pass submittal but will require to be submitted as a separate document.

1. The submittal shall include a list of all equipment submitted, listing out each product manufacturer and model number cross referenced with the equipment's Technology Equipment Schedule items Equipment List Abbreviation.
2. Alternate System Drawings: If an approved alternate manufacturer is submitted, the Contractor shall provide project-specific system CAD drawings. These will be required to be submitted with the product data.

    a. Provide a system block diagram noting system components and interconnection between components. The interconnection of components shall clearly indicate all wiring required in the system. When multiple pieces of equipment are required in the exact same configuration (e.g., multiple identical controllers), the diagram may show one device and refer to the others as "typical" of the device shown.

3. Product Data: Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

    a. Compliance with each requirement of these documents.
    b. All component options and accessories specific to this project.
    c. Electrical power consumption rating and voltage.
    d. Wiring requirements.
    e. Pre-terminated cable distances and requirements identified by each room where required.
    f. Product manuals are not an acceptable format and will be rejected.

E. Final Pass Submittals: To be submitted after all initial submittals have been approved but before the equipment is installed, configured and programmed.

1. System Drawings: Project-specific system drawings shall be provided as follows:

    a. Provide a system block diagram noting system components and interconnection between components. The interconnection of components shall clearly indicate all wiring required in the system. When multiple pieces of equipment are required in the exact same configuration (e.g., multiple identical controllers), the diagram may show one device and refer to the others as "typical" of the device shown.
    b. Submittals shall contain shop drawings indicating physical plan locations and placement of installed devices and accessories with associated scope or field conditions for review and coordination. Provide mounting details, suspensions, and rough-in notes with trade demarcations.

        1) Identify any non-standard back boxes or mounting assembly required by product or specifications and elaborate contractor means and methods for mounting.
        2) Provide rack drawing(s) showing the mounting of equipment in each rack or cabinet on the project.
        3) All display mounts shall be coordinated with the Architect to verify the exact vertical and horizontal positioning of the display. Coordinate in-wall stud locations for installation of recessed display mounts to install in the exact location as coordinated with the architectural drawings.
        4) Projector mounts shall be coordinated with other utilities on the ceiling and wall to minimize any potential obstructions for the visual beam of the projector prior to installation of the projector mount.
        5) Projector mounts, projector screens, recessed ceiling speakers, in-ceiling microphones, and all other above ceiling devices shall be coordinated with other trades in the field (e.g., mechanical ductwork, lights, diffusers, etc.) to minimize changes that will impact the performance of the system design.

    c. Reproduction of contract documents is not acceptable for submittals. Wire CAD type drawings and cable tag lists or schedules, or typical manufacturer's abbreviated single lines alone, are not complete.

2. The Contractor shall submit graphic or emulated representations of the control system touch panels for each unique space and layout prior to purchase, installation and programming for review and comment by the Architect/Engineer and Owner. These shall show and describe the intended programming/macro control features and functions of each button/icon for all pages.

F. Discontinued Products and New Model Releases:

1. For each product, the Contractor shall submit (in addition to the specified product) a product cut sheet if the specified product has been replaced, improved upon, phased out or otherwise upgraded at the time of shop drawing submittal.

a. The intent of this requirement is for the Contractor to submit only direct replacements for the specified products. A direct replacement shall be defined as a product of newer release that has equal or greater capabilities. The Contractor shall submit a letter from the manufacturer with a direct replacement that includes both model numbers to clarify the replacement.
b. It is not the intent of this requirement for the Contractor to submit new products or other product options that significantly differ in capability and/or cost from the specified product.

G. Coordination Drawings:

1. Include all ceiling-mounted devices in composite electronic coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

1.6 SYSTEM DESCRIPTION

A. This specification section describes the furnishing, installation, commissioning and programming of audio/video components and systems.

B. Performance Statement: This specification section and the accompanying Contract Documents are performance based, describing the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed, every equipment connection that must be made and every feature and function that must be programmed and configured. Based on the equipment constraints described and the performance required of the system, as presented in these documents, the Vendor and the Contractor are solely responsible for determining all wiring, programming and miscellaneous equipment required for a complete and operational system.

C. This document describes the major components of the system. All additional hardware, subassemblies, supporting equipment and other miscellaneous equipment required for proper system installation and operation shall be provided by the Contractor.

D. This document describes the major programming features and functions of the system. All additional programming, configuration and integration required for proper system installation and operation shall be provided by the Contractor.

E. When a specific manufacturer is not provided in this document for minor pieces of equipment, the Contractor shall provide only those materials considered to be of the same industry commercial and professional quality level as the major equipment manufacturers.

F. General System Description:

1. The purpose of this section is to define the overall AV system requirements for each space identified on the project drawings. This is to represent the end-user needs, applications, tasks and Functions and features for each space to assist with identifying programing requirements for each space.

G. Room Type Requirements:

1. Multi Purpose Room**:**

a. The multi purpose room system shall provide support for presentations.
b. System Requirements:

1) Provide in-room display of temporary video sources via multiple wall plate locations.
2) Provide routing of video sources and accompanying audio via an integrated switcher.
3) Provide projector mounted on the ceiling of the room as well as a projection screen recessed in the ceiling at the front of the room as the primary display device.
4) Provide ceiling loudspeakers and associated electronics to reproduce the mono or summed-stereo to mono audio signal.
5) Provide an ceiling mount equipment enclosures for the systems' permanently mounted equipment within the room.
6) Provide a control system with touch screen control panel.
7) The control system to provide control for:

a) System on/off
b) Audio and/or video source and destination selection
c) Audio level
d) Source on/off
e) Screen up/down

8) Provide portable ALS system compliant with 2013 CBC 11B-219 and 11B-706, signage compliant with 2013 CBC 11B-216.10, and two (2) receivers, one of which shall be hearing aid compatible.

c. Electrical Requirements:

1) At Projector:

a) Provide one (1) 120VAC, 20A duplex receptacle.

2) At Projection Screen:

a) Provide one (1) 120VAC, 20A circuit hardwired to projection screen.

3) At Ceiling Enclosure:

a) Provide one (1) 120VAC, 20A quad receptacle in ceiling enclosure.

4) Information Technology (IT) Requirements (Recommendations):

a) Provide WAN coverage.
b) Provide network drop at projector.
c) Provide network drop at touch screen location.
d) Provide network drop at ceiling enclosure location.

2. Conference Room**:**

a. The conference system shall provide support for video conferencing, presentations, and meetings, as well as serve as overflow for multi purpose room presentations.
b. Systems Description:

1) Provide video conferencing capability via AV bridging.

2) Provide the capability for the display of temporary video sources connected through an auxiliary input panel in the table.
3) Provide in-room display of temporary video sources via wall plate.
4) Provide ceiling-mounted conferencing microphones for audio input to the videoconferencing codec.
5) Provide a PTZ video camera for video input to the videoconferencing codec.
6) Provide routing of video sources and accompanying audio via an integrated switcher.
7) Provide panel display mounted on the front wall of the room as the primary display device.

a) Provide recessed box behind panel display for mounting of equipment.

8) Provide ceiling loudspeakers and associated electronics to reproduce the mono or summed-stereo to mono audio signal.
9) Provide a control system with touch screen control panel.

10) The control system to provide control for:

a) System on/off
b) Audio and/or video source and destination selection
c) Audio level
d) Source on/off
e) Codec functions such as camera control, dialup, address book, etc.

c. Architectural and Infrastructure Requirements:

1) Provide appropriate backing for mounting the display to the wall. Coordinate with electrical backboxes.
2) Coordinate table input plate with architect and furniture contractor.

d. Electrical Requirements:

1) At Display:

a) Provide one (1) 120VAC, 20A duplex receptacle behind display. Refer to drawings for elevation.
b) Provide flat panel display recessed back box with integrated surge suppression and hardwired 120VAC, 20A connection.

2) At Table:

a) Provide one (1) 120VAC, 20A duplex receptacle in floor box below table.

3) Information Technology (IT) Requirements (Recommendations):

a) Provide WAN coverage.
b) Provide network drop behind display.
c) Provide network drop in table.

1.7 LICENSING REQUIREMENTS

A. All user licenses required for system operation shall be included in the Contractor's bid. User licenses shall include, but not be limited to, server and workstation software and any other licensing that is required by the manufacturer for operation of any system component.

1. Licenses shall be provided on a one-to-one basis. One license shall be provided for each server, workstation, and device requiring a license. In the event the manufacturer requires the purchase of a block of licenses, the minimum standard licensing package to support all devices.

1.8 INTELLECTUAL PROPERTY OWNERSHIP

A. All supporting documentation, programming, uncompiled source code, graphic files, DSP code and diagrams, written and electronic files, including all latest versions of the documentation and software necessary to edit and adapt the system(s), shall be provided to the Owner for all spaces and all systems. The integrator and/or programmer shall also maintain a current copy to be provided at the Owner's request.

1. The Owner shall have the right to modify the intellectual property directly, or to have the intellectual property modified by any party of the Owner's choosing.

1.9 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 27 05 00.

B. Provide all applicable certifications.

C. Provide statement that system checkout test, as outlined in the shop drawing submittal, is complete and satisfactory.

D. Provide schedules documenting all terminal block wiring, including cable numbers.

E. Warranty: Submit written warranty and complete all Owner registration forms.

F. Complete all operation and maintenance manuals as described below.

G. The Contractor shall include all factory-provided test results for equipment installed on the project.

H. The Contractor shall include all test results from system demonstration and performance testing specified in this document.

I. Record Drawings shall minimally include:

1. All revisions to, or deviations from the original drawings, as well as final dimensions, cable routes, connector panel drawings, cable numbering charts, and control system programming documentation. A complete as-installed equipment list, listed by room, and with manufacturers' names, model numbers, serial numbers, and quantities of each item.
2. A complete and correct system schematic, showing detailed connections for all parts of the system, including wire numbers, terminal block numbers and layouts, and other designations and programming code.
3. Complete equipment rack layouts showing locations of all rack-mounted equipment items.
4. Additional information, diagrams or explanations as designated under respective equipment or systems specification section.

J. Upon completion and final acceptance of the project, the Contractor shall provide the Owner a copy of the programming code for any and all AV systems and devices programmed by the Contractor.

1. For any subsequent modifications to the programming code, an updated copy of the code shall be provided to the Owner.

1.10 OPERATION AND MAINTENANCE DATA

A. Submit documents under the provisions of Section 27 05 00.

B. Manuals: Final copies of the manuals shall be delivered after completing the installation. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of the Contractor responsible for the installation and maintenance of the system and the factory representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The final copies delivered after completion of the installation shall include all modifications made during installation, checkout, and acceptance. Manuals shall be submitted in electronic format. The manuals shall consist of the following:

1. Functional Design Manual: The functional design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be included.
2. Hardware Manual: The manual shall describe all equipment furnished including:

a. General description and specifications.
b. Installation and checkout procedures.
c. Equipment layout and electrical schematics to the component level.
d. System layout drawings and schematics.
e. Alignment and calibration procedures.
f. Manufacturers repair parts list indicating sources of supply.

3. Software Manual: The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

a. Definition of terms and functions.
b. System use and application software.
c. Initializations, startup, and shutdown.
d. Reports generation.
e. Details on forms customization and field parameters.

4. Operator's Manual: The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

    a. Computers and peripherals.
    b. System startup and shutdown procedures.
    c. Use of system, command, and applications software.
    d. Recovery and restart procedures.
    e. Use of report generator and generation of reports.
    f. Data entry.
    g. Operator commands.
    h. Alarm messages and reprinting formats.
    i. System permissions functions and requirements.

5. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

C. Intellectual Property Ownership: Provide all uncompiled source code and DSP programming for all systems and spaces as described in Part 3 of this specification section.

1.11 WARRANTY

A. Unless otherwise noted, provide warranty for one (1) year after Date of Substantial Completion for all materials and labor.

B. Operation: Upon the performance of any scheduled adjustments or repairs, Contractor shall verify operation of the systems.

C. Emergency Service: The Owner will initiate service calls when the systems are not functioning properly. Qualified personnel shall be available to provide service within the distance defined within this specification section. The Owner shall be furnished with telephone number(s) where service personnel can be reached 24/7/365. Service personnel shall be at site within 24 hours after receiving a request for service.

D. Records and Logs: The Contractor shall keep records and logs of each task completed under warranty. The log shall contain all initial settings at substantial completion. Complete logs shall be kept and shall be available for review on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the systems.

E. Work Requests: The Contractor shall separately record each service call request on a service request form. The form shall include the model and serial number identifying the component involved, its location, date and time the call was received, specific nature of trouble, names of service personnel assigned to the task, instructions describing what must be done, the amount and nature of the materials used, the time and date work started, and the time and date of completion. The Contractor shall deliver a record of the work performed within five (5) business days after work is accomplished.

F. System Modifications: The Contractor shall make any recommendations for system modification in writing to the Owner. No system modifications shall be made without prior approval of the Owner. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected. To the fullest extent possible, the Owner shall be provided with electronic restorable versions of all configurations prior to the modifications being made.

G. Software: The Contractor shall provide all software and firmware updates during the period of the warranty and verify operation of the system upon installation. These updates shall be accomplished in a timely manner, fully coordinated with system operators, shall include training for the new changes/features, and shall be incorporated into the operations and maintenance manuals, and software documentation.

H. Refer to the individual product sections for further warranty requirements of individual system components.

## PART 2 - PRODUCTS

### 2.1 SYSTEM COMPONENTS

A. Refer to the project drawings for basis of design system components. Equivalent products shall meet or exceed all requirements defined on the project drawings. The following product information represents the minimum additional requirements for equivalent products:

B. Audio/Video GUI Control Systems:

1. Contractor shall furnish a programmable software-based audio/video control system. The system shall be field configurable and programmable by the factory and/or a factory-trained programmer.
2. The control system shall be TCP/IP based allowing direct connection of the system processors to a 10/100BaseT compatible Ethernet network.
3. Refer to project drawings for required central processors, touch panels, keypads and additional information.

C. Audio Amplifiers:

1. Power Amplifier(s), 25, 70.7 and 100 Volt:

a. Power: The following calculation shall be used to determine the minimum required output of the amplifier(s):

1) Calculate the total power tap value of each transformer with insertion loss using the following equation:

a) Tap wattage x 10^(xdB/10) where x = the rated insertion loss at 1,000Hz.

2) Calculate the total wattage loss based on cable distance, cable gauge and cable resistance.

3) Add together all the speaker taps' total power values that will be on a single channel of the amplifier. Multiply that total by 1.2, which will allow for a 20% future expansion. Multiply that number by 1.25 to ensure the amplifier never exceeds 75% of its total output. Utilize the final number to determine the minimum amplifier power requirements.

D. Assisted Listening Systems (ALS):

1. Assisted listening requirements for this project shall follow the local jurisdiction's requirements to quantify the number of devices for use on this project.
2. All spaces with amplified audible communications require an ALS. The Contractor shall refer to the ADA and ADAAG guidelines, as well as IBC Section 1108.2.7 for ALS rules, regulations and guidelines. Refer to the table below for the required number of receivers to be provided for each space (Source: IBC, Table 1108.2.7.1). Alternatively, if the building is managed by a single entity and all systems are fully compatible and interoperable, the total number of seats for all areas can be used in accordance with the table below.

| Capacity of Seating in Assemble Areas | Minimum Required Number of Receivers | Minimum Number of Receivers to be Hearing-aid (T-coil) Compatible |
|---|---|---|
| 50 or less | 2 | 2 |
| 51 to 200 | 2, plus 1 per 25 seats over 50 seats | 2 |
| 201 to 500 | 2, plus 1 per 25 seats over 50 seats | 1 per 4 receivers |
| 501 to 1,000 | 20, plus 1 per 33 seats over 500 seats | 1 per 4 receivers |
| 1,101 to 2,000 | 35, plus 1 per 50 seats over 1,000 seats | 1 per 4 receivers |
| Over 2,000 | 55, plus 1 per 100 seats over 2,000 seats | 1 per 4 receivers |

3. Receivers required to be hearing-aid compatible shall interface with telecoils in hearing aids through the provision of neckloops and shall be over-the-ear type headphones. Earbuds are not acceptable for this use.
4. Receivers shall include a 1/8" (3.2mm) standard mono output jack.
5. Refer to the Access Board Research "Large Area Assistive Listening Systems: Review and Recommendations" ALS report for additional recommendations.

E. Power Conditioning and Surge Protective Devices:

1. All equipment shall be plugged in through a power conditioning surge arrestor.
2. Provide a minimum of 50 dB noise attenuation.
3. Provide a minimum of 1,500 joules of surge protection.
4. UL 1449 Standard for Safety for Surge Protective Devices listed to 330 volt clamping voltage.
5. Refer to the project drawings for additional information.

F. Refer to project drawings for all other equipment not listed.

2.2 AUDIO CABLING

A. Refer to Section 27 05 00 for cable rating requirements.

B. Line Level Audio Cabling:

1. For patch cables less than or equal to 25 feet:

a. 22 AWG 2-conductor, foil shield, twisted, stranded (7x30) tinned bare copper.

C. Constant Voltage Speaker Cabling:

1. Class 2, stranded, twisted, 2-conductor, minimum of 16-gauge wire for all 25/70.7/100-volt applications unless noted otherwise.
2. The Contractor shall size cabling as required for distance power and shall provide larger gauge cable as required.

2.3 DIGITAL VIDEO CABLING

A. All digital video cabling shall be pre-assembled and tested in a factory and not field terminated. The contractor shall field verify the cable distance and provide the proper cable type and length.

B. High Definition Multi-Media Interface (HDMI) Cable:

1. For cable runs less than or equal to 25 feet:

a. The cable shall be a minimum of HDMI 2.0 certified.
b. HDCP compliant.

2.4 CONTROL CABLING

A. Control:

1. For Bidding Purposes: Two-pair, twisted, shielded, one (1) #18 AWG pair and one (1) #22 AWG pair. Provide with plenum-rated jacket where used in a plenum space without conduit.
2. Size conductors as required for distance and voltage drop.
3. Coordinate exact requirements with selected manufacturer and system prior to submitting bid.

B. Other Control Circuits:

1. #20 AWG, stranded, shielded cable, number of conductors as required for the applications. Provide with plenum-rated jacket where used in a plenum space without conduit. Provide PVC jacket where installed in conduit or non-plenum areas.
2. Coordinate exact requirements with selected manufacturers prior to submitting bid.

2.5 HORIZONTAL COPPER DATA AND FIBER CABLING AND CONNECTORS

A. Refer to Section 27 15 00 - Horizontal Cabling Requirements, for telecommunications cabling and connector requirements including fiber optics being utilized for A/V systems.

B. Refer to Section 27 17 10 - Testing, for telecommunications cabling testing requirements including fiber optics being utilized for A/V systems.

C. All category-rated copper data cabling and fiber optic cabling shall be installed, terminated, tested and certified by the Division 27 Telecommunications contractor certified by the selected manufacturers for the copper and fiber optic cabling plant. The Contractor shall submit all cabling and certifications to the Architect/Engineer for approval in the shop drawings.

D. The A/V contractor shall coordinate purchase, installation, testing and certification with the telecommunications contractor for all required category-rated copper data cabling and fiber optic cabling required for A/V system operation prior to bid.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify field dimensions and coordinate physical size of all equipment with the architectural requirements of the spaces into which they are to be installed. Allow space for adequate ventilation and circulation of air.

C. Verify that required utilities are available, in proper location, and ready for use.

D. Beginning of installation means installer accepts existing conditions.

3.2 PRE-INSTALLATION

A. A pre-installation meeting shall be held after the project has been awarded but before any submittals or work has been conducted. The purpose of this meeting is to review the drawings and specifications to assist with the construction and installation process that will occur during construction. The meeting will include the Engineer, Architect, Owner's Representative, and all relevant installing contractors for this system. The meeting will be chaired by the project manager for the AV contract and will include the following topics:

B. The Contractor shall be responsible for submitting all requested submittals and holding the pre-installation meeting prior to any purchasing, installation, programming, and construction coordination. Any delays or changes to the project as a result of meeting this requirement will be at the Contractor's expense.

3.3 INSTALLATION

A. Comply with the manufacturer's instructions and recommendations for installation of all products.

B. Provide all system wiring between all components as directed by the manufacturer or required for proper system operation.

C. Mount all touch screen and keypad devices where shown on plans in accordance with Americans with Disabilities Act (ADA) requirements for both side reach and front reach.

D. Cabling Requirements:

1. Non-plenum rated cabling may be used instead of plenum when installed with-in conduit in plenum rated areas.
2. All cabling shall be routed according to function. Cabling shall be grouped and bundled by groups, such as: microphone and line level audio, control, video and speaker. In no case shall cabling from different functional groups be intermixed. No cabling shall be routed parallel to 120 VAC or higher power circuits unless separated by a minimum of 6" and the 120 VAC or higher power is installed in conduit.
3. When cabling is installed in conduit, a separate conduit shall be provided for each cabling functional type.
4. Cable bundles shall be loosely bundled to allow the visual following of individual cables within the bundle and to permit the easy removal and addition of cables as necessary.
5. Horizontal cabling installed as open cable or in cable tray shall be bundled at not less than 10' intervals with hook-and-loop tie wraps. The use of plastic cable zip ties is strictly prohibited in any situation.
6. Cabling shall not be spliced under any circumstances.

7. Each cable shall be appropriately identified (as defined on the record documents) at each end's termination point using pressure sensitive label strips.
8. Audio Cabling:

    a. All amplified audio cabling shall not be in the same enclosed pathway as any other type of cabling as required by the NEC. Refer to the NEC for definitions and additional requirements.
    b. The polarity of all cabling shall remain consistent throughout the project, on all equipment. Red conductors shall be used for the positive "+" side, and black used for the negative "-" side.
    c. Cable shield length shall be equal to the cable's conductor length.
    d. All shielded cables drain wire SHALL be grounded and continuous throughout the entire length of the system, including splices where speakers are installed.
    e. Balanced audio connections shall be used whenever the mating equipment allows.
    f. Do not run unbalanced cables longer than 3m. For interconnecting of unbalanced equipment in lengths longer than 3m, the Contractor shall provide a line driver located at the source.

9. Twisted Pair Cabling for All Applications:

    a. The Contractor shall ensure that the twists in each cable pair are preserved to within 0.5 inch of the termination. The cable jacket shall be removed only to the extent required to make the termination.
    b. The Contractor shall ensure that the cable shields are continuous throughout, terminated, and grounded according to the manufacturer's recommendations.

E. Grounding Requirements:

1. Provide a minimum of #6 AWG conductor from the nearest electrical service ground bus or nearest telecommunications room ground bus bar to the A/V equipment racks and cabinets regardless of location. Size cable as required by the NEC.
2. Cables containing shields shall not have the shields grounded at conduits, boxes, racks, etc. Ground the shield only at the equipment end.
3. Audio cable shields for line-level signals shall be connected to the metal equipment chassis at both ends of the cable.
4. Audio cables connected to transformers shall have the cable shield connected to the transformer shield and transformer case ground.
5. The Contractor shall not connect cable shields together from differing cables.
6. Signal-grounded balanced shields are not acceptable and shall not be installed. All balanced shields shall be chassis grounded.

F. Rack and Cabinet Requirements:

1. Ground equipment racks/cabinets as noted within this specification section and Section 27 05 26 - Communications Grounding.
2. Provide one (1) RU of space between adjacent pieces of equipment with top and/or bottom vents, above the topmost piece of equipment, and below the bottommost piece of equipment. Provide a vented cover panel covering each rack space.
3. Terminate all speaker cabling on individual barrier strips for positive "+", negative "-", and shield. The shield barrier strip shall be grounded.
4. Provide a power conditioning surge arrestor in the rack for distribution of AC power from the wall receptacles indicated on the plans. The quantity of plugs shall be adequate so that no equipment in the rack shall require plugging into an AC source outside the rack.

G. Audio System Installation Requirements:

1. The Contractor shall perform calculations for the optimal speaker tap settings to reach the desired SPL level and coverage without overloading the amplifier(s).

    a. At a minimum, the following calculations shall be used:

        1) Add together all speaker taps that will be on a single channel of the amplifier. Multiply that total by 1.2, which will allow for a 20% future expansion. Multiply that number by 1.25 to ensure the amplifier never exceeds 75% of its total output. Utilize the final number to determine the minimum amplifier power requirements.
        2) For direct coupled systems (low impedance), allow a minimum of 10 dB headroom before any distortion occurs at the amplifier input indicator when beginning gain stage tests are set up. Increase headroom as appropriate for high impact and clarity needs, typically exceeding 12 to 15 dB during continuous operation.

2. Connections of balanced to unbalanced equipment shall only be done through an active converter at the unbalanced side.
3. Connections of unbalanced to balanced equipment shall only be done through an active converter at the unbalanced side.
4. Connections from stereo balanced or unbalanced equipment to mono equipment of the same signal type shall only be done through a passive combiner.
5. Connections from mono balanced or unbalanced equipment to stereo equipment of the same signal type shall only be done through a passive divider.
6. The Contractor shall provide an isolation transformer for any balanced or unbalanced audio line that exhibits a hum, noise from EMI or RFI, power line noise, or ground loops.
7. The Contractor shall provide an active audio line driver for all balanced and unbalanced signals that exceed the distance limitations of the cabling.

H. Control System Installation Requirements:

1. The Contractor shall perform calculations for the required wire AWG size based on distance for system power for touch panels, keypads and other devices being powered. A minimum of a 15% overhead is required.

3.4 VIDEO SYSTEM TESTING AND CALIBRATION

A. All video equipment shall receive proper testing and configuration.

B. Color Space Optimization:

1. The Contractor shall set the color space of each source and display device to a uniform color space to optimize the switching speed and compatibility of a digital video system. Each device shall be set to an RGB or YCbCr color space depending on the systems primary function and compatibility of the devices.
2. If the primary function of the space is video and other digital media, the color space of each device shall be set to a YCbCr color space. If the primary function of the space is computer-based graphics and presentations, the color space of each device shall be set to an RGB color space.
3. Chroma subsampling shall be set to a consistent 4:4:4 or 4:2:2 across all devices. Set to 4:4:4 when all equipment is capable.
4. If all devices are not capable of displaying a certain color space, all devices shall be set to a common shared color space.

C. Extended Display Identification Data (EDID) Management:

1. The Contractor shall set the EDID management tables in capable equipment so all sources output the highest common EDID table of the displays (sinks).
2. For systems with capable matrix switches, the matrix shall dynamically adjust its EDID tables so any source will output the highest common EDID table of the displays (sinks) being outputted to.
3. If any source or Owner-furnished equipment (OFE) is not outputting properly, the Contractor shall provide and install an EDID Emulator and set it to the highest common EDID table of the displays (sinks) being outputted to.

D. Projectors, monitors and receivers shall be tested and adjusted for proper signal sync, convergence, brightness, contrast, and color level. The Contractor shall adjust all other parameters necessary to achieve a proper video image.

E. All video source selections shall be tested and verified.

F. All projectors and displays shall have a minimum burn-in time of 96 hours prior to any adjustments are made and the completion of the project.

G. All projectors and displays shall have their hue/tint and color/saturation calibrated with a video signal test generator and blue lens filter after a minimum warmup time of 20 minutes. Provide all calibrated settings results for each projector and display in the final documentation.

H. All projectors and displays shall have their brightness, contrast and sharpness calibrated with a video signal test generator after a minimum warmup time of 20 minutes. Provide all calibrated settings results for each projector and display in the final documentation.

I. All dynamic contrast functions shall be turned off.

3.5 AUDIO SYSTEM TESTING AND CALIBRATION:

A. All speakers shall be tested for polarity prior to high work and a table of test results shall be included for A/E inspection. All loudspeakers shall be connected with uniform polarity, where a positive pressure pulse at the input corresponds to a positive driver excursion, and all drivers are uniform always moving in the same direction. Main speakers shall not be lifted or hoisted into high access areas without polarity testing.

B. The Contractor shall make incremental adjustments on the equipment output and input tolerances to achieve matching signal levels while preserving +10 dB minimum headroom and also unity gain. Insert all broadband or high pass filters first for system protection after review of manufacturers specifications for power and bandpass.

C. The Contractor shall utilize a Real Time Audio (RTA) spectrum analyzer with AES2 Broadband pink noise at a minimum of 1/3 octave, capable of providing detailed plots and reports.

1. The Contractor shall have and own a calibrated Type 1 or Type 1.5 microphone for all measurements, that is recently calibrated within the last year.
2. Calibration by ear, tablets and portable phones with integrated microphones are never acceptable. All software analysis tools require a calibrated interface and calibrated microphone. No Android devices are used for metering or calibration. IOS devices with calibrated software and interfaces may be used.

D. Provide high quality media with full bandpass program material for critical listening. MP3 or streaming audio is not acceptable. Testing shall illustrate WAV file quality playback for impact and clarity.

E. The Contractor shall provide graphic plots of the reference ambient noise for each space at the time of the calibration and submit with the calibration results. Test signal shall be 10dB minimum above ambient noise levels during testing.

F. The Contractor shall use a listener sitting height of four (4) feet ± 1" for rooms where the primary function will be sitting. The Contractor shall use a listener standing height of five feet three inches (5.25') ± 1" for rooms where the primary function will be standing

3.6 ASSISTED LISTENING SYSTEM (ALS) PERFORMANCE REQUIREMENTS

A. The Contractor shall verify that the ALS system(s) meets the following minimum performance requirements at the earphone or headset:

1. Reach a minimum total SPL of 75 dBA and no greater than 95 dBA, with a minimum of a 50dB dynamic range volume control.
2. Achieve a minimum signal-to-noise (S/N) ratio of 18dB. It is recommended to achieve a minimum signal-to-noise (S/N) ratio of 25dB to accommodate children.
3. Ensure the peak clipping levels do not exceed 18dB down from the peak input signal level.

B. FM-based systems shall operate within the FCC-reserved assisted listening frequencies of 72 to 76 MHz or the 216 to 217 MHz (preferred) range and comply with the FCC transmitter power requirements.

3.7 DSP-BASED AUDIO PROCESSOR PROGRAMMING

A. Full system programming shall be provided for the system. Programming shall be performed by a factory trained and certified programmer or an employee of the equipment manufacturer.

B. DSP pathfile with initial settings shall be provided by the Contractor for review by the Architect/Engineer before installation.

C. The IP-based audio (IEEE AVB, Dante, etc.) and components shall be on a dedicated Virtual LAN (VLAN) for the A/V systems. These components shall be on a dedicated subnetwork of the VLAN. The Contractor shall coordinate these requirements with the Owner prior to installation.

D. A parametric EQ shall be provided after each crossover point or as approved in the DSP pathfile during shop submittal review. These equalizers should not be made available to the user to adjust.

E. Levelers, compressor/limiters, duckers, gates and delays shall be preset during testing and commissioning and are not available for user adjustment following commissioning.

F. Acoustic Echo Cancelation (AEC) shall be provided for each conference microphone input.

G. A broadband pink noise generator shall be provided with a selectable on/off control button within the DSP pathfile. The noise shall be routable through all processing EQs and speaker outputs during testing.

H. Provide volume meters with labeling for each input and each output.

I. The Contractor shall utilize the latest version of the programming software.

J. The Contractor shall ensure that all components are updated to the latest firmware at the completion of the project.

3.8 DSP-BASED AUDIO PROCESSOR CONTROL SOFTWARE PROGRAMMING

A. Full system software programming shall be provided for the system. Programming shall be performed by a factory-trained and certified programmer or an employee of the equipment manufacturer.

B. The Contractor shall schedule a series of meetings with the Owner and Architect/Engineer to define and determine the exact page layout requirements prior to the final configuration of the audio system. An Owner sign-off of the final layouts shall be required.

C. The Contractor shall use the latest version of the software.

D. At a minimum, there shall be password-protected pages for zone combining, input/output volume control with meters, speaker output volume control with meters, signal routing, signal processing (EQ's, feedback suppression, etc.), and supervision/maintenance for all spaces and combined zones.

3.9 MULTIMEDIA CONTROL SYSTEM INTEGRATION AND PROGRAMMING

A. Programming and Integration for Control Systems:

1. Full system programming shall be provided for the system. Programming shall be performed by a factory trained and certified programmer or an employee of the equipment manufacturer.
2. The Contractor shall schedule a series of meetings with the Owner and Architect/Engineer to define and determine the exact integration requirements of the control system prior to the installation of the control system and components. An Owner sign-off of the final configuration shall be required.
3. This section only defines the minimum requirements. The programmer shall provide complete programming for a fully functional system.
4. The Contractor shall utilize the latest version of the programming software.
5. The Contractor shall ensure that all components are updated to the latest firmware at the completion of the project.
6. The IP-based control system and controlled components shall be on a dedicated Virtual LAN (VLAN) for the A/V systems. These components shall be on a dedicated subnetwork of the VLAN. The Contractor shall coordinate these requirements with the Owner prior to installation.

7. Integration and programming of the following pieces of equipment shall be provided, with the following minimum features and functions:

    a. All equipment shall include on/off control, except for equipment that must remain active for system functionality.
    b. Integration of HDCP (High-bandwidth Digital Content Protection) and DPCP (Display Port Content Protection) protected content and sources:

        1) No protected sources or content shall be allowed to be selected to route through non-protected devices and displays. A warning shall be displayed stating this information to the user.

    c. AV Switching Integration:

        1) The Contractor shall provide the following minimum functions:

            a) Allow for independent video routing of individual video inputs to any audio number of audio outputs.
            b) Allow for audio follow video switcher mode.
            c) Provide source detection of video inputs.
            d) HDCP (High-bandwidth Digital Content Protection) and DPCP (Display Port Content Protection) Protection:
            e) For HDCP/DPCP - compliant sources; switcher shall only allow for routing of signals to HDCP compliant devices.

    d. DSP Audio Processor Integration:

        1) The Contractor shall provide the following minimum functions:

            a) Volume and mute control of all microphones and input sources.
            b) Volume and mute control of all outputs.
            c) Independent volume and mute control of all assisted listening outputs.
            d) On/off and reset control of feedback eliminators and suppressors.
            e) Advanced routing of audio signals.
            f) Acoustic Echo Cancelation (AEC) control.

e. Projector Integration:

1) The projectors shall be integrated into the A/V control system via bi-directional RS-232 or Ethernet control. Provide with the following minimum functions:

a) On/off control.
b) Lamp status feedback.
c) Filter status feedback.
d) Source switching control.
e) Audio volume control with mute.
f) Video mute.
g) Auto image.

f. Display Integration:

1) The displays shall be integrated into the A/V control system via bi-directional RS-232 or Ethernet control. Provide with the following minimum functions:

a) On/off control.
b) Display status feedback.
c) Source switching control.
d) Audio volume control with mute.
e) Video mute.

g. Motorized Projection Screen Integration:

1) Screens shall be integrated into the A/V control system via contact closures OR bi-directional RS-232 or Ethernet control.

a) Up/down and stop control shall be provided.

h. Pan/Tilt/Zoom (PTZ) Camera Integration:

1) The Contractor shall provide bi-directional RS-232 or Ethernet control system connections and programming with the following minimum functions:

a) Provide full pan, tilt and zoom control.
b) Provide presets for fixed camera positions, contractor shall coordinate with the Owner for desired preset positions.

B. Programming and Configuration for Touch Panels:

1. This section only defines the minimum requirements. The programmer shall provide complete touch panel layouts and programming for a fully functional system.
2. The Contractor shall schedule a series of meetings with the Owner and Architect/Engineer to define and determine the exact touch panel layout requirements prior to the purchase and installation of the touch panels. An Owner sign-off of the final layouts shall be required.

    a. Some tabs, pages, buttons and functions may be required to have a password at the Owner's discretion. This shall be coordinated during the meetings.

3. Contractor logos are not allowed on the touch panels. The Contractor shall coordinate with the Owner on desired logos to be displayed.
4. All programming for interface and control of all devices shown on the drawings shall be provided. Programming shall be provided for the following minimum functionality:

    a. The main screen shall include graphical buttons for the primary room functions.

        1) Upon selection of the graphical button, all the required functions shall be displayed on the screen. All required equipment shall turn on.

    b. Master System On/Off Control:

        1) When the master system off button is selected, all capable components within the system shall be turned off or placed on standby, except for equipment that is required to remain on for the system to function like the control system processor.

    c. The main screen shall include graphical buttons for the selection of individual source selections.

        1) Upon selection of the graphical button for a source selection, all functional controls for the pieces of equipment, as well as all status indicators, shall be provided in graphical format on the screen.
        2) Rooms with multiple independent outputs and displays shall have a source routing matrix to allow any input to be routed to any output.

    d. The main screen shall include a button for advanced equipment status and monitoring.

        1) Upon selection of the graphical button, the page shall display the on/off status of all monitored equipment, projector lamp hours, projector filter status, and all other features listed within this section that require monitoring

e. The main screen shall include a button for microphone volume control and muting.

1) Upon selection of the graphical button, it shall display the individual volume level of each microphone, with a mute for each.
2) Rooms with multiple independent audio outputs and zones shall have a source routing matrix to allow any input to be routed to any output or zone.

f. At all times, on all screens, a button shall be provided to return to the main screen, except for modal pop-ups.
g. A master volume control and mute shall be provided at all times on all screens, except for modal pop-ups.
h. A master video mute shall be provided at all times on all screens, except for modal pop-ups and audio-only functions.
i. A modal countdown timer shall be displayed showing the warmup and cooldown time of the projector. All functions shall be locked out while the projector is in cooldown mode.

C. Touch Panel Layout Principles, Considerations and Guidelines:

1. Icons and Buttons:

a. Icons shall not be used solely as a button but can be embedded in a button.
b. Icons shall appear to be flat and unpressable.
c. Status bars or text windows for time, date, room number, and similar information shall appear to be slightly depressed into the screen and appear to be unpressable.
d. Buttons shall appear to be pressable by appearing to come off the screen with beveled edges, lighting gradients, and shadows. When pressed, the button shall appear to be depressed into the screen.

1) Buttons that are momentary shall change color when pressed, appear to depress, then pop back up and revert to the original button color and state.
2) Buttons that are not momentary shall change color when pressed, appear to depress, remain depressed, then pop back up, and revert to the original button color and state when pressed again.

e. Buttons and icons shall appear to be lit from the top left corner of the screen.
f. Buttons shall be grouped together according to general function.
g. Button size shall be based on the ratio of Phi (1:1.618) and be sized appropriately based on the screen area and dpi (pixel pitch).
h. Maintain a minimum of 5 to 10 pixels between buttons on small to medium touch panels, and a minimum of 10 to 15 pixels between buttons on medium to large touch panels.
i. Telephone dialer keypads shall be based on the ITU-T E.161/ANSI TI-703 standard telephone layout and include the a-z letters below each appropriate number.

j. TV and radio tuner keypads shall be based on the ITU-T E.161/ANSI TI-703 standard telephone layout, except for the asterisk (*) being replaced by a dot (.) and the pound (#) being replaced with Enter.
k. IP-address keypads shall be based on the standard computer keyboard 10-key numeric keypad typically found on the right side of the keyboard.
l. Buttons such as Power, Play, Stop, Record, Rewind, Previous, Forward, Eject, Return, Next, Up, Down, Left, Right, Plus, Minus, etc. shall use standard industry symbols. Record shall always be a solid red circle.

2. Text and Fonts:

a. The Contractor shall use a standard sans-serif bold Arial or Calibri font style unless the Owner dictates otherwise.
b. Words shall have the first letter capitalized and the rest of the word lower case. No words shall be all capitals or all lower case. Follow standard grammatically correct sentence structure where the first word is capitalized and the rest of the sentence is lower case, followed by the appropriate punctuation mark with accurate syntax and correct verbs.
c. All font size in a single group or cluster shall maintain the same font size. Headers to a group or cluster shall have a slightly enlarged font size. and footers shall have a slightly smaller font size in comparison to the group font size to maintain a visual hierarchy.

3. Color Considerations:

a. Colors shall be selected so that, when converted to monochrome, all text, buttons, icons, groups, clusters, borders, etc. are clearly visible to accommodate all color blind or color-impaired individuals and ADA requirements.
b. Background colors shall be cool low saturation colors such as grey, blue, or green and their analogous colors, and be a gradient from top down or top left to bottom right.
c. Base colors shall be analogous to the background color but be of a higher saturation to stand out more clearly.
d. Button colors shall be analogous to the background color, stand out clearly from the base colors, and be of a higher saturation cool color, gray, or a low saturation black.
e. Icon, symbols, and text color shall be a neutral white or black, or a low saturation grey, and shall clearly stand out from the background or button it is placed on.
f. Buttons for modal acknowledgement, exit or return, or other modal action shall be a warm color such as red or yellow and their analogous colors.
g. Buttons, icons, symbols or text for emergency or urgent notifications shall be bright red.

4. Pages and Background:

   a. Groups and clusters shall have clearly defined borders, with spacing between adjacent groups.
   b. Modal pop-up windows or pages shall be required when a command requires user input before it is executed or when a button has multiple nested elements to control, such as microphone volumes, zone control, lighting and environment control, advanced system controls, etc.

      1) The modal pop-up pages shall dim and grey out the background and buttons, overlay the main page, and have a clear back or exit button to bring the user back into the active page the user was on before the modal pop-up.
      2) A model pop-up timer page shall appear when a projector is being turned on or off for the appropriate warmup or cooldown time. No additional commands shall be allowed during this time.
      3) Model pop-ups shall not replace or completely overlay the background.

   c. Images or pictures shall never be used as backgrounds to any page other than a master start page, if appropriate.

5. Medium to Large Format Touch Panel Layout Guideline Template:

   a. IMAGEClient Logo - Static Window
   b. A/V Source Selection - Static Window
   c. Display Power, Screen Controls, Light Controls, Shade Controls, and other Environmental Controls - Static Window
   d. Controls for Selected Source and Status or Home Page - Dynamic Window
   e. Master Volume and Mute, Video Mute, and Microphone Volume - Static Window
   f. Home Button - Static Window
   g. Date, Time, and Room Number - Static Window
   h. Master System Off - Static Window

## 3.10 SYSTEM COMMISSIONING

A. The Contractor shall notify the Architect/Engineer and Owner prior to conducting final system commissioning.

B. Contractor shall demonstrate system performance of all equipment and adjust settings as directed by the Architect/Engineer and/or Owner.

   1. All system settings, software options and other parameters shall be simulated and tested by the Contractor

3.11 FIELD QUALITY CONTROL

A. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product that meets the requirements of the specifications, as supplied and warranted by the system vendor. If the product or assembly is not available from the system vendor, provide product or assembly as recommended by the system vendor.

B. Periodic observations will be performed during construction to verify compliance with the requirements of the specifications. These services do not relieve the Contractor of responsibility for compliance with the Contract Documents.

3.12 FIELD SERVICES

A. The installer shall conduct a planning meeting with the Owner. The purpose of this meeting shall be to determine all equipment settings that are considered preferences (where proper system operation does not depend on the setting).

B. The installer shall include labor for all planning and all programming activities required to implement the Owner's preferences for equipment settings.

C. It shall be the responsibility of the Contractor/installer to provide a complete, functional system as described by the design documents. These responsibilities include:

1. Complete hardware setup, installation and wiring and software configuration.
2. Complete programming of software in accordance with the Owner's desires determined by the planning meeting.
3. Complete system diagnostic verification.
4. Complete system commissioning.

3.13 SYSTEM ACCEPTANCE

A. The Contractor shall submit for review a formal acceptance and system checkout procedure. The system checkout procedures shall include all system components and software. The Contractor shall perform the tests and settings and document all results.

3.14 SYSTEM DOCUMENTATION

A. Complete documentation shall be provided for the system. The documentation shall describe:

1. All operational parameters of the system.
2. Complete documentation of programming and features.
3. Complete operating instructions for all hardware and software.

B. The following sections shall be provided in the system documentation:

1. User Manual: A step-by-step guide and instructions detailing all system user functions.
2. Technical Manual: A comprehensive document providing all system operations, troubleshooting flowcharts, functional system layout, wiring diagrams, block diagrams and schematic diagrams.
3. Maintenance Manual: A comprehensive document on all aspects of physical maintenance of the systems, including cleaning of the displays, bulb changes, filter cleaning, filter changing and UPS maintenance.

3.15 SYSTEM TRAINING

A. All labor and materials required for on-site system training shall be provided. Training shall be conducted at the project site using the project equipment.

1. Provide two week's advanced notice of training to the Owner and Architect/Engineer.
2. The Architect/Engineer shall be presented with the option to attend the training.
3. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

B. At a minimum, the following training shall be conducted:

1. User Manual: A course detailing the system functions and operations that a daily user will encounter.
2. Technical User: Provide configuration training on all aspects of the system(s), including equipment and software.
3. Maintenance User: Provide training on all aspects of physical maintenance of the systems, including cleaning of the displays, bulb changes, filter cleaning and filter changing.

C. Minimum on-site training times shall be:

1. User Manual: One (1) day.
2. Technical user: One (1) day.
3. Maintenance user: Four (4) hours.

END OF SECTION

SECTION 27 51 13 - PAGING SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ceiling Speaker

B. Wall-Mounted Speaker

C. Wall-Mounted Speaker, Weather Resistant

D. Conduit

E. Non-Continuous Cable Hangers and Supports

1.2 RELATED WORK

A. Section 26 05 33 - Conduit and Boxes

B. Section 26 05 35 - Surface Raceways

C. Section 26 05 13 - Wire and Cable

D. Section 27 05 00 - Basic Communications Systems Requirements

E. Section 27 05 03 - Through Penetration Firestopping

F. Section 27 05 26 - Communications Bonding

G. Section 27 05 28 - Interior Communication Pathways

H. Section 27 15 00 - Horizontal Cabling Requirements

I. Section 27 05 53 - Identification and Administration

1.3 QUALITY ASSURANCE

A. Manufacturer: The manufacturer shall have five (5) years documented experience in the design and manufacture of paging system devices and equipment.

B. Installer: The Contractor shall have a minimum of three (3) years documented experience in paging system installation and must be a factory-authorized service and support company specializing in the selected manufacturer's product, with demonstrated prior experience with the selected manufacturer's system installation and programming.

1. The Contractor shall own and maintain all tools and equipment necessary for successful installation and testing of the system and have personnel adequately trained in the use of such tools and equipment.

C. The following qualifications have been endorsed by the AudioVisual and Integrated Experience Association (AVIXA), which is formerly known as InfoComm International.

1. The Contractor shall have a Certified Technology Specialist with a specialized installation endorsement (CTS-I) on staff and supervising the project. This service shall not be subcontracted.
2. The CTS-I shall perform the following tasks on the project:

a. Review contractor's submittals and provide a letter stating the submittals are in compliance with the contract documents.
b. Provide written and dated confirmation of an observation of the contractor's installation activities no less than every month during the construction period.
c. Provide a final written and dated confirmation of a final construction review prior to testing.
d. Review final testing and calibration of the systems and provide a letter with the documented results or transmittal of the results stating the test results and calibration compliance with the contract documents.

D. The Contractor shall have acquired and maintained all certifications for a minimum of one (1) month prior to the posted bid date of this project.

E. Service: The installer must be factory certified to provide service on the installed manufacturer's equipment and must have local service representatives within 60100miles of the project site.

F. The entire installation shall comply with all applicable electrical and safety codes. All applicable devices, equipment, and cabling shall be listed by Underwriters' Laboratories, Inc.

1.4 REFERENCES

A. ADA - Americans with Disabilities Act

B. ADAAG - Americans with Disabilities Accessibility Guidelines

C. NFPA 70 (NEC) – National Electrical Code

D. UL 813 - Standards for Commercial Audio Systems

E. UL 1480 - Speakers for Fire Alarm, Emergency, and Commercial and Professional Use

F. ISO R 266-1997

G. ANSI S1.6-1984

1.5 SUBMITTALS

A. Submit product data under the provisions of Section 27 05 00.

B. Provide materials documenting experience requirements of the manufacturer and installing contractor.

C. Product Data Submittal: Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

1. Compliance with each requirement of these documents. The submittal shall acknowledge each requirement of this section, item by item.
2. All component options and accessories specific to this project.
3. Electrical power consumption rating and voltage.
4. Heat generation for all power consuming devices.
5. Wiring and connection requirements.
6. Manufacturer's installation instructions, indicating application conditions and limitations of use as stipulated by product testing agency and instructions for storage, handling, protection, examination, preparation, installation, and initiating usage of product.

D. Certification Documentation Submittal:

1. Provide documentation of all required certifications. All certifications shall be current and valid. Any certificate with expired dates will not be accepted. Submittal shall include documentation of the following:

    a. Audiovisual and Integrated Experience Association (AVIXA) "" Formerly InfoComm:

        1) Certified Technology Specialist with a specialized Installation endorsement (CTS-I)
        2) Qualifications from InfoComm that have not expired will be accepted.

    b. System Equipment Manufacturer(s) dealer certification(s) and dealer number(s).
    c. System Equipment Manufacturer(s) programmer certification(s).
    d. All other applicable dealer, installation, and programming certifications.

2. If an alternate manufacturer is submitted, the equivalent certifications to the basis of design manufacturer's shall be required and submitted.

E. System Drawings:

1. Project-specific system CAD-generated drawings shall be provided as follows:

    a. Provide a system block diagram noting system components and interconnection between components. The interconnection of components shall clearly indicate all wiring required in the system. When multiple pieces of equipment are required in the exact same configuration (e.g., multiple identical speaker zones), the diagram may show one device and refer to the others as "typical" of the device shown.
    b. Where applicable, an equipment rack plan shall be provided showing rack elevations and dimensions in plan and elevation view. The plan shall include equipment layout within the rack.

F. Coordination Drawings:

1. Include all ceiling-mounted devices in composite electronic coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

G. Quality Assurance:

1. Provide list of test equipment proposed for use in testing the installed paging system.
2. Provide system checkout test procedure to be performed at acceptance, including demonstration of specified performance and all required system features and functions listed herein and as further detailed on the drawings.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under the provisions of Section 27 05 00.

B. Store and protect products under the provisions of Section 27 05 00.

1.7 SYSTEM DESCRIPTION

A. This specification section describes the furnishing, installation, commissioning and programming of a complete, turnkey supervised paging system.

B. Performance Statement: This specification section and the accompanying design documents are performance based, describing the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed or every equipment connection that must be made. Based on the equipment constraints described and the performance required of the system as presented in these documents, the vendor and the Contractor are solely responsible for determining all wiring, programming, and miscellaneous equipment required for a complete and operational system.

C. This Contractor shall furnish and install a paging system as hereinafter specified and further detailed on the drawings. System shall be completely wired and ready for use including, but not limited to, outlet boxes, conduit, wire, equipment, speakers, controls, and equipment cabinets.

D. Basic System Requirements: The system shall be capable of providing the following minimum features in addition to those specified elsewhere in this specification and on the drawings:

1. S paging system.
2. Supervised paging system, capable of expanding the quantity of zones by the addition of modular components. Expansion of the quantity of zones by the replacement of equipment is not acceptable without a documented trade-in policy by the manufacturer.
3. Live and pre-recorded emergency voice messages shall have priority over all non-emergency messages and other program material.
4. Live all-call voice messages via microphone.
5. Live and pre-recorded all-call voice message via workstation.
6. Live all-call voice messages via universal telephone paging interface.
7. Live and pre-recorded voice announcements to a specific zone or group of zones via workstation. Zone or group shall be user-selectable via touch-tone dialing at the initiation of a message.
8. System-wide background music from media player located at head end equipment. Background music shall be automatically muted during a voice message.
9. Two-way talkback communication with selected zone.
10. Digital feedback elimination for live voice messages.
11. Field-configurable priority override hierarchy for signal source inputs.
12. Individual volume control for each signal source input.

13. Uninterruptible power supply to support continued system operation in the event of a loss of utility power.

1.8 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 27 05 00.

B. Provide floor plans identifying actual locations of all installed overhead paging system equipment and devices.

C. Provide final system block diagram showing any deviations from shop drawing submittal. Block diagram shall include cable number documenting the numbers installed on both ends of the cable in the field.

D. Provide documentation of all test results and statement that system checkout test, as outlined in shop drawing submittal, is complete and satisfactory.

E. Warranty: Submit written warranty and complete all Owner registration forms.

F. Complete all operation and maintenance manuals as described herein.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit data under provisions of Section 27 05 00.

B. Operation and Maintenance data shall be submitted in hard copy and electronic .pdf format.

C. Operation data shall include:

1. Manufacturer's full operation instructions for each piece of equipment.
2. Complete documentation of all settings and programming.
3. Detailed, step-by-step instructions for system operation, including accessing, initiating, and performing all required system features and functions listed herein.

D. Maintenance data shall include:

1. Description of servicing procedures:

a. Documentation of all manufacturers' recommended preventive and remedial maintenance procedures to be performed by the Owner.
b. Troubleshooting flowcharts.

2. Spare parts list.

1.10 WARRANTY

A. Unless otherwise noted, provide warranty for a minimum of one (1) year after Substantial Completion, as defined by the Contract. Certain system components may require additional manufacturer's warranty as described herein.

B. The warranty shall:

1. Cover the replacement or repair of the defective product(s) and labor for the replacement or repair of such defective product(s).
2. Include emergency service and repair on-site, with response times of 24 hours from time of notification. The system shall be repaired and restored to operation within 24 hours of technician's arrival on site.

C. Refer to the individual product sections for further warranty requirements of individual system components.

PART 2 - PRODUCTS

2.1 CEILING SPEAKER

A. Refer to the drawings for manufacturer and part number.

2.2 WALL-MOUNTED SPEAKER

A. Refer to the drawings for manufacturer and part number.

2.3 WALL-MOUNTED SPEAKER, WEATHER RESISTANT

A. Refer to the drawings for manufacturer and part number.

2.4 PAGING SYSTEM CABLE

A. Refer to Section 27 05 00 for plenum or non-plenum cable rating requirements.

B. Refer to Section 27 15 00 for requirements.

2.5 CONDUIT

A. All conduit for paging system cabling shall be a minimum of 3/4" trade size.

B. Flexible conduit shall be used only for "fixture whip" type applications at speakers in accessible ceilings, between a speaker and nearby junction box. Flexible conduit for this application shall be no longer than four (4) feet. Flexible conduit shall not be installed for any other paging system cabling.

C. Refer to Division 26 for additional requirements.

2.6 NON-CONTINUOUS CABLE HANGERS AND SUPPORTS

A. Refer to Section 27 05 28 for requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with all manufacturer's instructions and recommendations for installation of all equipment, devices, and materials.

B. Wiring:

1. Refer to Division 26 for conduit requirements and additional wiring requirements. Wiring not installed in conduit shall be plenum rated.
2. All cabling shall be run in conduit "free-air" in non-continuous cable supports above accessible ceilings, and in conduit in exposed areas. Supports shall be spaced at a maximum 4-foot interval. If cable "sag" at mid-span exceeds 6 inches, another support shall be used.
3. Manufacturer's minimum bend radius specifications for cables shall be observed in all instances.
4. All cable shall be installed at right angles and be kept clear of work by other trades. To reduce or eliminate EMI, the following minimum separation distances from £ 480V power lines shall be adhered to:

    a. 12 inches from power lines of 5-kVa
    b. 18 inches from high voltage lighting (including fluorescent)
    c. 39 inches from power lines of 5-kVa or greater
    d. 39 inches from transformers and motors

5. It shall be noted that all cables shall be installed in continuous lengths from endpoint to endpoint. No splices shall be allowed unless noted otherwise.
6. All cable shall be free of tension at both ends.
7. Both ends of all cables shall be clearly labeled with an alphanumeric identifier. On speaker cables, the label shall indicate the speaker cable circuit zone or run and the telecommunications room in which the zone or run initiates; on line-level cables, the label shall indicate the signal and signal source. Record all speaker cable identifiers on record drawings.
8. Provide all system wiring between all components as shown on project documents, as directed by the manufacturer, and/or required for proper system operation and to provide specified system functionality.

C. Equipment:

1. All necessary devices, sub-components, accessories, and incidental materials required to provide a complete, turn-key paging system that provides specified performance and all required system features and functions listed herein and as further detailed on the drawings shall be provided and installed as part of a complete system.
2. Install all head end equipment and devices in a manner that allows ample air flow for cooling.
3. Install and tighten all connectors in accordance with manufacturer's instructions, using the appropriate purpose-designed tools recommended by the manufacturer for that purpose. Use caution to avoid stripping or damaging connectors, terminals, or equipment by over-tightening termination fasteners.
4. The conductor color code used in terminating system cabling at system equipment and devices shall remain consistent from device to device for each unique device type throughout the project.

D. Grounding Requirements:

1. Furnish and install a minimum #6 AWG bonding conductor from each overhead paging system head end component to the nearest wall-mounted telecommunications grounding busbar. Actual bonding conductor size determined by its installed length. Refer to Section 27 05 26 for grounding and bonding conductor sizing criteria.

3.2 FIELD QUALITY CONTROL

A. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product that meets the requirements of the specifications, as supplied and warranted by the system vendor. If the product or assembly is not available from the system vendor, provide product or assembly as recommended by the system vendor.

B. Furnished products shall be listed and classified by UL as suitable for purpose specified and indicated.

C. Periodic observations will be performed during construction to verify compliance with the requirements of the project documents. These services do not relieve the Contractor of responsibility for compliance with the project documents.

## 3.3 SYSTEM SETUP, PROGRAMMING, AND ADJUSTMENT

A. The Contractor shall provide all system programming, startup, balancing, tuning, and adjustment required as part of this project. This shall include all calibration and adjustments of equipment controls, troubleshooting, and final adjustments that may be required.

B. Complete all necessary programming to provide the indicated functionality.

C. Program priority override hierarchy as follows:

1. Emergency voice message input
2. Emergency tones
3. Voice Universal telephone paging interface input
4. Voice message input
5. Schedule tones
6. Background music

D. Paging system shall be adjusted to provide 10 dBA of sound above the ambient sound level in the space in which they are installed measured at one (1) meter from each speaker when voice pages are made. Sound shall be clear, even, and undistorted and free of any hum, noise, or sonic anomalies. Where speakers are controlled via local volume controls, adjustments shall be made with the volume control set at 70.

## 3.4 TESTING

A. The Contractor shall conduct all system testing as part of the requirements of this project. This shall include all calibration and adjustments of equipment controls, troubleshooting, and final adjustments or corrective action that may be required to provide a complete system that provides the specified performance and all required system features and functions listed herein and as further detailed on the drawings.

B. At a minimum, the installer shall perform the following inspections and tests of the installed overhead paging system:

1. Verify that all features and functionality are operating properly.
2. Verify that the system receives signal from all sources and routes those signals as specified.
3. Verify that priority override hierarchy functions properly and according to the hierarchy specified.
4. Verify that system output meets specified sound level at each speaker.
5. Verify that all controls are properly labeled and interconnecting wires and terminals are identified.

C. Document all test results and submit as part of final system documentation package.

3.5 TRAINING

A. All labor and materials required for on-site system training shall be provided. Training shall be conducted at the project site using the project equipment.

B. Provide two weeks' advanced notice of training to the user.

C. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

D. At a minimum, the following training shall be conducted:

1. Users:

a. Provide training on the system functions and operations that a daily user will encounter, including navigation of the user interface to accomplish common operations.

2. Maintenance Staff:

a. Provide training on the system functions and operations that a daily user will encounter, including navigation of the user interface to accomplish all common operations.
b. Provide training on all system components and the basic configuration of the system.
c. Identify and describe preventive and remedial maintenance procedures to be performed by the Owner.
d. Review troubleshooting flow charts and describe troubleshooting procedures for common issues.

E. Minimum on-site training times shall be:

1. Users: Two (2) hours.
2. Maintenance Staff: Two (2) hours.

END OF SECTION

SECTION 28 05 00 - BASIC ELECTRONIC SAFETY AND SECURITY SYSTEM REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Basic Safety and Security System Requirements (herein referred to Security) specifically applicable to Division 28 sections, in addition to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 REFERENCES

A. CCR California Code of Regulation

B. CBC California Building Code

C. CFC California Fire Code

D. CEC California Electric Code

E. CMC California Mechanical Code

F. CPC California Plumbing Code

G. California Title 24 - Building Energy Efficiency Standards

H. SCAQMD South Coast Air Quality Management District

1.3 SCOPE OF WORK

A. This Specification and the accompanying drawings govern the work involved in furnishing, installing, testing and placing into satisfactory operation the security systems as shown on the drawings and specified herein.

B. Each Contractor shall provide all new materials as indicated in the schedules on the drawings, and/or in these specifications, and all items required to make the portion of the security systems a finished and working system.

C. All work will be awarded under a single General Contract. The division of work listed below is for the Contractor's convenience and lists normal breakdown of the work.

D. Description of systems include but are not limited to the following:

1. Electronic access control system
2. Electronic intrusion detection system
3. Video surveillance
4. Fire detection and alarm.
5. Low voltage security wiring (less than +120VAC) as specified and required for proper system control and communications.
6. All associated electrical backboxes, conduit, miscellaneous cabling, and power supplies required for proper system installation and operation as defined in the "Suggested Matrix of Scope Responsibility".
7. Firestopping of penetrations of fire-rated construction as described in Section 28 05 03.

1.4 DIVISION OF WORK BETWEEN ELECTRICAL AND SECURITY CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described in the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described in the contract documents. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Electrical Contractor" as referred to herein refers to the Contractors listed in Division 26 of this Specification.
2. "Electrical Contractor" shall also refer to the Contractor listed in Division 28 of this specification when the "Suggested Matrix of Scope Responsibility" indicates the work shall be provided by the EC. Refer to the Contract Documents for the "Suggested Matrix of Scope Responsibility".
3. "Security Contractor" as referred to herein refers to the Contractors listed in Division 28 of this Specification.
4. Low Voltage Security Wiring: The wiring (less than 120VAC) associated with the Security Systems, used for analog and/or digital signals between equipment.

C. General:

1. The purpose of these Specifications is to outline typical Electrical and Security Contractor's work responsibilities as related to security systems including back boxes, conduit, power wiring and low voltage security wiring. The prime contractor is responsible for all divisions of work.
2. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals are approved. Therefore, only known wiring, conduits, raceways, and electrical power as related to such items, is shown on the Security Drawings. Other wiring, conduits, raceways, junction boxes, and electrical power not shown on the Security Drawings but required for the successful operation of the systems shall be the responsibility of the Security Contractor and included in the Contractor's bid.

3. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of Security systems, the final installation shall not begin until a coordination meeting between the Electrical Contractor and the Security Contractor has convened to determine the exact location and requirements of the installation.
4. Where the Electrical Contractor is required to install cable tray that will contain Low Voltage Security Wiring, the installation shall not begin until the Security Contractor has completed a coordination review of the cable tray shop drawing.
5. This Contractor shall establish Electrical and Security utility elevations prior to fabrication and installation. The Security Contractor shall cooperate with the Electrical Contractor and the determined elevations in accordance with the guidelines below. This Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

    a. Lighting Fixtures
    b. Gravity Flow Piping, including Steam and Condensate
    c. Sheet Metal
    d. Electrical Busduct
    e. Sprinkler Piping and other Piping
    f. Conduit and Wireway
    g. Open Cabling

D. Electrical Contractor's Responsibility:

1. Assumes all responsibility for all required conduit and power connections when shown on the "Suggested Matrix of Scope Responsibility" to be provided by the Electrical Contractor.
2. Assumes all responsibility for providing and installing cable tray.
3. Responsible for Security Systems grounding and bonding.
4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Security Contractor's Responsibility:

1. Assumes all responsibility for the low voltage security wiring of all systems, including cable support where open cable is specified.
2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being provided by the Electrical Contractor on the "Suggested Matrix of Scope Responsibility."
3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined herein).
4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of security equipment which is required to be bonded to the telecommunications bonding system.
5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other contractors to determine a viable layout.

1.5 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

    a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.
    b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
    c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
    d. Maintenance clearances and code-required dedicated space shall be included.
    e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. Spaces with open/cloud ceiling architecture shall indicate the overhead utilities and locate equipment as required to maintain clearance above lights. The intent for the installation is to maintain a maximum allowable vertical clearance and an organized/clean manner in the horizontal. Notify Architect/Engineer of the maximum clearance which can be maintained. Failure to comply will result in modifications with no cost to Owner.
3. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.
2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

    a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of applicable drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

    a. Scale of drawings:

        1) General plans: 1/4 Inch = 1 '-0" (minimum).
        2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).
        3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).
        4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).
        5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.
3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.
4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion but will not perform as a coordinator.
2. A plotted set of coordination drawings shall be available at the project site.
3. Coordination drawings are not shop drawings and shall not be submitted as such.
4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in the bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.
5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.
6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.
8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.
9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

    a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.
    b. Potential layout changes shall be made to avoid additional access panels.
    c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.
    d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.
    e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain signoff of the drawings by all contractors prior to installing any of the components.
11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements or installed their work without proper coordination.
12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.6 QUALITY ASSURANCE

A. Qualifications:

1. Only products of reputable manufacturers as determined by the Architect/Engineer will be acceptable.
2. Each Contractor and their subcontractors shall employ only workers who are skilled in their respective trades and fully trained. All workers involved in the installation, termination, testing, and placing into operation electronic security devices shall be individually trained by the manufacturer.
3. The Contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.
4. The Contractor shall own and maintain tools and equipment necessary for successful installation and testing of electronic security devices and have personnel adequately trained in the use of such tools and equipment.
5. Conform to all requirements of the State of California Codes, Laws, Ordinances and other regulations having jurisdiction.
6. Conform to all published standards of San Bernardino County.
7. In the event there are no local codes having jurisdiction over this job, the current issue of the National Electrical Code shall be followed.

8. If there is a discrepancy between the codes and regulations having jurisdiction over this installation, and these specifications, Architect/Engineer shall determine the method or equipment used.
9. If the Contractor notes, at the time of bidding, that any parts of the drawings or specifications do not comply with the codes or regulations, Contractor shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time to follow this procedure, Contractor shall submit with the proposal a separate price to make the system comply with the codes and regulations.
10. Verify the installation environment prior to purchasing or installing any cable. Cable installed in a plenum environment shall be appropriately rated. Bring all discrepancies between the contract documents and installation conditions to the attention of the Architect/Engineer prior to purchase or installation.
11. All changes to the system made after the letting of the contract, in order to comply with the applicable codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.

B. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.
2. Abide by all applicable laws, regulations, ordinances, and other rules of the State or Political Subdivision wherein the work is done, or as required by any duly constituted public authority.
3. Pay all applicable charges for such permits or licenses that may be required.
4. Pay all applicable fees and taxes imposed by the State, Municipal and/or other regulatory bodies.
5. Pay all charges arising out of required inspections due to codes, permits, licenses or as otherwise may be required by an authorized body.
6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized independent agency/consultant.
7. All equipment, and materials shall be as approved or listed by the following: (Unless approval or listing is not applicable to an item by all acceptable manufacturers.)

    a. Factory Mutual
    b. Underwriters' Laboratories, Inc.

C. Examination of Drawings:

1. The drawings for the Security Systems work are diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment etc., and the approximate sizes of equipment.
2. Contractor shall determine the exact locations of equipment and the exact routing of cabling to best fit the layout of the job. Scaling of the drawings will not be sufficient or accurate for determining this layout. Where a specific route is required, such route will be indicated on the drawings.
3. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

4. If an item is either shown on the drawings, called for in the specifications or required for proper operation of the system, it shall be considered sufficient for including same in this contract.
5. The determination of quantities of material and equipment required shall be made by the Contractor from the drawings. Schedules on the drawings and in the specifications are completed as an aid to the Contractor but where discrepancies arise, the greater number shall govern.
6. Where words "provide", "install", or "furnish" are used on the drawings or in the specifications, it shall be taken to mean, to furnish, install and terminate completely ready for operation, the items mentioned.

D. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.
2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.
3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by IMEG. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
4. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
5. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.
6. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.
7. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

E. Field Measurements:

1. Before ordering any materials, this Contractor shall verify all pertinent dimensions at the job site and be responsible for their accuracy.

1.7 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

| Referenced Specification Section | Submittal Item | Coordination Drawings |
|---|---|---|
| 28 05 03 | Through-Penetration Firestopping | |
| 28 13 00 | Electronic Access Control | |
| 28 16 00 | Intrusion Detection System | Yes |
| 28 23 00 | Video Surveillance | Yes |
| 28 26 05 | Rescue Assistance Communication System | |

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

a. Date
b. Project title and number
c. Contractor's name and address
d. Division of work (e.g., plumbing, heating, ventilating, etc.)
e. Description of items submitted and relevant specification number
f. Notations of deviations from the contract documents
g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

a. Date
b. Project title and number
c. Architect/Engineer
d. Contractor and subcontractors' names and addresses
e. Supplier and manufacturer's names and addresses
f. Division of work (e.g., plumbing, heating, ventilating, etc.)
g. Description of item submitted (using project nomenclature) and relevant specification number
h. Notations of deviations from the contract documents
i. Other pertinent data
j. Provide space for Contractor's review stamps

3. Composition:

    a. Submittals shall be submitted using specification sections and the project nomenclature for each item.
    b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).
    c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.
5. Contractor's Approval Stamp:

    a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.
    b. Unstamped submittals will be rejected.
    c. The Contractor's review shall include, but not be limited to, verification of the following:

        1) Only approved manufacturers are used.
        2) Addenda items have been incorporated.
        3) Catalog numbers and options match those specified.
        4) Performance data matches that specified.
        5) Electrical characteristics and loads match those specified.
        6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
        7) Dimensions and service clearances are suitable for the intended location.
        8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
        9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

    d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.

e. The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.

6. Submittal Identification and Markings:

   a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.
   b. The Contractor shall clearly indicate the size, finish, material, etc.
   c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.
   d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.
8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.
9. Reproduction of contract documents alone is not acceptable for submittals.
10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.
11. Submittals not required by the contract documents may be returned without review.
12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.
13. Submittals shall be reviewed and approved by the Architect/Engineer before releasing any equipment for manufacture or shipment.
14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.
15. Schedule shall allow for adequate time to perform orderly and proper review of submittals, including time for consultants and Owner if required, and resubmittals by Contractor if necessary, and to cause no delay in Work or in activities of Owner or other contractors.

    a. Allow at least two weeks for Architect's/Engineer's review and processing of each submittal.

16. Architect/Engineer reserves the right to withhold action on a submittal which, in the Architect/Engineer's opinion, requires coordination with other submittals until related submittals are received. The Architect/Engineer will notify the Contractor, in writing, when they exercise this right.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. Submittal file name: 28 XX XX.description.YYYYMMDD
    b. Transmittal file name: 28 XX XX.description.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.

1.8 CHANGE ORDERS

A. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders shall be broken down by sheet or associated individual line item indicated in the change associated narrative, whichever provides the most detailed breakdown. Change orders with inadequate breakdown will be rejected.

B. Itemized pricing with unit cost shall be provided from all distributors and associated subcontractors.

C. Change order work shall not proceed until authorized.

1.9 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to prevent damage to fixtures, equipment and materials.

B. Store materials on the site to prevent damage.

C. Keep fixtures, equipment and materials clean, dry and free from harmful conditions.

1.10 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.11 WARRANTY

A. At a minimum, provide a one (1) year warranty for all equipment, materials, and workmanship. Individual specifications sections within Division 28 may require additional warranty requirements for specific equipment or systems.

B. The warranty period for the entire installation described in this Division of the specifications shall commence on the date of substantial completion unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner or their representative.

C. Warranty requirements shall extend to correction, without cost to the final user, of all work and/or equipment found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from such defects or nonconformance with contract documents exclusive of repairs required as a result of improper maintenance or operation, or of normal wear as determined by the Architect/Engineer.

1.12 INSURANCE

A. Contractor shall maintain insurance coverage as set forth in Division 0 of these specifications.

1.13 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the first named manufacturer constitutes the basis for job design and establishes the equipment quality required.

B. Equivalent equipment manufactured by the other named manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meets all requirements of the drawings and specifications and fits in the allocated space. When using other listed manufacturers, the Contractor shall assume responsibility for any and all modifications necessary (including, but not limited to structural supports, electrical connections and rough-in, and regulatory agency approval, etc.) and coordinate such with other contractors. The Architect/Engineer shall make the final determination of whether a product is equivalent.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer via addendum. The Contractor bears full responsibility for the unnamed manufacturers' equipment adequately meeting the intent of design. The Architect/Engineer may reject manufacturer at time of shop drawing submittal. The Contractor assumes all costs incurred by other trades on the project as a result of changes necessary to accommodate the offered material, equipment or installation method.

D. Should this Contractor be unable to secure approval from the Architect/Engineer for other unnamed manufacturers as outlined above, this Contractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder. Should a voluntary alternate material be accepted, This Contractor shall assume all costs that may be incurred as a result of using the offered material, article or equipment necessitating extra expense on This Contractor or on the part of other Contractors whose work is affected.

PART 2 - PRODUCTS

2.1 Refer to individual sections.

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or the employees and subconsultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Installation of all conduit and cabling shall comply with Sections 26 05 33 and 26 05 13. Additional conduit requirements described within this Division shall be supplemental to the requirement described in Section 26 05 33. Should conflicts exist between the two Divisions the more stringent (more expensive material and labor) condition shall prevail until bidding addendum or construction clarification or RFI can be submitted and responded to. In no case shall the Contractor carry the least stringent condition in the pricing.

B. It is the Contractor's responsibility to survey the site and include all necessary costs to perform the installation as specified.

C. The Contractor shall be responsible for identifying and reporting to the Architect/Engineer any existing conditions including but not limited to damage to walls, flooring, ceiling and furnishings prior to start of work. All damage to interior spaces caused by this Contractor shall be repaired at this Contractor's expense to pre-existing conditions, including final colors and finishes.

D. All cables and devices installed in damp or wet locations, including any underground or underslab location, shall be listed as suitable for use in such environments. Follow manufacturer's recommended installation practices for installing cables and devices in damp or wet locations. Any cable or device that fails as a result of being installed in a damp or wet location shall be replaced at the Contractor's expense.

3.3 FIELD QUALITY CONTROL

A. General:

1. Refer to specific Division 28 sections for further requirements.
2. The Contractor shall conduct all tests required and applicable to the work both during and after construction of the work.
3. The necessary instruments and materials required to conduct or make the tests shall be supplied by the Contractor who shall also supply competent personnel for making the tests who has been schooled in the proper testing techniques.
4. In the event the results obtained in the tests are not satisfactory, This Contractor shall make such adjustments, replacements and changes as are necessary and shall then repeat the test or tests which disclose faulty or defective work or equipment and shall make such additional tests as the Architect/Engineer or code enforcing agency deems necessary.

B. Protection of cable from foreign materials:

1. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to, overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.

2. Application of foreign materials of any kind on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

3.4 PROJECT CLOSEOUT

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. The Architect/Engineer will not perform a final jobsite observation until the project is ready. This is not dictated by schedule, but rather by completeness of the project.
2. Refer to the end of this section for a "STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION."
3. The Contractor shall sign this form and return it to the Architect/Engineer so that the final observation can commence.

C. Before final payment will be authorized, this Contractor must have completed the following:

1. Submitted operation and maintenance manuals to the Architect/Engineer for review.
2. Submitted bound copies of approved shop drawings.
3. Record documents including edited drawings and specifications accurately reflecting field conditions, inclusive of all project revisions, change orders, and modifications.
4. Submitted a report stating the instructions given to the Owner's representative complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representative as having received the instructions.
5. Submitted testing reports for all systems requiring final testing as described herein.
6. Submitted start-up reports on all equipment requiring a factory installation inspection and/or start.

7. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site; submit receipt to Architect/Engineer prior to final payment being approved.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.
2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. O&M file name: O&M.div28.contractor.YYYYMMDD
    b. Transmittal file name: O&Mtransmittal.div28.contractor.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.
6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.
7. All text shall be searchable.
8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.
2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.
3. Copies of all final approved shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.
4. Copy of final approved test and balance reports.
5. Copies of all factory inspections and/or equipment startup reports.
6. Copies of warranties.
7. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
8. Dimensional drawings of equipment.
9. Capacities and utility consumption of equipment.
10. Detailed parts lists with lists of suppliers.
11. Operating procedures for each system.
12. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
13. Repair procedures for major components.
14. List of lubricants in all equipment and recommended frequency of lubrication.
15. Instruction books, cards, and manuals furnished with the equipment.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. Adequately instruct the Owner's designated representative or representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representative or representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. Notify the Architect/Engineer of the time and place for the verbal instructions to be given to the Owner's representative so a representative can be present if desired.

E. Refer to the individual specification sections for minimum hours of instruction time for each system.

F. Operating Instructions:

1. The Contractor is responsible for all instructions to the Owner and/or Owner's operating staff on the security systems.
2. If the Contractor does not have Engineers and/or Technicians on staff that can adequately provide the required instructions on system operation, performance, troubleshooting, care and maintenance, the Contractor shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 SYSTEM STARTING AND ADJUSTING

A. The security systems included in the construction documents are to be complete and operating systems. The Architect/Engineer will make periodic job site observations during the construction period. The system start-up, testing, configuration, and satisfactory system performance is the responsibility of the Contractor. This shall include all calibration and adjustments of electrical equipment controls, equipment settings, software configuration, troubleshooting and verification of software, and final adjustments that may be required.

B. All operating conditions and control sequences shall be simulated and tested during the start-up period.

C. The Contractor, subcontractors, and equipment suppliers are expected to have skilled technicians to ensure that the system performs as designed. If the Architect/Engineer is requested to visit the job site for the purpose of trouble shooting, assisting in the satisfactory start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period through no fault of the design; the Contractor shall reimburse the Owner on a time and material basis for services rendered at the Architect/Engineer's standard hourly rates in effect at the time the services are requested. The Contractor shall be responsible for making payment to the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.8 RECORD DOCUMENTS

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Mark specifications to indicate approved substitutions, change orders, and actual equipment and materials used.

C. This Contractor shall maintain at the job site, a separate and complete set of Security Drawings which shall be clearly and permanently marked and noted in complete detail any changes made to the location and arrangement of equipment or made to the Technology Systems and wiring as a result of building construction conditions or as a result of instructions from the Architect or Engineer. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable. Should This Contractor fail to complete Record Documents as required by this contract, This Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer's hourly rates in effect at the time of work.

D. Record actual routing of all conduits sized 2" or larger.

E. The above record of changes shall be made available for the Architect and Engineer's examination during any regular work time.

F. Upon completion of the job, and before final payment is made, This Contractor shall give the marked-up drawings to the Architect/Engineer.

3.9 ADJUST AND CLEAN

A. Contractor shall thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Contractor shall clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from equipment.

C. Contractor shall remove all rubbish, debris, etc., accumulated during the Contractor's operations from the premises.

3.10 SPECIAL REQUIREMENTS

A. Adhesives and Sealants: All sealers, adhesives, and sealants shall comply with the low emitting material limits of the following standards: CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions VOC from Indoor Sources Using Environmental Chambers Version 1.1.
   1. South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications. All adhesives and sealants wet-applied on site shall comply with the applicable chemical content requirements of SCAQMD Rule 1168.
   2. South Coast Air Quality Management District Rule SCAQMD 1113 - Wet Applied Paints and Coatings. All paints and coatings wet-applied on site must meet the applicable VOC limits of SCAQMD Rule 1113.

STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION

To assist the contractor in a timely close-out of the project, it is crucial that the final jobsite observation is not conducted prior to the project being ready. The contractor is required to review the completion status of the project at the time the observation is scheduled. This review, and the subsequent submittal of this form to the Architect/Engineer, shall indicate the contractor's agreement that the area of the project being requested for final observation is ready as defined below. The following list represents the degree of completeness required prior to requesting a final observation:

1. All cabling pathways (cable tray, ladder rack, conduit sleeves, etc.) are installed and all cabling has been pulled through them.
2. All mechanical firestop products are installed and all other penetrations have been sealed.
3. All CCTV cameras, mounts, cabling and all headend equipment are installed, programmed and operational.
4. All access control system equipment, including card readers, conduits, cabling, electronic locks, controllers and all headend equipment, is installed, programmed and operational.

Prime Contractor: _____ By: _____

Requested Observation Date _____ Today's Date: _____

Contractor shall sign this readiness statement and transmit to Architect/Engineer at least 10 days prior to the requested date of observation.

It is understood that if the Architect/Engineer finds that the project is not complete as defined above and that the final jobsite observation cannot be completed on the requested date, the Architect/Engineer will return to the site at a later date. All additional visits to the site for the purposes of completing the final observation will be billed T&M to the Contractor at our standard hourly rates, including travel expenses or the contractor's retainage may be deducted for the same amount.

END OF SECTION

SECTION 28 05 03 - THROUGH PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Through-Penetration Firestopping.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this Section.

B. Installer: Individuals performing work shall be certified by the manufacturer of the system selected for installation.

1.3 REFERENCES

A. UL 263 - Fire Tests of Building Construction and Materials

B. UL 723 - Surface Burning Characteristics of Building Materials

C. ANSI/UL 1479 - Fire Tests of Through Penetration Firestops

D. UL 2079 Tests for Fire Resistance of Building Joint Systems

E. UL Fire Resistance Directory Through Penetration Firestop Systems (XHEZ)

F. Intertek / Warnock Hersey - Directory of Listed Products

G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials

H. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Firestops

I. CBC California Building Code

J. The Building Officials and Code Administrators National Building Code

K. 1997 Uniform Building Code

L. 2021 International Building Code

M. NFPA 5000 - Building Construction Safety Code

1.4 SUBMITTALS

A. Submit under provisions of Section 28 05 00.

B. Submit Firestopping Installers Certification for all installers on the project.

C. Shop Drawings: Submit for each condition requiring firestopping. Include descriptions of the specific penetrating item, actual wall/floor construction, manufacturer's installation instructions, and UL or Intertek / Warnock Hersey Assembly number.

D. Through-Penetration Firestop System Schedule: Indicate locations of each through-penetration firestop system, along with the following information:

1. Types of penetrating items.
2. Types of constructions penetrated, including fire-resistance ratings and, where applicable, thicknesses of construction penetrated.
3. Through-penetration firestop systems for each location identified by firestop design designation of qualified testing and inspecting agency.
4. F ratings for each firestop system.

E. Maintain a notebook on the job site at all times that contains copies of approved submittals for all through penetration firestopping to be installed. Notebook shall be made available to the Authority Having Jurisdiction at their request and turned over to the Owner at the end of construction as part of the O&M Manuals.

F. Submit VOC rating of firestopping material in g/L (less water) with documentation that it meets the limits set forth in SCAQMD Rule 1168.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store, protect and handle products on site. Accept material on site in factory containers and packing. Inspect for damage. Protect from deterioration or damage due to moisture, temperature changes, contaminants, or other causes. Follow manufacturer's instructions for storage.

B. Install material prior to expiration of product shelf life.

1.6 PERFORMANCE REQUIREMENTS

A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

1. Fire-resistance-rated walls including fire partitions, fire barriers, and smoke barriers.
2. Fire-resistance-rated horizontal assemblies including floors, floor/ceiling assemblies, and ceiling membranes of roof/ceiling assemblies.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per UL 1479:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.

C. For through-penetration firestop systems exposed to light, traffic, moisture, or physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

E. For through-penetration firestop systems in air plenums, provide products with flame-spread and smoke-developed indexes of less than 25 and 50, respectively, as determined per ASTM E 84.

F. Adhesives and Sealants: All sealers, adhesives, and sealants shall comply with the low emitting material limits of the following standards:

1. CDPH Standard Method V1.1-2010 - Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions VOC from Indoor Sources Using Environmental Chambers Version 1.1.
2. South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications. All adhesives and sealants wet-applied on site shall comply with the applicable chemical content requirements of SCAQMD Rule 1168.
3. South Coast Air Quality Management District Rule SCAQMD 1113 - Wet Applied Paints and Coatings. All paints and coatings wet-applied on site must meet the applicable VOC limits of SCAQMD Rule 1113.

1.7 MEETINGS

A. Pre-installation meeting: A pre-installation meeting shall be scheduled and shall include the , General Contractor, all Subcontractors associated with the installation of systems penetrating fire barriers, Firestopping Manufacturer's Representative, and the Owner.

1. Review foreseeable methods related to firestopping work.
2. Tour representative areas where firestopping is to be installed; inspect and discuss each type of condition and each type of substrate that will be encountered, and preparation to be performed by other trades.

1.8 WARRANTY

A. Provide one year warranty on parts and labor.

B. Warranty shall cover repair or replacement of firestop systems which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability, or appear to deteriorate in any manner not clearly specified by the manufacturer as an inherent quality of the material.

PART 2 - PRODUCTS

2.1 THROUGH PENETRATION FIRESTOP SYSTEMS

A. Provide materials and systems classified by or listed by Intertek / Warnock Hersey to provide firestopping equal to time rating of construction being penetrated.

B. All firestopping materials shall be free of asbestos, lead, PCB's, and other materials that would require hazardous waste removal.

C. Firestopping shall be flexible to allow for normal penetrating item movement due to expansion and contraction.

D. Provide firestopping systems capable of supporting floor loads where systems are exposed to possible floor loading or traffic.

E. Provide firestopping systems allowing continuous insulation for all insulated pipes.

F. Any opening in walls or floors shall be coordinated with the firestopping manufacturer.

G. Any openings in floors or walls not described in the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory, or outlined in manufacturer's information shall be sealed in a manner agreed upon by the Firestopping Manufacturer, Owner, and the Authority Having Jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Ensure all surfaces that contact seal materials are free of dirt, dust, grease, oil, rust, or loose materials. Clean and repair surfaces as required. Remove laitance and form-release agents from concrete.

B. Ensure substrate and penetrating items have been permanently installed prior to installing firestopping systems. Ensure penetrating items have been properly spaced and have proper clearance prior to installing firestopping systems.

C. Surfaces to which sealing materials are to be installed must meet the selected UL or Intertek / Warnock Hersey system substrate criteria.

D. Prime substrates where recommended in writing by through-penetration firestop system manufacturer. Confine primer to area of bond.

3.2 INSTALLATION

A. Install penetration seal materials in accordance with printed instructions of the UL or Intertek / Warnock Hersey Fire Resistance Directory and with the manufacturer's printed application instructions.

B. Install dams as required to properly contain firestopping materials within openings and as required to achieve required fire resistance rating. Remove combustible damming after appropriate curing.

3.3 CLEANING AND PROTECTING

A. Clean excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not cause damage.

B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

3.4 INSPECTION

A. All penetrations shall be inspected by the manufacturer's representative to ensure proper installation.

B. Access to firestop systems shall be maintained for examination by the Authority Having Jurisdiction at their request.

C. Proceed with enclosing through-penetration firestop system with other construction only after inspection reports are issued and firestop installations comply with requirements.

D. The contractor shall allow for visual destructive review of 5% of installed firestop systems (minimum of one) to prove compliance with specifications and manufacturer's instructions and details. Destructive system removal shall be performed by the contractor and witnessed by the engineer and manufacturer's factory representative. The engineer shall have sole discretion of which firestop system installations will be reviewed. The contractor is responsible for all costs associated with this requirement including labor and material for removing and replacing the installed firestop system. If any firestop system is found to not be installed per manufacturer's specific instructions and details, all firestop systems are subject to destructive review and replacement at the engineer's discretion and the contractor's expense.

END OF SECTION

SECTION 28 13 00 - ELECTRONIC ACCESS CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Server

B. Client Workstations

C. Field Control Hardware

D. Application Software

E. Access Control Graphical User Interface

F. Credentials and Badging

G. Portal Devices

H. Interfaces and Integrations

1.2 RELATED WORK

A. Section 08 71 00 - Door Hardware

B. Section 26 05 13 - Wire and Cable

C. Section 26 05 33 - Conduits and Boxes

D. Section 26 05 35 - Surface Raceways

E. Section 27 05 26 - Communications Bonding

F. Section 27 05 28 - Interior Communication Pathways

G. Section 27 05 43 - Exterior Communication Pathways

H. Section 27 05 53 - Identification and Administration

I. Section 27 15 00 - Horizontal Cabling Requirements

J. Section 28 05 00 - Basic Electronic Safety and Security System Requirements.

K. Section 28 05 03 - Through Penetration Fire stopping.

L. Section 28 16 00 - Intrusion Detection System

M. Section 28 23 00 - Video Surveillance

N. Section 28 31 00 - Fire Detection and Alarm Systems.

1.3 QUALITY ASSURANCE

A. Contractor:

1. Shall be a factory-authorized installation, service and support company specializing in the selected manufacturer's product, with demonstrated prior experience of a minimum of three (3) years installing, programming and supporting the selected manufacturer's system.
2. Shall have been in business for a minimum of three (3) years and shall have installed a minimum of three (3) similar or larger sized systems. Contractor shall have a minimum of two (2) service technicians who are certified in the proposed manufacturer's system.
3. Shall retain the services of a minimum of one employee with the following certification(s) or education

a. A certification of RCDD from BICSI or CNIDP from CNet.
b. A certification of MCSA: Server: Server Infrastructure from Microsoft.
c. A certification of CCNA or CCNP from CISCO.

B. Material:

1. All material which is Contractor furnished shall be new, unused and free from defects.
2. Where more than one of any specified item of equipment or material is used, all such items shall be the same product from the same manufacturer.

1.4 REFERENCES

A. International Building Code

B. NFPA 70 - National Electrical Code.

C. The BOCA National Building Code

D. UL 294 - Standard for Access Control Systems.

E. UL 365 - Standard for Police Station Connected Burglar Alarm Units and Systems.

F. UL 464 - Standard for Audible Signal Appliances.

G. UL 603 - Standard for Power Supplies for Use with Burglar Alarm Systems.

H. UL 609 - Standard for Local Burglar Alarm Units and Systems

I. UL 634 - Standard for Connectors and Switches for Use with Burglar Alarm Systems.

J. UL 827 - Standard for Central Station Alarm Services.

K. UL 1076 - Standard for Proprietary Burglar Alarm Units and Systems.

L. UL 1449 - Standard for Surge Protective Devices.

M. UL 1635 - Standard for Digital Alarm Communicator Systems.

N. UL 1638 - Standard for Visual Signaling Appliances – Private Mode Emergency and General Utility Signaling.

O. UL 1778 - Uninterruptible Power Systems.

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 28 05 00.

B. Product Data Submittal: Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

1. Compliance with each requirement of these documents. The submittal shall acknowledge each requirement of this section, item-by-item.
2. All component options and accessories specific to this project.
3. Electrical power consumption rating and voltage.
4. Wiring requirements.
5. Server processor(s), workstation configurations, total and available disk space, and memory size.
6. All network bandwidth, latency and reliability requirements.

C. System Drawings: Project-specific system CAD drawings shall be provided as follows:

1. Provide a system block diagram noting system components and interconnection between components. The interconnection of components shall clearly indicate all wiring required in the system. When multiple pieces of equipment are required in the exact same configuration (e.g., multiple identical controllers), the diagram may show one device and refer to the others as "typical" of the device shown. The diagram shall list room numbers where each controller will be located. This block diagram shall be provided in Adobe PDF.
2. Provide a schedule of all controllers and the doors/points each controller controls. This schedule shall be provided in Adobe PDF.
3. Provide schedules describing each system input location by an architecturally familiar reference, e.g., Door 312A. The architectural door schedule shall be used as the basis. These schedules shall be provided in Adobe PDF

D. Submit sample format of site specific programming guides to be used for system planning/programming conference with Owner. These guides shall be provided in Adobe PDF.

E. IP Addresses: Contractor shall provide to Owner, in a documented transmittal and in Microsoft Excel format, the names and locations of devices which require an IP address. An authorized representative of the Owner shall furnish the addresses for the associated devices in Microsoft Excel format in a documented transmittal. Should Owner change the IP address structure after approval of the list, Owner may be responsible for additional fees involved with reprogramming.

F. Quality Assurance:

1. Provide system checkout test procedure to be performed at acceptance. Test procedures shall include all external alarm events.

1.6 SYSTEM DESCRIPTION

A. This section describes the furnishing, installation, programming and commissioning of a complete, turnkey access control system. The terms "access control system" and "security management system", or SMS, may be used interchangeably herein.

B. The company, manufacturer, and product names used in this section are for identification purposes only. All trademarks and registered trademarks are the property of their respective owners.

C. Performance Statement: This section and the accompanying access control-specific design documents are performance based, describing the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the equipment constraints described and the performance required of the system, as presented in these documents, the vendor and the Contractor are solely responsible for determining all wiring, programming, and miscellaneous equipment required. The Contractor shall be responsible for determining quantities of materials required for a complete and operational system. Floor plan drawings and schedules have been developed to aid the Contractor in determining device quantities and installation locations, but, where discrepancies between floor plans and schedules arise, the greater number shall govern.

D. Basic System Description:

1. The access control system shall provide the following functionality:

a. Electronic control access to designated areas.
b. Validation of cardholder credentials by use of personnel database, card formats, PINs. The system shall compare the time, location, and unique credentials of an attempted entry with information stored in the database.
c. Access to designated areas will be validated only when a user's credential has a valid number for its facility and the number is valid for the current time and for the reader where it is used.
d. The system software shall access the hardware that validates the person and monitors the security of a building by use of intelligent system controllers, reader interfaces, locks, readers, inputs and outputs. When access has been validated, a signal to the portal locking device shall be activated to enable alarm free access at that location.
e. The system shall be configured by use of application software.
f. The system shall monitor activities using operator monitoring software which includes graphical maps which display alarms, status and activity.
g. The system shall differentiate and restrict administrative and operational access through use of password authentication.

h. The system shall report on various aspects of the system by use of reports, both default and customizable. Reports shall be able to be printed.
i. The system shall have the capability to report alarms both audibly and visually.
j. The system shall control hardware from the monitoring station by use of manual actions and events.
k. The system shall provide record and data management by use of journals. There shall be a full audit trail.
l. The system shall allow for data to be imported from other products by use of database migration tools. These products may include Human Resources databases for name and/or time and attendance information, information from previous access control systems consisting of badge numbers from credentials that will be re-used, Microsoft Excel spreadsheets, or other systems as defined herein.
m. The system shall allow access using a web interface or a mobile application for use on the iOS and Android operating systems.

E. Integrations, Software Development Kit (SDK) and Application Programming Interface (API):

1. The manufacturers of the systems that are integrated shall make an SDK available to other manufacturers.
2. Prior to the release of this section, the manufacturers of the systems that are to be integrated shall have made available to each other all APIs to perform the specific integrated functions required in this section.
3. The integrations shall be completed and tested, and shall have been implemented on at least one system of similar size prior to the release of this section. The integrations shall not be accomplished for the first time for this project unless written pre-approval has been granted by Owner to Contractor prior to bid deadline.
4. During the warranty period, should a new API or version of software be released by the SMS manufacturer or any of the manufacturers of systems or devices that are integrated, that API or version of software shall be installed in the appropriate system or device defined in this section at no charge to Owner. Should any loss of functionality in the integration be exposed through this installation, as compared to the accepted system, Contractor shall correct the functionality at no charge to Owner.
5. Any and all development costs for specified functionality or inter-system integrations shall be included in the Contractor's bid. No additional costs or fees for the integrations shall be charged to Owner from the time of notice to proceed through system acceptance.

1.7 OWNER FURNISHED MATERIAL

A. Data circuit / internet service

B. Active telephone service equipment, such as key system, PBX or VOIP switch equipment

C. Active computer network equipment:

1. Routers
2. Switches
3. Hubs
4. Wireless access points
5. Uninterruptible power supplies for Owner furnished products

D. Active computer equipment:

1. SMS workstation(s) - refer to Part 2 for details
2. SMS badging station(s) - refer to Part 2 for details
3. Uninterruptible power supplies for Owner furnished products

1.8 LICENSING REQUIREMENTS

A. All user licenses required for system operation shall be included in the Contractor's bid. User licenses shall include server and workstation software, network controllers, card readers, printers, badging stations, and any other licensing that is required by the manufacturer for operation of any system component.

1. Licenses shall be provided on a one-to-one basis. One license shall be provided for each device requiring a license. In the event the manufacturer requires the purchase of a block of licenses, license blocks provided shall be no greater than what is required for the number of devices in this project. Contractor shall document the number of remaining licenses in the project record documents and Operations and Maintenance data.
2. In addition to the licensing requirements listed above, provide licensing and configuration of system administration/operation software for two (2) workstations. The workstation licenses shall be concurrent use seats, and the client software shall be able to be loaded on an unlimited number of workstations at no extra cost to the Owner. Contractor shall install client software on the same number of machines as licenses provided. As part of the training, Contractor shall demonstrate to Owner how to install client software on additional workstations.

3. All Contractor-furnished software shall contain a perpetual, permanent license in which no other fees beyond the single payment for the work of this section are required in order to use the proposed software indefinitely. Owner understands that, after the initial warranty period has expired, maintenance and technical support fees may be required annually, quarterly, or monthly in order to receive software updates and technical support. However, it remains the option of Owner to purchase or decline this service. If Owner chooses to discontinue or never purchase this service, the software shall continue to be legally licensed for use. All software shall be the latest version released, and all Contractor-furnished servers and workstations shall be current on all patches and updates for all software on the machines at the time of acceptance of the associated systems.
4. The SMS shall require only a single license key present on the server for the SMS to operate. The key shall be a physical device or a software key. License keys shall not be required at the client workstations.

1.9 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 28 05 00.

B. Provide final system block diagram showing any deviations from shop drawing submittal.

C. Provide statement that system checkout test, as outlined in the shop drawing submittal, is complete and satisfactory.

D. Provide schedules documenting:

1. Controller installation locations including specific door numbers being controlled.
2. All terminal block wiring, including cable numbers.

E. Warranty: Submit written warranty and complete all Owner registration forms.

F. Complete all operation and maintenance data manuals as described below.

1.10 OPERATION AND MAINTENANCE DATA

A. Submit documents under the provisions of Section 28 05 00.

B. Manuals: Final copies of the manuals shall be delivered within 14 days after completing the installation test. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of the contractor responsible for the installation and maintenance of the system, and the factory representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The final copies delivered after completion of the installation test shall include all modifications made during installation, checkout, and acceptance testing. Manuals shall be submitted in electronic format only, Adobe PDF. The manuals shall consist of the following:

1. Hardware Manual: The manual shall describe all equipment furnished including:

   a. General description and specifications.
   b. Installation and check out procedures.
   c. System and equipment layout and electrical schematics to the control board and field device level. For multiple devices wired identically, only one wiring diagram is required per door configuration, to be labeled "TYPICAL".
   d. Alignment and calibration procedures.
   e. Manufacturers repair parts list indicating sources of supply.

2. Software Manual: The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

   a. Definition of terms and functions.
   b. System use and application software.
   c. Initializations, startup, and shutdown procedures.
   d. Reports generation.
   e. Details on forms customization and field parameters.

3. Operator's Manual: The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

   a. Computers and peripherals.
   b. Log in/Log out procedures.
   c. Use of system, command, and applications software.
   d. Recovery and restart procedures.
   e. Graphic alarm presentation.
   f. Use of report generator and generation of reports.
   g. Data entry.
   h. Operator commands.
   i. Alarm messages.
   j. System permissions functions and requirements.

4. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, cleaning, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.11 WARRANTY

A. Unless otherwise noted, provide warranty for one (1) year after date of Substantial Completion for all materials and labor.

B. Onsite Work During Warranty Period: This work shall be included in the Contractor's bid and performed during regular working hours, Monday through Friday.

C. Operation: Upon the completion of any scheduled adjustments or repairs, Contractor shall verify operation of the SMS.

D. Service: The Owner will initiate service calls when the SMS is not functioning properly. If requested by the Owner, the Contractor shall respond or remain at the site after normal business hours, and the Owner shall reimburse the Contractor for the incremental cost difference between premium labor rates and standard labor rates. This reimbursement applies to premium labor rates that do not exceed time-and-one-half rates after normal business hours and double-time rates for Sundays and holidays. The Owner shall be furnished with telephone number(s) where service personnel can be reached 24/7/365. Qualified service personnel shall be at the site within 24 hours after receiving a request for service.

E. Records, Logs and Work Requests: Contractor shall keep records and logs of each task completed under and outside of warranty. These logs shall be maintained in Microsoft Word or Excel. The log shall include the model and serial number identifying the component involved, its location, date and time the call was received, specific nature of trouble, names of service personnel assigned to the task, description of work performed, the amount and nature of the material used, and the time and date of commencement and completion of the work. Complete logs shall be kept and shall be available for review on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the SMS. The Contractor shall deliver a record of the work performed within three (3) business days after work is completed. Defective items that have been replaced shall be given to the Owner. Should the replacement item be a temporary replacement until the removed item is repaired, Contractor shall retain possession of the defective item for repair and subsequent re-installation.

F. System Modifications: Modifications by the Contractor are allowed after system acceptance. Contractor shall make recommendations for system modification in writing to the Owner. No system modifications shall be made without prior, written approval of the Owner. Any modifications made to the system shall be incorporated into the Operations and Maintenance Manuals, and other documentation affected. The Owner shall be provided with electronic restorable versions of all configurations prior to the modifications being made.

G. Software: At no charge, the Contractor shall provide to Owner all updates released by the manufacturer during the period of the warranty and verify operation of the system upon installation. These updates include system software updates, patches, bug fixes and revisions, as well as firmware updates. These updates shall be accomplished in a timely manner, fully coordinated with SMS administrators and operators, shall include training for the new changes/features, and shall be incorporated into the Operations and Maintenance Manuals and software documentation.

H. Refer to the individual product sections for further warranty requirements of individual system components.

## PART 2 - PRODUCTS

### 2.1 ELECTRONIC ACCESS CONTROL SYSTEM MANUFACTURERS

A. Genetec Synergis

B. Should the access control manufacturer offer, as an option, the use of hardware by Mercury Security, the Contractor proposed solution shall utilize this hardware. Contractor shall state whether or not the software is compatible with the SCP, AP and EP families of Mercury Security hardware. For future additions or defective hardware replacements, the system shall not be "locked" to require Mercury Security hardware be purchased only from the access control software manufacturer or from the original Installing Contractor.

### 2.2 SERVER

A. The system shall not be required to have a traditional or virtual server and, instead, may be provided with embedded server functionality integral to the controller if the following three (3) conditions are met. The server specified below shall apply if the system does not meet these three (3) conditions:

1. The network controller is a distributed architecture, native IP network appliance.
2. The network appliance contains an onboard, embedded operating system (e.g., Linux-based), web server, ODBC-compliant database engine, data storage device and application logic controller.
3. The network appliance contains onboard SSL communications.

B. The system shall communicate on a TCP/IP based Ethernet LAN capable of utilizing 10/100/1000 BaseT.

C. The system shall be functional in a virtual server environment.

D. Provisioning:

1. The server shall be furnished by the Contractor and shall meet the specifications defined by the SMS software manufacturer to meet or exceed the functionality and performance specifications of the system and integrations defined in this and related sections. Contractor shall coordinate with Owner for possible requirements to utilize a specific manufacturer. Contractor furnished server shall have a three (3) year limited warranty.
2. Acceptable manufacturers of Contractor-furnished server are:

    a. Genetec Synergis

E. Hardware:

1. Enterprise class server meeting the manufacturer's minimum performance requirements for the system.

F. Database:

1. Provide the latest version of database software. Coordinate version with Owner prior to purchase/installation.

G. Upgrades or expansion of the SMS to a larger size system in scale shall not require installation of a different and/or new SMS application or require the administrator/operator to learn a different and/or new interface from the previous version.

H. Associated Software:

1. Support for web client.
2. Support for mobile client.

2.3 CLIENT WORKSTATIONS

A. Provisioning:

1. The workstation(s) shall be furnished by the Owner and shall meet the specifications defined by the SMS software manufacturer to meet or exceed the functionality and performance specifications of the system and integrations defined in this and related sections. Contractor shall furnish specifications to the Owner in writing as part of the submittals.
2. Contractor shall install client software on up to two (2) workstations.

2.4 FIELD CONTROL HARDWARE

A. Interior Control Panels:

1. Control boards, power distribution and terminals shall be enclosed in a NEMA 1 rated enclosure that is key lockable. Contractor shall not furnish padlock. All enclosures that are part of this project shall be keyed alike. Contractor shall furnish and install a mechanically fastened tamper switch on the interior of the enclosure.
2. Control boards are allowed to be in an enclosure separate from the power supplies/power distribution. Should they be in separate enclosures, the interface wiring shall be in rigid metallic conduit, RMC, with Myers hubs at both ends of the conduit.
3. Intra-enclosure wiring shall be dressed using tie wraps and/or covered plastic wire way. Hook-up wires for identical purposes shall have the same color insulation. For example, if one input pair utilizes green and white insulated conductors, all similar inputs shall use green and white insulated conductors. The same color scheme shall be followed for all access control panels that are part of this project.
4. Cabling from field devices such as readers, door position switches, request-to-exit devices and locking devices shall not be directly terminated to the control boards and power supplies. The field devices shall be terminated to terminals located on the left side, right side or both sides of the enclosure back panel. Intra-enclosure wiring shall be routed from the terminals to the control boards and power distribution. Quantity and functional sequence of the terminals shall be identical portal to portal.
5. All devices inside the enclosure, less cabling and batteries, shall be mechanically fastened to a removable solid or perforated metal back panel with either:

    a. Metal or plastic standoffs
    b. DIN rail

6. Hook and loop fasteners, double sided tape or adhesives are not allowed to attach devices to the back panel. Mounting devices to the interior of the door shall only be allowed when the following two (2) conditions are met:

    a. The access control hardware manufacturer offers prefabricated enclosures with devices mounted to the interior of the door.
    b. Only the same devices that the access control manufacturer mounts to the interior of the door are allowed to be mounted in a different enclosure, and those devices shall be mounted in an identical manner.

7. Power to the locking devices shall be provided by a power distribution board with no fewer than four (4) outputs. Each lock shall be individually protected. The power distribution board shall:

    a. Provide protection with fuses or positive temperature coefficient (PTC) devices.
    b. Provide control so that each output is individually selectable as latching or non-latching with fire alarm activation.
    c. Provide control so that each output shall have Fail Safe and Fail Secure terminals.
    d. Provide a fire alarm input with associated trigger LED.
    e. Provide an individual LED per output to indicate when an input has been triggered and the associated output has been activated.
    f. Accept a dry, closed contact input to activate the individual lock outputs.
    g. Provide a dry, Form C relay that energizes on activation of the fire alarm input. This output may then be used as a fire alarm input to other power distribution boards in the same or a different enclosure, or may provide input to another device such as a multi-pole relay.

8. A minimum of four (4) 12V rechargeable, sealed, lead acid batteries shall be located in the bottom of the enclosure. Two of the batteries shall be connected in series for 24V devices, and two batteries shall be connected in parallel for 12V devices. Contractor shall provide appropriately sized batteries as needed to power all devices for a minimum of two (2) hours. Connections to the batteries shall be made with appropriate terminals crimped on the connecting conductors. Batteries shall be clearly labeled in a permanent manner with the date of installation.
9. Power to control boards, readers and auxiliary devices such as request-to-exit motion detectors shall be provided by a power distribution board with no fewer than four (4) outputs. All devices powered by the same voltage at an individual portal shall be protected by the same fuse or PTC unless current requirements dictate otherwise. Individual fuses or PTCs may protect more than one control board.
10. All access control panels, when populated with control boards and power supplies, shall have the following capacities:

    a. Control of a minimum of two (2) portals.
    b. Spare capacity of a minimum of one (1) access control portal, two (2) auxiliary inputs and two (2) auxiliary outputs greater than the requirements of the project at the time of system specification.
    c. Five (5) spare fuses of each type used, to be in their original packaging, to be located in each power supply enclosure.
    d. 50% spare current capacity on all power supplies located in unconditioned spaces and 40% spare capacity for those in conditioned spaces. Lower spare capacities are allowable based on prior approval of Contractor-provided power calculations.

11. Locations where enclosures may be mounted are shown on the plans. Final location, with approval of Owner's representative, shall be selected by Contractor based on distribution of controlled portals and devices.

12. At time of Substantial Completion, Contractor shall furnish a schematic diagram of intra-enclosure wiring and a complete bill of materials for the enclosures and the devices located within. This documentation shall include a schedule of fuses and the device(s) that each fuse protects. This documentation shall be placed by Contractor in a Contractor-furnished print pocket located on the inside of the enclosure door.

B. Intelligent System Controllers (ISC):

1. The controller shall communicate with the host via an on board 10/100/1000 Base T Ethernet port.
2. The controllers shall be a distributed architecture with full peer-to-peer networking capability. Parent/Child controller configurations are not acceptable. All controllers in the system shall be capable of operating in a standalone mode if communication is lost with the server or main controller. In no case shall a controller depend on communication with an upstream controller for proper standalone operation.
3. The communications bus shall be supervised for wiring integrity. If a communication failure is detected, the system shall report the loss. All controllers unable to receive communication shall operate as standalone devices including grant/deny decisions, complete with event buffers. All events shall be uploaded to the server upon restoration of communications.
4. The controllers shall utilize flash memory or similar technology, allowing program updates to be downloaded from the server. Program storage shall be in ROM.
5. The controllers shall have the capacity for 15,000 cardholders and 45,000 transactions. All access decisions involving these cardholders shall be made at the lowest controller level without communication to the server.
6. Handle all non-host related access control monitoring and decision making.
7. LED indicators for power, fault and communications.
8. Provide for local and global input/output linking:

    a. The SMS shall support a global linkage feature whereby any input/output/event shall be linked to any other input/output/event in the SMS. Input/output linkages shall be able to span across intelligent system controllers.
    b. System administrators shall be able to create global input/output function lists, each consisting of a sequence of actions to be performed, such as changing card reader modes, activating outputs, and opening or closing anti-pass back areas. Each function list may include up to six actions.

9. Reporting of transactions and status information to the server.

10. Interface with standard reader technologies without special interface hardware, additional logic panels or other integrators. Supported technologies shall include:

    a. 13.56 MHz Contactless Smart with or without biometrics or keypad
    b. 13.56 MHz Multi-technology Smart
    c. Proximity, with or without keypad
    d. Magnetic stripe, with or without keypad
    e. Wiegand
    f. Bar code
    g. Keypad
    h. Biometric, with Wiegand output

C. Reader Interface Module (RIM):

1. Reader interface modules are not shown on the plans. Refer to the installation section of this specification for allowable equipment mounting locations. It is the responsibility of the Contractor to determine the number and configuration of reader interface modules required based on the inherent characteristics of each product line and the requirements and restrictions described in this document.
2. RIM shall interface with and accept data from TTL, Wiegand and RS-485 type readers and door hardware.
3. RIM shall provide a minimum of three (3) inputs per portal for portal position, request to exit and auxiliary input.
4. RIM shall provide a minimum of two (2) outputs per portal for locking device and auxiliary output. Each output shall be Form C and shall be rated at 3A at 28VDC.
5. RIM shall communicate to controller by RS-485.

D. Input Control Module (ICM):

1. The input control module shall provide supervised and non-supervised alarm input zones and monitor/report line fault conditions, alarm conditions, power faults and tampers.
2. Input control modules are not shown on the plans. Refer to the installation section of this specification for allowable equipment mounting locations. It is the responsibility of the Contractor to determine the number and configuration of input control modules required, based on the inherent characteristics of each product line and the requirements and restrictions described in this document.
3. UL 294 and 1076 listed.
4. Each input configurable for normally open or normally closed.
5. Each input configurable for timing.
6. Each input configurable for end of line resistance.
7. Status LEDs for communication to the host, heartbeat and input status.
8. Communications line supervision.
9. AES 128 bit encryption.
10. 2-wire RS485 communications.
11. No fewer than eight (8) inputs per board/control module.
12. Alarm Masking: The ability to mask the alarm input on a time zone basis.
13. Activate Output: The ability for any input to activate any output.

14. Configuration of Debounce Time: The ability to control the amount of time that an input state change must remain consistent in order for it to be considered a real change of state.
15. Entry/Exit Delay: The ability to set up entry/exit delays for inputs that are attached to any ICM. This shall include:

    a. Non-Latched Entry: When an input activates, the alarm will not be reported until the entry delay expires. If the input is still active when the entry delay expires, the alarm will be reported. If the input is not active when the entry delay expires, then the alarm will not report.
    b. Latched Entry: When an input activates, the alarm will not be reported until the entry delay expires. If the input is still active when the entry delay expires and the alarm has not been masked, the alarm will be reported. If the input has been masked when the entry delay expires, then the alarm will not report.
    c. Exit Delay: When an input activates, the alarm will not be reported (operates as if masked) until the exit delay expires. If the input is still active when the exit delay expires, the alarm will be reported. If the input is not active when the exit delay expires, the alarm will not be reported.

E. Output Control Module (OCM) and Functionality:

1. Output control modules are not shown on the plans. Refer to the installation section of this specification for allowable equipment mounting locations. It is the responsibility of the Contractor to determine the number and configuration of output control modules required, based on the inherent characteristics of each product line and the requirements and restrictions described in this document.
2. The output control module(s) shall provide Form C relay contacts for load switching, rated at 3A at 28VDC.
3. Each relay shall support "On" "Off" and "Pulse."
4. Outputs can be pulsed from 0.1 seconds to 24 hours.
5. Status LEDs for communication to the host, heartbeat and relay status.
6. 2-wire RS485 communications.
7. No fewer than eight (8) outputs per board/control module.
8. Communications line supervision.

2.5 APPLICATION SOFTWARE

A. General Performance:

1. The application software, in conjunction with the associated hardware, shall have the following features, functionality and capabilities. The functions that are to be implemented shall be determined in the planning conference between Contractor and Owner referenced in Part 3 of this section.
2. All Users:

   a. All users shall be capable of being authenticated against Active Directory using LDAP before being granted system access. Should the Owner not use Active Directory, the system shall provide a built-in login and credential management tool to permit rules-based access rights on a per-user basis.
   b. The access rights shall be selectable on a per-user basis. In addition, user groups shall be capable of being assigned whereby each user group has a common set of access rights. Users shall be capable of being assigned to these user groups by the system administrator.

3. Operators:

   a. Operator Groups: A minimum of 32 operator groups, allowing specific system module privileges to be accessed with each module being granted specific views, edit and execute privileges.
   b. Operator Levels: System access shall require a valid operator name and password, governing a specific operator's level of access to each menu item.
   c. The SMS shall allow a system operator to login over another system operator who is already logged into the same client workstation without the need to reboot the system. This process shall log the first system operator off alarm monitoring and log the new system operator on, changing any permission necessary for that system operator.

4. Logs, Status, Maintenance, Diagnostics:

   a. Historical Log: The system shall allow event history to be written to the hard disk in an archive format. At a minimum, the system shall support 500,000 transactions. Warning messages shall be generated at a user defined level of capacity. The system shall have the ability to offload the archive files to removable media automatically or manually.
   b. System Status: The system shall query the status of any or all of the system's access control points, inputs and outputs.
   c. System Maintenance/Diagnostics: The system shall provide for remote diagnostic capabilities. In addition, online diagnostics and communications maintenance shall be able to be activated from the operator interface.

5. Administrator:

    a. The SMS shall provide system administrators with the ability to segment their access control SMS field hardware devices into various zones or areas where alarm monitoring client workstations will monitor. These zones shall be assigned an alphanumeric name using up to a minimum of 64 characters.
    b. Updating of monitor zones shall take place in real time and without requiring operators to re-login.

6. General:

    a. Elevator control support for the number of floors and cabs shown on the drawings.
    b. The SMS shall use an open architecture where all data must reside on a single database and must be accessible in real time to every SMS workstation or web-based client connected to the network. The system database shall be used to create and maintain the cardholder database. A screen designer module shall allow the creation and editing of custom database tables and data entry screens.
    c. The SMS shall be able to connect to and interface bi-directionally with external data sources using all of the following methods:

        1) ASCII with support for XML-formatted text exchange of data using a direct table interface activated both manually and automatically.
        2) Real time exchange of data via Active Directory/LDAP utilizing an API supported by the SMS manufacturer. The live exchange of data shall permit exposure of SMS events and transactions to other data sources in real time and allow for receipt of data into the SMS, permitting this data to be acted upon and trigger linked events in the SMS in real time.

    d. Security: Access privileges within the application software shall be permitted by use of a password protection system. The cardholder database shall have the following password security levels.

        1) A minimum of six (6) unique operator access levels
        2) Ability to view only the database fields
        3) Ability to restrict operator viewing to any of the individual database screens within a record
        4) Ability to restrict operator viewing to any of the database partitions

    e. Cardholder Configurations: Each cardholder shall be capable of having up to five (5) access levels actively assigned to their account.
    f. The system shall have cardholder identifications for "Visitor" and "Escort", with an associated optional validity period assignable with an activation and deactivation date.

g. The cardholder database screen shall have the following data associated with each cardholder:

1) Last edit by operator with edited date and time
2) Last date/time card was used
3) Last reader giving valid access
4) Last reader denying access
5) Anti-pass back status

h. The system shall provide advanced query capability with the following search criteria: equal to, not equal to, greater than, greater than or equal to, less than, less than or equal to, like, is empty, is not empty, is between, and, or, not.
i. Access Control Configuration: The configuration application shall be password protected, restricting what each individual may edit or display inside the configuration application.
j. Text descriptions of access points such as doors.

7. Time Zones:

a. The SMS shall be capable of creating and storing up to 255 time zones. Each time zone shall have a minimum of six (6) intervals. Each interval shall be assignable to any day of the week.
b. Each time zone shall be assignable to an alphanumeric name. Time zones shall be applied to access levels, card reader modes, alarm inputs, alarm outputs, and alarm masking and logging functions. Time zones shall be allowed to belong to any or all access levels so that the time zone only has to be defined once.

8. Access Levels:

a. The SMS shall be capable of defining a minimum of multiple access levels per cardholder.

9. Access Groups:

a. The SMS shall be capable of assigning access groups.
b. Each access group shall be assignable to an alphanumeric name.

10. Precision Access Levels:

a. The SMS shall be capable of assigning precision access levels in addition to the access levels, with the ability to assign unlimited card reader and time zone combinations. Precision access levels provide capability of assigning a unique access level on a per card basis.
b. Each precision access level shall be assignable to an alphanumeric name.

11. Holidays:

    a. The SMS shall provide holiday assignments using an embedded calendar. Access rights, card reader modes, and alarm masking schedules must be able to be altered when the current date is designated as a holiday.
    b. Dates for Daylight Saving Time changes shall be definable and shall take effect automatically.
    c. The SMS shall support holiday ranges that allow a single holiday to span across multiple calendar days.

12. Database Segmentation:

    a. The SMS shall be required to support data segmentation whereby each segment shall have its own set of cardholders, field hardware, and system parameters (time zones, access levels, etc.).

13. Field Hardware Communications:

    a. The SMS shall support communications with the intelligent system controllers (ISCs) by the following protocols:

        1) TCP/IP

    b. Upon loss of communications between the SMS server and the ISC, an alarm shall be created with a time stamp. Upon re-established communication, the SMS and the ISC shall automatically re-synchronize from the point of communication loss without operator intervention.

14. Area Control:

    a. Cardholder Escort Control:

        1) The SMS shall support comprehensive escort functionality based upon access levels. Access levels shall include options for "Escort Required", "Designated Escort", "Not an Escort" and "Does not require an Escort." Contractor shall integrate escort level and designation into badge design in cooperation with Owner.
        2) The escort feature shall be capable of one-to-one and one-to-many Escort to Escorted functionality.

    b. Extended Individual Strike Times:

        1) The SMS shall support Extended Individual Strike Times that allows a card reader's strike to be active for an extended period of time beyond the pre-determined standard strike time on a per cardholder basis. The extended strike time shall be user definable up to 255 seconds. Extended strike times shall be set on a card reader by card reader basis.

c. Extended Individual Door Held Open Times:

1) The SMS shall support Extended Individual Door Held Open Times that allow a card reader's door to be held open for an extended period of time beyond the pre-determined standard held open time on a per cardholder basis. The extended held open time shall be user definable up to eight (8) hours. Extended held open times shall be set on a card reader by card reader basis.

d. Extended, On Demand, Door Held Open Times:

1) The SMS shall support Extended, On Demand, Door Held Times via a command keypad located in the field. The Extended Held Open command configuration shall consist of a command key sequence that shall be from three to six keys used to enter the number of minutes to extend the door held open time (up to 999 minutes) and a pre-alarm time (from 0 to 30 minutes).
2) Only those cardholders having command authority at a given card reader configured for 'Allow User Commands' shall have the ability to execute the Extended Held Open command at that card reader. The Extended Held Open command shall be available after a valid cardholder has received an access grant at the card reader. The cardholder shall have a period of 15 seconds after the access grant to enter the extended held open command sequence.

e. Graphical System Overview Tree:

1) A Graphical System Overview Tree shall display a graphical representation of all field hardware including hardware from other systems which are interfaced. System administrators shall be able to modify a device that is depicted on the Graphical System Overview Tree or see its properties by double clicking on the icon, and the SMS shall bring them to the appropriate form.

f. Alarm/Event Logging:

1) All alarms and events in the SMS shall, by default, always be recorded in the database. The SMS shall give system administrators the ability to select, on a time-zone basis, the times that they require the SMS to log specific events to the database.
2) System administrators shall have the option for particular alarm/events to be set to log or not to log on any individual reader and/or input.

g. Scheduling Utility:

1) The SMS shall provide an integral Scheduling Utility. The Scheduling Utility shall allow system administrators to schedule actions to occur on a one-time or a recurring basis. Recurring schedules shall be configured to begin immediately, last indefinitely, or have optional start and end dates.
2) The Scheduling Utility shall be available from both the system administration and alarm monitoring modules.

a) The types of actions that shall be schedulable include, but are not limited to:
b) Action Group
c) Event Archiving/Purging
d) Arm/Disarm Area
e) Execution of Scripts
f) Activate, Deactivate, Pulse Device Output and Device Output Groups
g) Download Firmware to equipment.
h) Download Database to ISCs
i) Execute Function List
j) Mask/Unmask Inputs, Input Groups, Alarm Mask Groups, Door Forced Open or Held Open
k) Open Door, Open Door Group
l) Change Reader Mode
m) Automatic Reports
n) Reset Use Limit
o) Move Bulk Credentials from an Area
p) Deactivate Credentials
q) Logout Visitors

3) The Scheduling Utility shall maintain a history log in the database for actions that it executes.

15. Denied Access Attempts Counter:

a. The SMS shall support a Denied Access Attempts Count on a per card reader basis. The "Denied Attempts Count" value shall be configurable from 0 to 255. The following access denial types shall cause the current denied count to be incremented:

1) Invalid cipher entry at a card reader in Cipher Mode.

16. Card Reader Time Zone Overrides:

    a. The SMS shall allow for the pre-defined default card reader settings to be overridden or temporarily changed on a time-zone basis. At the beginning of the selected time zone, the selected card reader's operational mode shall be modified from its default mode to any one of the following modes: Locked, Unlocked, Facility Code, Card Only, Card or PIN, Card and PIN, Card and Biometric, Card or PIN and Biometric, and/or Card and PIN and Biometric. The aforementioned options shall be available depending on the type of card reader used.
    b. Each card reader shall have the ability to have multiple time zone setting overrides assigned to them as required by the system administrator.

17. Alarm/Event Routing:

    a. The SMS shall be capable of allowing system administrators to route alarms and events to various alarm monitoring client workstations on the network. The SMS shall allow any alarm or event to be routed to one or multiple client workstations on the network regardless of where the alarm is generated in the field. Alarms shall be routed to client workstations on a device-by-device level.
    b. The SMS shall be capable of automatic re-routing of an alarm from workstation X to workstation Y if the alarm is not responded to within a user definable time period.
    c. The SMS shall implement network synchronization such that in the event that an alarm is routed to multiple client workstations, once the first client workstation acknowledges the alarm, the alarm shall be cleared from all other client workstations. As such, alarms that are routed to an Alarm Monitoring client workstation that does not have a System Operator logged in shall be queued so that all unacknowledged alarms will report to that client workstation once a System Operator has logged into the SMS. Alarms/Events shall be routed based on default settings or time zone control.

18. Alarm Attributes:

    a. The system administrator shall have the ability to configure how the SMS handles the annunciation of alarms on an individual basis. Each alarm and/or event shall have the option(s) to:

        1) Display at one or more alarm monitoring client workstation.
        2) Allow higher priority alarms to be displayed on the alarm monitoring client workstation ahead of lower priority alarms.
        3) Require the field device that generated the alarm to be restored to its normal state before the alarm is cleared.
        4) Print the alarm to the local event printer.
        5) Have the alarm breakthrough to the alarm monitoring window should the system operator be working in another application
        6) Allow system operators to change the journal entry once the alarm has been acknowledged.

7) Ensure that the alarm will not be able to be deleted from the alarm monitoring window upon acknowledgment.
8) Display text and audio instructions outlining the procedures to follow when responding to the alarm.
9) Automatically call-up associated maps.
10) Automatically call up the associated cardholder record.
11) Require acknowledgment to clear.
12) Allow mandatory journal entry upon acknowledgment.
13) Use pre-defined journal entries for alarms.
14) Select the option for journal entry based upon the specific alarm.
15) Send surveillance interface commands to the surveillance system.
16) Have the alarm appear on the alarm monitoring window with a flashing colored coded bar across the alarm for high priority alarms.
17) Trigger a function list(s) when the alarm is acknowledged.
18) Require user logon for acknowledgment.
19) Have the ability to mark an alarm as "In Progress" where the system shall silence any repeating audio notifications on the workstation where the alarm was routed, and remove the alarm sprite notification on the graphical map. Additional operators' monitoring alarms shall be notified that the alarm has been marked "In Progress".

19. Alarm-Event Mappings:

a. The SMS attributes in Alarm Attributes shall be assignable on a 'global' basis to all devices that share an alarm description. Thus, the 'Door Forced Open' alarm attributes shall apply to any door with a card reader that is forced open in the SMS. The SMS shall have the capability to assign a unique group of alarm attributes to specific device/alarm combinations to override the global settings for specific case settings. Each device/alarm combination shall have the ability to have its own unique attribute set if the system administrator desires.

20. System Downloads:

a. The SMS shall provide for the downloading of data to the ISCs. Downloads shall load SMS information such as time zones, access levels, alarm configurations, cardholder information and card reader configurations.
b. All ISCs on the SMS shall be capable of either full or selective downloads to individual intelligent system controllers, and bi-directionally so that alarms will still report to their respective alarm monitoring client workstations as cardholder information is being downloaded.
c. Information on cardholder status, credential status, time zones or access levels shall download in real time as they are added, modified, or deleted from the SMS.

21. Portal Configuration Options:

    a. The SMS shall include the following options for each portal on the system:

        1) Allow user commands such as manual door unlock
        2) Rename auxiliary inputs
        3) Rename auxiliary outputs
        4) Independently supervise REX and DPS
        5) Configure REX and DPS as Normally Open or Normally Closed
        6) Deny if duress
        7) Assume door used
        8) Activate outputs
        9) Checkpoint
        10) Do not activate strike on REX
        11) The ability to allow system administrators to determine on a time-zone basis to log or not to log on a card reader by card reader basis
        12) Access grants
        13) Access denied
        14) Card reader status alarms
        15) The SMS shall allow for user definable door strike functionality for each card reader in the SMS
        16) The SMS shall allow for each card reader to be selected as either an 'In' reader, 'Out' reader, or 'None' to allow for ease of reporting time and attendance basic 'Time In' and 'Time Out' data.
        17) Supervise Door: Sets the SMS so that the card reader door contact is wired as a supervised input

22. Traces:

    a. The SMS shall allow for a live or historical trace on any ISC, ICM, alarm input, credential (cardholder), intrusion detection device, monitor zone, or card reader. If applicable, the SMS shall allow for a trace on any asset, intercom, or camera. Multiple traces may be run simultaneously. The SMS shall allow system operators to filter alarm types from the history trace window. Alarms that shall be filtered from the trace window are access granted alarms, access denied alarms, system alarms, duress alarms, and area control alarms.
    b. Destination Assurance: The system shall provide the ability to alert the system operator when a cardholder does not reach a required location and present their credential after entering at a designated checkpoint in a designated period of time.

23. Real-Time, Dynamic Graphical Maps:

    a. The SMS shall support graphical maps that display device and group status, function lists and video cameras dynamically in real time. The maps may be configured to appear on command or when specified alarms are selected for acknowledgment. Map device icons shall have the ability to dynamically change shape and/or color to reflect the current state of the device.
    b. The SMS shall support all map formats listed below:

        1) Adobe Photoshop (.psd)
        2) AutoCAD DXF (.dxf)
        3) Encapsulated Post Script (.eps)
        4) JPEG (.jpg)
        5) TIFF (.tif)
        6) Windows Metafile (.wmf, .emf)
        7) Windows Bitmap (.bmp, .dib)

    c. The SMS shall support map hierarchies or maps within maps. There shall be no limit to the number of maps that shall be nested hierarchically with each other. Multiple maps may be displayed simultaneously.
    d. The SMS shall support user defined icons for field hardware devices. The SMS shall also give system operators the ability to affect the mode of card readers, open doors, start a trace on a device, mask/unmask alarm inputs, and activate/deactivate/pulse an output from the map icons.
    e. The graphical maps shall have the ability to be printed to a local printer.

2.6 ACCESS CONTROL GRAPHICAL USER INTERFACE (GUI)

A. A workstation based custom GUI shall be provided for complete display of real time system activity.

B. The GUI shall provide the following features:

1. Display in real-time, the status of devices by dynamically changing shape or color to indicate status.
2. Acknowledge alarm conditions.
3. Perform manual operations on all monitor and control points.
4. Perform graphic editing functions.
5. Customization of icons color or shape based on status.

C. Graphical representations shall be made of the following activity:

1. Cardholder Activity: Access granted (including duress), access denied, lost card used, stolen card used, inactive card used, unescorted visitor.
2. Input Point Activity: Input condition (normal, abnormal, cut, short, shunt, unshunt).
3. Output Point Activity: On status (automatic, by operator, by link), off status (automatic, by operator, by link), access level on, access level off.
4. Door Activity: Auto unlock, auto lock, closed, opened, forced open, left open, door switch cut, door switch shorted, REX status (cut, shorted, normal, abnormal), input unlock, operator lock, operator unlock.
5. Controller Activity: Controller on-line, controller off-line, controller communications normal, communications cut.
6. System Activity: System error, workstation start, workstation stop, printer off-line, printer unavailable, printer overflow, unknown card.
7. Regional Group Activity: Occupancy restriction (high limit, low limit), anti-pass back (entry, exit), policy violation, escort left, number of escorts, numbers of users, number of visitors.

D. The GUI shall display custom graphical screens, developed by the SMS vendor with electronic maps provided by Owner.

E. The system shall have the ability to automatically call up specific maps. Each input point shall be linked to a primary map.

F. Graphical editing software shall be included, allowing the Owner to create and edit the graphical screens.

G. Graphics screens shall be developed using a minimum of eight (8) colors from a palette of 64 available.

H. The system shall operate on a Windows workstation as provided and recommended by the SMS vendor.

2.7 PORTAL DEVICES

A. Credential Readers:

1. Manufacturers:

a. HID Multiclass SE
b. Refer to drawings for approved manufacturers.

2. Multi-Technology:

a. Compatible with 125 kHz proximity, 13.56 MHz Contactless Smart card, MIFARE, DESFire EV1.
b. Backwards compatibility with legacy 13.56 MHz Contactless Smart cards and 125 kHz proximity access control formats, including 26, 32, 35, 37 bit as well as HID Corporate 1000 format.

3. Card readers manufactured specifically for non-access control applications shall not be acceptable.
4. Provide compatibility with most access control systems by providing card data outputs in Wiegand and Clock/Data.
5. Allow the firmware to be updated in the field without the need to remove the reader from the wall.
6. Secure mounting methods using tamper resistant screws.
7. An audio beeper that provides various tones to signify access granted, access denied, power up and diagnostics.
8. Tri-color LED or three (3) LEDs for visual notification of various conditions.
9. ISO1443A, 1443B and 15693 compliant.
10. The ability to transmit an alarm from an integrated tamper switch.
11. Support dual authentication of identity through the combined use of access badge and personal identification number (PIN) on an integrated 12 key keypad.
12. PBT polymer or UL94 polycarbonate.
13. Read Range:

    a. Using 125 kHz cards or 13.56 MHz Contactless Smart cards, minimum operational read range shall not be less than one (1) inch after the readers have been installed in their permanent locations.

14. Operational voltage of 5-16 VDC, with operating temperature range of -31° F to 150° F, and rated for outdoor use with a minimum rating of IP55.
15. Readers and credentials shall be compatible with each other and shall be from the same manufacturer.
16. Available in sizes to be mounted to a standard single gang box or to a mullion. Maximum sizes:

    a. Single gang box mount, with or without keypad: 5.1" x 3.1" x 1.1"
    b. Mullion mount: 6.0" x 1.9" x 0.9"

17. Lifetime warranty against defects in material and workmanship.

B. Door Position Switch:

1. Manufacturers:

    a. GE
    b. GRI
    c. Honeywell
    d. Pre-approved equal

2. Interior or Perimeter Door:

    a. One (1) inch or 0.75 (3/4) inch diameter, recessed
    b. DPDT contacts
    c. 0.75" to 1.25" (3/4" to 1-1/4") gap for wood door
    d. Maximum 0.375" to 0.625" (3/8" to 5/8") gap for steel door
    e. Basis of Design: UTC/GE/Sentrol 1076D

3. Overhead Door:

    a. Three (3) inch gap
    b. SPDT contacts
    c. 18" stainless steel armored cable
    d. Aluminum construction
    e. Basis of Design: UTC/GE/Sentrol 2207AU

4. Steel Door:

    a. A rare earth magnet shall be used.

5. Cage/Gate:

    a. Maximum 1.5 (1-1/2) inch gap
    b. DPDT contacts
    c. Three feet (3') stainless steel armored cable
    d. Aluminum construction
    e. Basis of Design: UTC/GE/Sentrol 2507AD

C. Cable:

1. Composite cable is allowed, although sufficient conductors may not be available in composite cables for all portal configurations. Contractor shall be responsible for additional required cables beyond one composite cable to each portal to meet functional requirements of the system.

    a. Reader: 18 AWG, 3 pair, stranded, overall shield. Shield shall be grounded at control panel end only.
    b. Door Position Switch: 22 AWG, 2 conductor, stranded.
    c. Lock: Minimum 18 AWG, 4 conductor, stranded.

        1) Lock may require heavier gauge cable depending on door hardware solution power requirements. Contractor shall coordinate with door hardware provider for higher current devices and shall adjust the gauge of the lock cable accordingly.

    d. Auxiliary Devices: Refer to plans for requirements.

D. Locks and Door Hardware:

1. Electric/electronic locks shall be furnished and installed by the door hardware provider.
2. Access Control Contractor shall interface with and terminate cables to locks.
3. Access Control Contractor shall coordinate with door hardware provider for specified sequences of operation at the various portals.
4. Refer to architectural specifications and/or the architectural door schedule.

2.8 INTERFACES AND INTEGRATIONS

A. Video Surveillance Integration and Interface:

1. The SMS shall be required to integrate with the surveillance system.
2. The SMS integration to the surveillance system shall be classified as a high-level interface. The supported surveillance system manufacturers shall be those listed in Section 28 23 00. Dry contact closure or other low-level interface methods are not acceptable. The SMS shall be capable of passing alarm information via a Serial RS232 interface with any surveillance system that utilizes ASCII commands, or by a TCP/IP protocol interface using APIs. The two systems may be from different or the same manufacturers.
3. Command information sent through the high-level interface shall include input point, door event, terminal controller points, operator events and system events, with the associated surveillance system commands.
4. The SMS vendor shall be responsible for providing the interface programming in a protocol that is understandable by the surveillance system.
5. The SMS to surveillance system integration shall perform the following:

    a. Any alarm event in the SMS shall have the ability to be associated with a video clip in real time, with configurable pre- and post-event recording duration.
    b. Video alarm acknowledgement, such as motion detection, and alarm reset shall be supported from the SMS.
    c. Ability to view recorded images based on operator selected date, time and duration through the SMS.
    d. Linking of an access control event to a video clip so that clicking on an event begins playing of that clip.
    e. Ability to click on a camera icon on the SMS map to display live video from that camera and to select recorded video from the same camera.

6. Should the integration fail or malfunction after installation, the systems shall be able to operate independently until the problem(s) is resolved.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with the manufacturer's instructions and recommendations for installation of all products.

B. Provide all system wiring between all components as shown on the project drawings or as directed by the manufacturer, whichever is the more stringent requirement.

C. Network controllers shall be installed centralized in the nearest telecommunications room(s). Mount controllers to the structural walls in a location coordinated with other utilities. Coordinate exact location with Architect/Engineer prior to installation. Provide dedicated +120 VAC emergency power circuit to the controllers using #12 AWG wiring from the nearest emergency electrical power distribution panel board.

D. Provide wiring and connection to all electrified locking hardware devices. Complete programming and testing of all electrified locking hardware devices.

E. Install all credential readers in accordance with manufacturer's instructions where shown on floor plans, in accordance with the Americans with Disabilities Act (ADA) requirements. Provide wiring and connection to all credential readers. Complete programming, adjustment, and testing of all credential readers.

F. Install all door alarm contacts in accordance with manufacturer's instructions either recessed in the door header or surface mounted as required. Provide wiring and connection to door alarm contact devices. Complete programming, adjustment and testing of all door alarm contacts.

G. Install, wire, configure, adjust, program and test all access control system servers, workstations, badging workstations and other user interfaces.

H. Install, wire, configure, adjust, program, and test all specified interfaces and integrations between access control and other systems. Contractor shall provide all cabling, wiring, terminations, components, devices, accessories, hardware, software and other material and accessories necessary to complete all specified interfaces and integrations and make them fully operational.

I. All low voltage access control cabling shall be installed in conduit from end to end.

J. Electronic access control system cabling shall not be spliced.

K. Flexible conduit is not allowed except with prior approval. Refer to Section 26 05 33 for conduit requirements. Refer to Section 27 05 28 for cable hanger and support requirements.

L. Each cable shall be appropriately identified, as defined on the record documents, at each end's termination point using pressure sensitive label strips.

M. The conductor color code used in terminating system cabling at system devices shall remain consistent from device to device for each unique device type throughout the project.

N. Install and tighten all connectors in accordance with manufacturer's instructions using the appropriately designed tools recommended by the manufacturer for that purpose. Do not strip or damage connectors, terminals, or equipment by over tightening termination fasteners.

O. Grounding and Bonding Requirements:

1. Provide a minimum of 6AWG bonding conductor from each electronic access control system control panel, power supply and surge suppression device to the nearest telecommunications grounding busbar. Actual bonding conductor size is determined by its length; refer to Section 27 05 26 for grounding and bonding conductor sizing criteria.
2. Cables containing shields shall not have the shields grounded at conduits, boxes, racks, etc. Ground the shield only at the control panel end.

P. Coordinate installation of all devices with other trades and utilities in the vicinity.

Q. Cabling shall be plenum rated when installed outside conduit in plenum ceilings.

3.2 FIELD QUALITY CONTROL

A. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product that meets the requirements of the specifications as supplied and warranted by the system manufacturer. If the product or assembly is not available from the system vendor, provide product or assembly as recommended by the system manufacturer.

B. Periodic observations will be performed during construction to verify compliance with the requirements of the specifications. These services do not relieve the Contractor of responsibility for compliance with the contract documents.

C. Furnish products listed and classified by Underwriters Laboratories, Inc. (UL) as suitable for purpose specified and indicated.

3.3 MANUFACTURER AND INTEGRATOR COMBINED FIELD SERVICES

A. Installation shall be performed by a factory-trained and certified Contractor.

B. The Contractor shall provide a comprehensive, site-specific customer planning guide for the system. The Contractor shall conduct conference(s) with the Owner prior to any installation to discuss the programming and configuration options of the system and the planning guide.

C. The Contractor shall include labor for all planning and all programming activities required to implement the Owner's access policies for each system point and each operator and administrator. Any software programmable access policy, within the bounds of the hardware specified, shall be included.

D. It shall be the responsibility of the Contractor to provide a complete, functional system as described by the design documents. These responsibilities include:

1. Complete hardware setup, installation, wiring and software configuration of the system server, all workstations and all peripheral hardware.
2. Complete programming of all operator software in accordance with the Owner's access policies determined by the planning guide conference(s).
3. Configuration of the network software for operation of the system. Templates shall be established representative of all user access right levels.
4. Programming of all custom graphic GUI screens including devices.
5. Complete system diagnostic verification.

E. The SMS Installation Contractor shall be present at meetings to coordinate all door hardware requirements with the door hardware vendor.

3.4 SYSTEM DOCUMENTATION

A. Complete documentation shall be provided for the system. The documentation shall describe:

1. All operational parameters of the system
2. Complete documentation of programming and access policies
3. Complete operating instructions for all hardware and software

B. The following sections shall be provided in the system documentation:

1. System Administrator Manual: Provides an overview and a step-by-step guide and instructions detailing all system administrator responsibilities and functions.
2. User Manual: A step-by-step guide and instructions detailing all system user functions.
3. Alarm Monitoring Manual: A step-by-step guide and instructions detailing all alarm monitoring system functions and responsibilities.
4. Technical Maintenance Manual: A comprehensive document providing all maintenance actions, system testing schedules, troubleshooting flowcharts, functional system layout, wiring diagrams, block diagrams and schematic diagrams.
5. Refer to Part 1 for details.

3.5 SYSTEM TRAINING

A. All labor and materials required for on-site system training by a certified representative of the system manufacturer shall be provided. Training shall be conducted at the project site using the project equipment.

B. Coordinate training days and times with Owner.

C. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

D. At a minimum, the following training shall be conducted:

1. Operators: A course detailing the operational features of all aspects of the user interface. Topics shall include alarm monitoring functions, reports, error handling, alarm handling, output relay control, operation of integrated systems interface, and general overview of the report hardware.

E. Minimum on-site training times shall be:

1. Operators: Eight (8) hours.

3.6 SYSTEM ACCEPTANCE

A. The SMS vendor shall submit for review a formal acceptance and system checkout program. The system checkout procedures shall include all system components, software and functionality. The Contractor shall perform the tests and document all results under the supervision of the manufacturer's systems engineer.

B. All operational scenarios, as defined by the customer planning guide, shall be tested to simulate the actual use of the system in the normal operating environment. The successful completion of these operational scenarios shall be documented.

C. The system shall not be accepted until all requirements of system documentation and training have been completed.

END OF SECTION

SECTION 28 23 00 - VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Network Video Management System (NVMS).

B. Video Printer.

C. Equipment Racks.

D. Cabling.

1.2 RELATED WORK

A. Section 26 05 33 - Conduit and Boxes

B. Section 26 05 13 - Wire and Cable

C. Section 27 15 00 - Horizontal Cabling Requirements

D. Section 28 05 00 - Basic Electronic Safety and Security System Requirements

E. Section 28 31 00 - Fire Detection and Alarm Systems

F. Section 28 13 00 - Electronic Access Control

1.3 QUALITY ASSURANCE

A. NVMS Software Developer (Manufacturer): The NVMS system shall be a single-source manufacturer such that the single manufacturer develops, supports, and warranties the NVMS software solution. The manufacturer shall have three (3) years documented experience.

1. The software developer shall be, at a minimum, a Microsoft Gold Certified Integrator and Partner for systems that reside in a Microsoft environment.
2. The software developer shall be an active ONVIF member with current available product recognized by ONVIF as a Conformant Product.

B. Integrator/Installer (Contractor): The Contractor must be a NVMS-certified installation, service, and support company specializing in the selected manufacturer's product, with demonstrated prior experience with the selected manufacturer's system installation and programming.

1. The installer shall retain a Microsoft MCSE or equivalent technician for the purposes of server deployment, software configuration, and system integration.
2. The integrator must have local service representatives within 100 miles of the project site.

1.4 REFERENCES

A. NFPA 70 - National Electrical Code

B. Electronic Industries Association (EIA) Video Surveillance Equipment Standards

C. UL 2044 - Standard for Commercial Closed Circuit Television Equipment

D. UL 3044 - Standard for Safety for Surveillance Closed Circuit Television Equipment

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 28 05 00.

B. Product Data Submittal: Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

1. Compliance with each requirement of these documents.
2. All component options and accessories specific to this project.
3. Electrical power consumption rating and voltage.
4. Heat generation for all power consuming devices.
5. All required wiring shall be identified.
6. Number of IP addresses that will be required from the Owner's Information Systems Department.
7. Statement of Acceptability of Designed Server:

    a. If the Contractor agrees that the server(s) designed and described herein is acceptable for the chosen manufacturer's solution and meets the demand of the application, this shall be stated in writing and submitted as part of the shop drawing submittal.
    b. If the Contractor does not agree that the server(s) designed and described herein is acceptable for the chosen manufacturer's solution, Contractor shall itemize the quantity, technical specifications, and capacities of the servers required to support the functionality and device quantities required by the project drawings. Indicate the capacity utilization factor for each server.
    c. Contractor's bid shall include any required changes in server(s) capacity.

8. Calculation for storage required using the criteria contained in the project drawings.
9. Provide annual cost and all terms and conditions for the NVMS Software Maintenance Agreement. Include all additional costs and terms and conditions for any Annual Service Contracts provided by the Contractor for all services that are not included in the Software Maintenance Agreement.

C. System Drawings: Project-specific system CAD drawings shall be provided as follows:

1. Provide a system block diagram noting system components and interconnection between components. The interconnection of components shall clearly indicate all wiring required in the system. When multiple pieces of equipment are required in the exact same configuration (e.g., multiple identical cameras), the diagram may show one device and refer to the others as "typical" of the device shown.

D. Sample format of site specific programming guides to be used for system planning/programming conference with Owner.

E. Meeting agenda for planning/programming conference required in Part 3 of this specification.

F. Submit detailed description of Owner training to be conducted at project end, including specific training time.

G. Quality Assurance:

1. Provide materials documenting experience requirements of the manufacturer and installing contractor.
2. Provide system checkout test procedure to be performed at acceptance. Test procedures shall include all external alarm events.

H. Coordination Drawings:

1. Include all ceiling-mounted devices in composite electronic coordination files. Refer to Section 28 05 00 for coordination drawing requirements.

1.6 SYSTEM DESCRIPTION

A. This specification section describes the furnishing, installation, commissioning and programming of a complete, turnkey, video surveillance system.

B. Performance Statement: This specification section and the accompanying project drawings are performance based, describing the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the equipment constraints described and the performance required of the system as presented in these documents, the vendor and the Contractor are solely responsible for determining all wiring, programming and miscellaneous equipment required for a complete and operational system.

C. Refer to the project drawings for model numbers for the Basis of Design for all equipment.

1.7 LICENSING REQUIREMENTS

A. All licenses required for system operation shall be included in the Contractor's bid. Licenses shall include, but not be limited to, server and workstation software, cameras, encoders/decoders, and any other licensing that is required by the manufacturer for operation of any system component.

1. Camera licenses shall be provided for all cameras listed on the Camera Schedule whether cameras are new or existing.
2. The system shall be provided with installed software capacity to accommodate a minimum quantity of 100 cameras. The licensing for all 100 cameras shall ***NOT*** be included in the Contractor's bid. Licensing shall only be included for the quantity of cameras shown on the Camera Schedule. However, the system's ability to support up to a total capacity of 100 cameras shall ***ONLY*** require future payment of additional per-unit camera licensing fees by the Owner. In no case shall the Owner be required to upgrade the software provided in the Contractor's bid to achieve support for a total of 100 cameras, including the payment of any software upgrade fees, installing a different software version, etc.
3. If the manufacturer requires the purchase of a block of licenses (instead of selling a single license for a single device) the Contractor's bid shall include the appropriate block of licenses that accommodates all device quantities described by the project drawings.
4. The Contractor shall fill out the NVMS Bid Inventory Form located herein and provide at the time of bid.

1.8 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 28 05 00.

B. Provide final system block diagram showing any deviations from shop drawing submittal.

C. Provide statement that system checkout test, as outlined in shop drawing submittal, is complete and satisfactory.

D. Provide final camera type and camera requirements schedules documenting all changes made during construction.

E. Warranty: Submit written warranty and complete all Owner registration forms.

F. Complete all operation and maintenance manuals as described below.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit documents under the provisions of Section 28 05 00.

B. Manuals: Final copies of the manuals shall be delivered within 14 days after completing the installation test. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of the contractor responsible for the installation and maintenance of the system and the manufacturer for each piece of equipment for each system. The manuals shall have a table of contents and labeled sections. The final copies delivered after completion of the installation test shall include all modifications made during installation, checkout, and acceptance testing. The manuals shall consist of the following:

1. Hardware Manual: The manual shall describe all equipment furnished including:

   a. General description and specifications.
   b. Installation and check out procedures.
   c. System layout drawings and schematics.
   d. Alignment and calibration procedures.

2. Software Manual: The software manual shall describe the functions of all software and shall include all other information necessary to enable proper installation, testing, and operation. The manual shall include:

   a. Definition of terms and functions.
   b. System use and application software.
   c. Graphical user interface use.
   d. Reports generation.

3. Operator's Manual: The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

   a. Computers and peripherals.
   b. System startup and shutdown procedures.
   c. Use of system.
   d. Recovery and restart procedures.
   e. Use of report generator and generation of reports.
   f. Data entry.
   g. Operator commands.
   h. Alarm messages.
   i. System permissions functions and requirements.

4. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.10 WARRANTY

A. Unless otherwise noted, provide warranty for one (1) year after Date of Substantial Completion for all materials and labor.

B. Onsite Work During Warranty Period: This work shall be included in the Contractor's bid and performed during regular working hours, Monday through Friday.

C. Operation: Upon the performance of any scheduled adjustments or repairs, verify operation of the NVMS system.

D. Emergency Service: The Owner will initiate service calls when the NVMS system is not functioning properly. Qualified personnel shall be available to provide service within the distance defined above. The Owner shall be furnished with telephone number(s) where service personnel can be reached 24/7/365.

E. Records and Logs: Keep records and logs of each task completed under warranty. The log shall contain all initial settings upon Substantial Completion. Complete logs shall be kept and shall be available for review on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the NVMS system.

F. Work Requests: Record each service call request on a service request form. The form shall include the model and serial number identifying the component involved, its location, date and time the call was received, specific nature of trouble, names of service personnel assigned to the task, instructions describing what must be done, the amount and nature of the materials used, the time and date work started, and the time and date of completion. Deliver a record of the work performed within five (5) days after work is accomplished.

G. System Modifications: Make any recommendations for system modification in writing to the Owner. No system modifications shall be made without prior approval of the Owner. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected. To the fullest extent possible, the Owner shall be provided with electronic restorable versions of all configurations prior to the modifications being made.

H. Software: Provide all software updates during the period of the warranty and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with NVMS system operators, shall include training for the new changes/features enabled, and shall be incorporated into the operations and maintenance manuals, and software documentation.

I. Refer to the individual product sections for further warranty requirements of individual system components.

1.11 SOFTWARE MAINTENANCE AGREEMENT/ANNUAL SERVICE CONTRACT

A. Provide annual cost and all terms and conditions for the Software Maintenance Agreement (SMA) provided by the NVMS manufacturer and/or the Contractor.

B. The Owner will enter into a contract directly with the vendor. This specification is not a contract between the Owner and the vendor to perform these services. The cost and terms of the SMA ***may*** be used by the Owner for NVMS solution selection.

PART 2 - PRODUCTS

2.1 NETWORK VIDEO MANAGEMENT SYSTEM - GENERAL REQUIREMENTS

A. The network video management system (NVMS) shall be an enterprise-class client/server based video security solution that provides management of digital video, audio and data across a TCP/IP network.

B. The VMS shall utilize network switch ports provided by the Owner for all required IP connections. Provide the Owner with a complete list of all IP ports required.

C. ONVIF Compliance:

1. The NVMS system shall match the ONVIF profile of the specified cameras.

D. The NVMS system shall be an "open system."

1. To meet this requirement, the NVMS must directly support cameras from a minimum of three (3) readily available camera manufacturers.
2. "Directly support" shall be defined as plug-n-play using drivers that are commercially available at the time of bid that utilize the ONVIF specification as the means of integration.
3. In addition to the requirement to support three (3) independent manufacturer's cameras, the NVMS may support an unlimited additional quantity of in-house or other proprietary cameras.

4. The open system shall support third party storage solutions, including:

    a. Commercially available Direct Attached Storage (DAS) devices.
    b. Network Attached Storage (NAS) devices.
    c. Storage Area Networks (SAN) for ***primary*** or archival storage purposes. Primary support for SAN shall be defined as:

        1) The ability to directly record to SAN device without first recording to an NAS or DAS.
        2) The NVMS is provided with a user experience that makes the video recorded to the SAN transparent to the user. This shall be defined as:

            a) Full search, bookmarking, and other software features for finding, marking, locating, and identifying video are supported by the NVMS for video recorded to a SAN in an identical way to video that is recorded to an NAS or DAS.
            b) No loading of the video from the SAN into the NVMS shall be required.
            c) Full playback, windowing of camera video, archiving, and exporting is supported by the NVMS for video recorded to the SAN in an identical way as video recorded to an NAS or DAS.

5. The system must have a published API/SDK permitting third party integrations to the product without restrictions.
6. The NVMS shall support active directory using LDAP protocol.

E. The NVMS system shall consist of the following hardware/software components:

1. Software:

    a. Server and client software
    b. Recording services, archival services, and storage management
    c. Configuration tools

2. System storage as specified on the project drawings.
3. Cameras and related hardware as specified on the project drawings.
4. Hardware: Servers, workstations, and miscellaneous hardware (keyboard, mouse, KVM) as specified on the projects drawings.
5. Network electronics and related hardware and software as specified on the project drawings.

F. Video from any camera on the system (on the LAN, WAN or Internet) shall be capable of being viewed from single or multiple workstations simultaneously at any time, limited only by network bandwidth.

G. The NVMS shall support simultaneous displaying of live (30 fps) video of a minimum of 16 cameras while the video monitoring screen is configured in a 16-camera split configuration. In no case shall the frame rate of the camera be required to be restricted to less than 30 fps to display a 16-camera split view.

H. Simultaneous display and recording of every camera shall be supported with independent user-adjustable frame rates that can be set differently for the display stream and the recording stream. These independent settings shall be unique per camera.

I. The NVMS monitoring software shall support any combination of recorded and live video in any multiple camera split view, including viewing recorded video and live video from the same camera.

J. The NVMS shall support continuous recording and event-based recording simultaneously. This shall be capable of being set on a per camera basis.

K. Viewing of video (live and recorded) shall be possible from client software from any client hardware that is connected to the security LAN/WAN or Internet (through appropriate firewalls). In addition, system administration shall be permitted from remote client hardware.

2.2 NVMS MANUFACTURERS

A. Basis of Design:

1. Genetec Milestone

2.3 NVMS SERVER REQUIREMENTS

A. The NVMS shall operate on the most currently available version of Windows 2019 Server Operating System. The server software shall be a multi-tasking, multi-threading application system architecture designed specifically for the Windows environment.

B. The server shall communicate on a TCP/IP based Ethernet LAN capable of utilizing 10GBaseT.

C. The server shall be provided by the NVMS system vendor.

D. The server(s) requirements have been calculated based on the NVMS Basis of Design manufacturer noted above. By submitting a bid, the Contractor acknowledges that the calculated server requirements listed here may not be sufficient for a listed alternate, acceptable manufacturer selected by the Contractor. The Contractor shall modify the calculated server requirements listed herein based on the calculated requirement of the chosen manufacturer. The server requirements for the basis of design are as follows:

1. Server Quantity and Location: Refer to project drawings for quantity of servers required and their location.
2. Server Hardware Specification:

    a. Enterprise class server meeting the manufacturer's minimum performance requirements for the system.
    b. Rack mount configuration.
    c. Dual, redundant, hot swappable power supplies.
    d. Rack-mount LCD monitor with integrated keyboard, touchpad, and KVM switch. This monitor, keyboard, and touchpad may also serve the video management system server, if present, through the KVM switch.

2.4 NVMS CLIENT REQUIREMENTS

A. The NVMS PC workstation(s) shall be provided by the Owner.

B. The workstation(s) for the basis of design are as follows:

1. Workstation Quantity and Location: Contractor to provide and install software on up to (2) owner provided workstations. Coordinate with owner for locations..

2.5 NVMS SYSTEM DETAILED REQUIREMENTS

A. Workstation Client Software Requirements:

1. The client software for the NVMS shall run as an application on the most current available version of Windows or Apple PC. The client software shall not require a PC more robust than that defined above in the section entitled "NVMS CLIENT REQUIREMENTS." Should the workstation client software require a PC configuration more robust than that defined herein, the cost of upgrading the workstation hardware to the more robust requirement shall be paid by the Contractor.
2. Licensing:

    a. Provide licensing for two (2) concurrent clients on the system.

3. The client software shall provide video signal detection and provide alerts whenever video is lost on any input channel.
4. Updates to the client software shall be capable of being pushed to all clients from the NVMS server.

5. The client software shall provide a graphical mapping feature. The graphical map shall accommodate the importation of CAD files, or custom development of floor plans or site plans to create a to-scale or not-to-scale graphical representation of the system layout including all cameras.

    a. For site cameras, the graphical map shall consist of an overall site plan showing all exterior cameras. Buildings and other physical entities on the site shall be graphically represented.

        1) The buildings shown on the site plan shall visually indicate to the user that cameras are located inside that building's interior, if applicable.

    b. The user shall be able to click a building that contains cameras to obtain a new graphical layout of that building. Once the building interior layout graphical map is on screen, interior cameras shall be represented by icons.
    c. The user shall have the ability to navigate back to the main (previous) graphical map via a single-click graphical icon.

6. Camera Configuration:

    a. Each camera shall be configurable for an alphanumeric character name.
    b. The system shall allow for the setup and adjustment of brightness, contrast, archiving, motion detection, and Pan/Tilt/Zoom on a per camera basis.
    c. The NVMS shall support a separate frame rate for recording and a separate frame rate for viewing for every camera input (assuming the camera provides two streams). These frame rates shall be capable of being independently set for each camera input.
    d. The compression algorithm formats MPEG4, H.264 and H.265 shall be supported in the same system and shall be individually selectable on a per-camera basis.

e. Each individual camera shall be capable of having individual camera settings that shall include (at a minimum):

1) Continuous recording.
2) Motion-based recording capability shall be provided including:

a) Motion as determined by the NVMS software using entire screen motion detection and user defined area triggers.
b) Motion as determined at the camera.
c) Motion trigger by digital inputs from external trigger systems such as contact closures, alarm inputs, POS integration, etc. Motion triggers received by external trigger inputs shall be recorded by the event recording capabilities of the NVMS and identifiable on a timeline during playback and in reports.
d) Motion triggers received by external trigger inputs shall be recorded by the event recording capabilities of the NVMS and identifiable on a timeline during playback and in reports.

3) Alarm-initiated recording.

a) When a camera enters alarm recording mode, the NVMS shall have the capability of changing to different camera settings for the recorded video during the duration of the alarm mode. The settings capable of being changed shall include the frame rate and the resolution. These setting changes shall be configurable in advance per camera by the User through the software GUI.

4) Time-based recording on a preset schedule.
5) Manual (user) activation of the start and stop of the recording process through the GUI.

a) The NVMS software shall prevent any user from manually starting and stopping the recording of video based on that user's login credential.

6) Defined pre-event and post-event recording buffers shall be provided for all non-continuous recording events.

B. Software Security Requirements:

1. All users shall be capable of being authenticated against Active Directory using LDAP, before being granted system access. Should the Owner not use Active Directory, the NVMS shall provide a built-in login and credential management tool to permit rules-based access rights on a per-user basis.
2. The access rights shall be selectable on a per-user basis. In addition, user groups shall be capable of being assigned whereby each user group has a common set of access rights. Users shall be capable of being assigned to these user groups by the system administrator.
3. Access rights available for customization shall include:

    a. Live Video Viewing:

        1) Start and stop of manual recording.
        2) Access to and exclusive from individual cameras and monitors.
        3) Access to system settings.

    b. Viewing Recorded Video:

        1) Ability to export recorded video, including email.
        2) Access to system archiving and backup.
        3) Ability to watch recorded video from individual cameras.
        4) Ability to delete recorded video.

    c. Camera Setup:

        1) Add or remove cameras from the system.
        2) Change camera settings including resolution and frame rate.
        3) Change motion detection and other defined triggers.

    d. General Settings:

        1) Change client software settings.
        2) Ability for user to configure or change custom viewing screen configurations.
        3) Modify server settings.
        4) Change recording or bandwidth settings.
        5) Configure users.
        6) Access and configure external messaging capabilities.
        7) View, print, save and clear the system log.

C. Video Archiving:

1. The archiving feature shall be hardware independent, providing the ability to utilize commercial off-the-shelf mass storage devices as archived video destinations, including optical DVD, DAS, NAS, SAN, and other external storage drives.
2. The archiving software shall provide the ability to manage and store video information from multiple recorded video locations to a central location.

3. Each NVMS server shall have the ability to set its own unique archiving settings. Video shall automatically be archived based on user-defined "percentage full" settings. When the NVMS reaches the designated capacity threshold, video shall be automatically copied to the archive storage destination, and space on the source of the recorded video shall be released for overwrite by new video information using a first-in, first-out algorithm.

    a. Exception: Video marked or tagged by the user or by automated alarm inputs shall be retained by the archiving process despites its location in the first-in, first-out timeline.

4. Regardless of the video's storage location (local or in the archive), the NVMS software shall automatically retrieve video associated with an event on demand by the user in response to a search, browse, or other retrieval action. The actual storage location of the video shall be transparent to the user.

    a. Exception: Video archived to removable media shall require prompting to the user to insert the appropriate media.

5. Archiving shall be capable of being scheduled such that archiving will only run during certain hours defined by the Owner.
6. The NVMS solution shall be permitted to utilize advanced algorithms for managing onboard storage such as reducing the frame rate of recorded video for the oldest video as an alternative to completely removing the video using a first-in, first-out algorithm. If this option exists in the NVMS software, it must have the following features:

    a. Ability of the Owner to completely disable the feature.
    b. Ability to set a minimum frame rate that the system will not exceed.
    c. Ability to set the feature on a per-camera basis.

D. Video Viewing Layouts:

1. The NVMS shall support the ability to save the list of camera views currently being displayed, along with the currently selected template, with a user-defined name to be loaded as needed by the system operator.
2. System operators shall have the ability to define multiple viewing templates that can be recalled and configured on an as-needed basis.
3. This feature shall be subject to the access rights provided by the system administrator through their login credential.

E. Still Image Capture/Save:

1. During playback or monitoring of video, the system shall have the ability to create and save a still picture. This operation shall not affect any other operation and shall not alter the recorded video. The file format shall be an industry standard format (JPEG, TIFF) allowing for file transfer via e-mail, printing, or file transfer to other media.
2. This feature shall be subject to the access rights provided by the system administrator through their login credential.

F. Export Video Clip to File:

1. The NVMS shall have to ability to save and export recorded video to a file for sharing and reviewing video clips. The start and end times for each video segment shall be user defined. The exported video clip shall be viewable via a standard media player.
2. This feature shall be subject to the access rights provided by the system administrator through their login credential.

G. Automated Motion Video Searching:

1. The system shall support advanced automated motion video searching against pre-recorded video. The automated motion video search shall analyze frames in a video segment to detect motion activity from image to image. It shall display thumbnail images of the frames with activity, complete with a histogram depicting the relative amount of activity within each frame.
2. The search shall be defined by selecting a specific camera and a specific time period in which the suspected activity took place. All motion events associated with that camera and time period shall be displayed in either a trace or thumbnail format for review.
3. Motion shall be capable of being restricted to any user-defined area of the screen as drawn by the user using a windowing tool in the software.

H. Video System Analytics (VSA):

1. The NVMS shall provide an embedded Video System Analytics solution.
2. The result of a trigger of an VSA shall be user definable and shall include:

    a. Marking video.
    b. Adjusting recording characteristics including frame rate and resolution.
    c. Activating changes in the monitoring of cameras, including showing full screen video of the triggered camera.
    d. Providing screen prompting to the system operator.

3. The set of Intelligent Video Analysis algorithms shall provide the following functionality:

    a. The VSA shall support the ability to store the graphical output for a specific event for use with VSA alarms. This feature shall allow the graphical output of a specific event to be stored as a file and later used as an overlay to be used and associated with an alarm for historical searching.
    b. The VSA shall support full video resolution during video processing.
    c. The VSA shall support video infrared imaging.

4. License Plate Recognition:

    a. License Plate Recognition shall be used for vehicle access control.

I. The NVMS shall provide up to 10 different and independent programmable recording schedules.

1. The schedules may be programmed to provide different record frame rates for day, night, and weekend periods, as well as holidays and exception days.
2. Advanced task schedules may also be programmed that could specify allowed log-on times for user groups, when events may trigger alarms, and when data backups and archiving should occur.

2.6 NVMS RECORDING REQUIREMENTS

A. The NVMS shall provide management of the recording and playback of video, audio, and data (bookmarking, alarm data, etc.).

B. Refer to the Individual Camera Requirement Schedules on the project drawings for specific variables to be used on a per-camera basis for the purpose of calculating storage capacity and retention.

1. Total distributed storage requirements shall be determined based on a minimum of 365 days storage retention.
2. Cameras, unless otherwise noted on the Camera Schedule(s), shall be assumed to be recording 24 hours per day, 7 days per week, 365 days per year. Specific per-camera assumptions stated on the Camera Schedule for percent motion shall be used in the storage calculation.
3. Compression shall be permitted to be used in the storage calculation. The compression algorithm (MPEG-4, H.264, H.265, etc.) shall be used on a per-camera basis. If the NVMS permits variable levels of compression intensity, the use of the "average" or "medium" level setting shall be used in the storage calculation unless otherwise noted.
4. The Contractor shall provide the complete storage analysis and calculation as a shop drawing.

C. Network Video Recorder (NVR) Hardware Platform:

1. The NVR shall be defined as a storage device for recording IP video streams from IP cameras or from analog cameras that have been encoded to IP. In both cases, the NVR shall record IP streams from cameras or encoders located anywhere on the IP network without being direct-cable connected to the NVR.
2. Refer to the project drawings for specific requirements, model numbers, and basis of design for the NVR.
3. NVR Configuration:

a. The NVR shall contain one hard drive for the operating system and software, and all hard drive storage required to achieve the required storage retention.

4. The NVMS shall provide a failover function where an NVR can be assigned as a backup to other NVRs. When an assigned NVR goes out of service, the failover NVR takes over the responsibilities of the failed NVR. When the primary NVR returns to service, the control shall be automatically transferred back to the primary NVR.
5. It shall be possible to assign a redundant NVR to every NVR for use in normal operation of all NVR(s) in the system. The redundant NVR shall record the same streams as the primary NVR. The redundant NVR shall have its own disk drives where it shall store the recorded data.

    a. It shall be possible to view the data recorded by the redundant NVR in the client software. The redundant NVR shall have camera symbols that can be placed in the camera selection tree. These cameras shall have the same name as the cameras of the primary NVR. An indication shall be provided to indicate that the camera names are located on the redundant NVR.

2.7 NVMS ALARM REQUIREMENTS

A. The NVMS shall provide the capability to accept external alarm triggers in the following formats:

1. Momentary or maintained low voltage contact closures
2. Digital I/O (0 / 10V DC)
3. RS-232 integration
4. Custom integration

B. Alarms shall be capable of being scheduled such that they are only active during defined times.

C. The NVMS shall allow alarms to be individually restricted to specific user groups or users.

D. A single alarm event shall be capable of activating a series of output events including:

1. Mark recorded video.
2. Initiate an email, text message, or both.
3. Initiate an on-screen alarm prompt in a segmented "Alarm Queuing Window."
4. Modify recorded video settings including resolution and frame rate.
5. Modify video viewing options including bringing associated video full screen on any output.

E. The alarm queue shall display alarms in order of their priority, with rows for higher priority alarms always displayed above lower priority alarm rows. The display order for equal priority alarms shall be selectable between new alarms displayed above existing alarms or new alarms displayed below existing alarms.

F. Alarm Processing: The video management system shall operate as follows:

1. When an alarm is accepted by a user, it shall be removed from the other users' alarm lists.
2. The user shall be able to cancel acceptance of any alarm that has been previously accepted. In this case, the alarm shall re-appear in the alarm lists of all members of the user groups assigned to this alarm.

G. The NVMS shall support the association of workflows with alarms. Workflows shall consist of action plans and comment boxes. An action plan shall display a text document, HTML page, or web site that typically contains instructions for handling the alarm. Comments entered in the comment boxes shall be logged in the system logbook.

1. The NVMS shall be configurable to force an alarm workflow. In this case, the alarm cannot be cleared until the workflow is processed.

H. The NVMS shall offer the possibility to automatically clear alarms when the originating event condition is no longer true.

2.8 NVMS INTERFACES AND INTEGRATIONS

A. Security Management System Integration:

1. Refer to the project drawings for all information regarding the Security Management System (SMS).
2. The NVMS shall be integrated with the SMS to provide communication and alarm functionality between the two systems defined as follows, at a minimum:

a. Any alarm/event in the SMS shall have the ability to be associated with a digital video clip in real time.

1) The NVMS shall support user-defined video marking that includes time before and after the alarm event.
2) SMS alarm events shall be capable of triggering a defined video sequence of operation.

b. The integration shall support bidirectional alarm monitoring, alerting, and acknowledgement for either system from either system.

1) Both alarm acknowledgement and alarm reset shall be supported.

c. Video Camera Groups/Video Camera Tours:

1) The NVMS shall support camera grouping to allow for video camera tours in the SMS Alarm Monitoring Module.
2) An unlimited number of camera groups shall be supported in the SMS, and each camera group shall support an unlimited number of cameras. Cameras within a camera group shall be capable of spanning any storage media. Individual cameras shall have the ability to be placed into multiple camera groups.
3) The SMS shall provide for video camera tours that rotate live video between each of the cameras defined in the video camera group at a user-defined increment. The time increment shall be user definable in whole seconds.

3. The integration shall be:

a. An integrated product from a single manufacturer, such that a single manufacturer supplies, supports, and warrants the entire solution including the integration.
b. An integration of two separate companies through ONLY an open API/SDK. The API/SDK integration must be complete, functional, and in use in the marketplace. The ability to integrate through an API/SDK without the integration being done in the marketplace is not acceptable. Custom or proprietary integrations are not acceptable.

B. Additional Integration Requirements:

1. Relays from devices connected to the system shall be controllable from command scripts, the NVMS SDK, and icons on the user interface.
2. Input and relay state changes from devices connected to the system shall be recognizable as events in the NVMS.
3. The video management system shall be capable of monitoring third party equipment using SNMP protocols.
4. The video management system shall provide a software interface that allows third-party software to generate events in the video management system.
5. The NVMS shall allow third-party software to include up to 10 data fields and an alarm ID, along with the virtual input event.

a. These fields shall be searchable in the system logbook.
b. The virtual input data shall be capable of being displayed in playback mode synchronously with the associated video.

C. SDK Integration:

1. The video management system shall provide a documented Software Development Kit (SDK) to allow integration with third-party software.
2. The SDK shall expose all functionality of the command scripts, including, for example:

    a. Control of operator workstation image window layout
    b. Sending messages to specific workstations
    c. Assignment of cameras, documents, URLs, and maps to operator client workstation image panes
    d. Assignment of cameras to analog monitors connected to encoders
    e. Alarm generation
    f. Recording mode control
    g. Exporting of recorded data
    h. Relay control

3. SDK functionality shall be password protected.
4. The SDK shall be accessible from all .Net programming languages.

2.9 NVMS CABLING

A. Refer to Division 27 for all cabling requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with the manufacturer's instructions and recommendations for installation of all products.

B. Provide all system wiring between all components as shown on the project drawings or as directed by the manufacturer, whichever is the more stringent requirement.

C. Mount all cameras in the approximate locations shown on the drawings. Coordinate installation with other trades and utilities in the vicinity. Cameras containing fixed lenses, moved by more than 1'-0" from their location shown on the drawings, shall have a new lens calculation performed by the Contractor. Provide Architect/Engineer with results of lens calculation before proceeding with installation.

D. Coordinate with Owner's IT Department to acquire network connections as well as any network configuration information, such as IP numbers, that will be required to connect NVMS to Owner network (if applicable).

E. Provide all low voltage and +120 VAC power to all devices as required for proper system operation. Refer to Division 26 specification sections for further requirements.

F. All low voltage security wiring shall be routed with other low voltage cabling.

G. Cabling shall be plenum rated when installed outside of conduit in plenum ceilings.

3.2 FIELD QUALITY CONTROL

A. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product that meets the requirements of the specifications as supplied and warranted by the system vendor. If the product or assembly is not available from the system vendor, provide product or assembly as recommended by the system vendor.

B. Periodic observations will be performed during construction to verify compliance with the requirements of the specifications. These services do not relieve the Contractor of responsibility for compliance with the project drawings.

C. It shall be the Contractor's responsibility to correct all inadequate picture quality issues prior to acceptance of the system.

3.3 MANUFACTURER'S FIELD SERVICES

A. Installation shall be performed by a factory-trained and certified Contractor.

1. Provide a comprehensive, site-specific customer planning guide for the system. Conduct a conference with the Owner prior to any installation to discuss the programming options of the system and the planning guide. The result of this planning guide shall be the determination of the system options for each device and for the software.

B. Include labor for all planning and all programming activities required to implement the Owner's operational preferences for each device and software. Any software programmable option, within the bounds of the capabilities of the hardware specified, shall be included.

C. Provide a complete, functional system as described by the project drawings. These responsibilities include:

1. Complete hardware setup, installation, wiring, and software configuration of the system, including all remote operator locations and all peripheral hardware.
2. Complete programming of all hardware and software options in accordance with the Owner's preferences as determined by the planning guide conference.
3. Programming of all custom graphic GUI screens including devices.
4. Complete system diagnostic verification.

3.4 SYSTEM ACCEPTANCE

A. Submit for review a formal acceptance and system checkout program. The system checkout procedures shall include all system components and software. Perform the tests and document all results under the supervision of the manufacturer's system engineer.

B. All operational scenarios, as defined by the customer planning guide, shall be tested to simulate the actual use of the system in the normal operating environment. The successful completion of these operational scenarios shall be documented.

3.5 SYSTEM DOCUMENTATION

A. Complete documentation shall be provided for the system. The documentation shall describe:

1. All operational parameters of the system.
2. Complete documentation of all programming and options.
3. Complete operating instructions for all hardware and software.

B. The following sections shall be provided in the system documentation:

1. System Administrator Manual: Provides an overview and a step-by-step guide and instructions detailing all system administrator responsibilities and functions.
2. User Manual: A step-by-step guide and instructions detailing all system user functions.
3. Technical Maintenance Manual: A comprehensive document providing all maintenance actions, system testing schedules, troubleshooting flowcharts, functional system layout, wiring diagrams, block diagrams, and schematic diagrams.

3.6 SYSTEM TRAINING

A. All labor and materials required for on-site system training by a certified representative of the system manufacturer shall be provided. Training shall be conducted at the project site using the project equipment.

B. Provide two weeks advanced notice of training to the Owner.

C. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

D. At a minimum, the following training shall be conducted:

1. System Administrators: A course detailing the system functions and operations. Provide configuration training on all aspects of the system.
2. Users: Provide a detailed course outlining the operational features of all aspects of the user interface. Topics shall include alarm monitoring functions, reports, error handling, alarm handling, output relay control, and general overview of the report hardware.
3. GUI Editing: Conduct detailed training on using the GUI editing software. Topics shall include the editing of existing graphical maps and the creation of new graphical maps.

E. Minimum on-site training times shall be:

1. System Administrators: Three (3) days.
2. Users: One (1) day.
3. GUI Editing: One (1) day.

NVMS Bid Inventory Form

| Item | Cost/Other |
|---|---|
| Total fixed (lump sum cost) for the entire project: | |
| Itemize the total fixed lump sum cost as follows: | |
| Software cost for NVMS including all implementation services. | |
| Cost for all camera hardware and associated accessories. | |
| Itemize software cost for the following (show the math): | |
| Fixed, non-reoccurring flat base cost (if any) | |
| Fixed, non-reoccurring per-camera licensing fee (if any) | |
| Recurring flat base cost (if any - do NOT include optional software maintenance agreement costs) | |
| Recurring flat per-camera licensing fee (if any) | |
| Client workstation licensing fees (if any) | |
| Remote Client licensing fees (if any) | |
| Mobile Client licensing fees (if any) | |
| Itemize all other license fees not included above. | |
| Add all required and optional software maintenance agreement costs (do NOT include in bid cost). | |

| | |
|---|---|
| Acknowledge receipt of addenda by writing addendum number to the right. | _____ through _____ inclusive |

| |
|---|
| Include below Server Acknowledgement Statement per Section 28 23 00, Article 2.3, Paragraph D. |
| |
| List below all separate software options, licensing or other monetary features that the Integrator interprets as not being requested by this RFP, but that are available from the NVMS manufacturer for purchase. Attach separate document if needed. |
| |

END OF SECTION

SECTION 28 26 05 - RESCUE ASSISTANCE COMMUNICATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. General:

1. Furnish all labor, materials, tools, equipment and services for a complete area of Rescue Assistance Communication System as indicated in Contract Documents and as required by the American with Disabilities Accessibility Guidelines (ADAAG).
2. Completely coordinate with work of all other trades.
3. Although such work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure and complete installation.

1.2 QUALITY ASSURANCE

A. Transistors, capacitors, resistors, integrated circuits and other components shall not be operated to exceed their rated values. Design systems for 24-hour continuous operation.

1.3 SUBMITTALS (REFER TO SECTION 28 05 00)

A. Product Data:

1. Technical data on each product including finishes.
2. Description of system operation.
3. Riser diagrams and system data.
4. Equipment design considerations for future expansion when indicated.
5. Materials list and backbox schedule (including unique backboxes).

B. Project Data:

1. Operating and Maintenance Data: Refer to Section 28 05 00.

a. Factory-prepared operation and service manual for each system.
b. Include operation details, schematics, wiring diagrams, color coding, terminal numbers and component values for printed-circuit boards.
c. Owner Instruction Reports: Refer to Section 28 05 00.

1.4 OPERATION

A. General: Provide two way audible/visual communication between a master annunciator station and the area of rescue assistance communication stations.

1.5 SYSTEM OPERATION

A. The master annunciator panel shall be located as defined by the Authority Having Jurisdiction. Calls placed between rescue assistance stations and the master annunciator panel shall be identifiable at the master annunciator panel to indicate which station has placed a call. The master annunciator panel shall include both a handset and a speakerphone to allow two-way communication to each station. Upon activation of an emergency pushbutton at call stations, a call will automatically be placed to the master annunciator panel. If no one answers the call, it shall automatically dial a secondary location to a continuously manned location.

B. Rescue assistance stations shall be located on each level above and below the first floor of the building within elevator lobbies.

C. Call stations shall provide audible and visual indication that a call has been placed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Rath IP Series

2.2 EQUIPMENT

A. Master Remote Annunciator shall consist of a modular arrangement of intercom 'ON' and flashing red zone LED indicators in multiples of four zones. The annunciator panel shall include a "push to talk" and an audible alarm device with a sound level of not less than 90 dB at 30 cm. The panel shall be constructed of 0.125" thick clear anodized aluminum. Permanent silk-screened zone designations shall be provided on the panel as well as a designation strip. Backbox and panel dimensions will vary depending upon system configuration and number of zones required.

B. Power source shall be a transformer rated for total system devices with an optional battery-backed DC power supply with battery supply for continuous operation of 4 hours.

C. Wiring to call station shall be supervised. In the event of a wire fault, a yellow LED zone indicator on the annunciator shall illuminate and a repeating audio alarm shall sound.

D. Remote rescue assistance call station shall consist of one momentary switch with LED, incandescent lamp not acceptable, and one audible alarm device with a minimum sound level of not less than 70 dB at 30 cm all mounted on a one gang stainless steel plate. Permanent silk-screened designations shall be provided on the plate.

E. Wiring shall consist of 22 gauge (minimum) wire or as indicated on drawings. Three conductors plus one shielded pair are required between each rescue assistance call station and the annunciator panel not to exceed 3,000 feet. Power wire shall be 12 gauge (minimum). Two conductors are required between the power supply or transformer and the annunciator panel.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install all components and complete system as indicated and in accord with manufacturer's recommendations and instructions.

B. All cabling shall be installed to meet the applicable requirements for pathway survivability. Cabling installation shall consist of the following:

1. 2-hour fire rated circuit integrity (CI) cable
2. 2-hour fire rated cable system
3. 2-hour fire rated enclosure or protected area

C. Contractor is to provide and install a typewritten list in a Plexiglas frame permanently fastened to the wall next to the master rescue assistance annunciator panel to indicate the building location of each of the remote area of rescue assistance call stations and to which annunciator zone and LED they correspond.

D. Contractor is to provide a typewritten list of area of rescue assistance communication instructions in a Plexiglas frame permanently fastened to the wall next to each remote switch and the annunciator panel to explain the operation of the system.

E. Provide code-required signage acceptable to the Authority Having Jurisdiction at each call station location.

### 3.2 SYSTEM TESTING

A. Test each component and complete system for proper operation, including all modes. Perform correctional work when required. Testing shall be done in the presence of the Owner's Representative(s).

### 3.3 OWNER PERSONNEL INSTRUCTION

A. Instruct maintenance and staff personnel in complete operation, including actual staff use of system, by authorized distributor personnel. Arrange timing of the session in writing to best coordinate with Owner's working hours. Allow four (4) hours of training. This training session shall be videotaped by the Contractor.

### 3.4 SPARE PARTS

A. Provide one spare remote station.

END OF SECTION

SECTION 28 31 00 - FIRE ALARM AND DETECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fire alarm and detection systems.

1.2 RELATED WORK

A. Section 26 05 53 - Electrical Identification: Refer to electrical identification for color and identification labeling requirements.

1.3 QUALITY ASSURANCE

A. Manufacturer: Company specializing in smoke detection and fire alarm systems with ten years' experience.

B. Installer: A factory-authorized Electrical or Security Contractor licensed with the State and local jurisdiction with five years' experience in the design, installation, and maintenance of fire alarm systems by that manufacturer.

C. Qualifications: The person managing/overseeing the preparation of shop drawings and the system installation/programming/testing shall be trained and certified by the system manufacturer and shall be Fire Alarm Certified by NICET, minimum Level 2. This person's name and certification number shall appear on the start-up and testing reports.

1.4 REFERENCES

A. ASME A17.1 - Safety Code for Elevators and Escalators

B. NFPA 20 - Standard for Centrifugal Fire Pumps

C. NFPA 70 - National Electrical Code (NEC)

D. CEC California Electrical Code

E. NFPA 72 - National Fire Alarm and Signaling Code

F. NFPA 101 - Life Safety Code

G. UL 2017 - General Purpose Signaling Devices and Systems

H. UL 217 / 268 - Standard for Smoke Alarms / Smoke Detectors for Fire Alarm Systems

I. UL 2572 - Control and Communication Units for Mass Notification Systems

J. Fire Code (CFC)

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00 and as noted below.

1. Failure to comply with all the following and all the provisions in 26 05 00 will result in the shop drawing submittal being rejected without review.
2. Failure to submit the fire alarm without all requirements fulfilled in a single comprehensive submittal will be grounds to require a complete resubmittal.

B. Provide product catalog data sheets as shop drawings.

1. Provide a product catalog data sheet for each item shown on the Electrical Symbols List and for each piece of equipment that is not shown on the drawings, but required for the operation of the system.
2. Where a particular Electrical Symbols List item has one or more variations (such as those denoted by subscripts, etc.) a separate additional product catalog data sheet shall be provided for each variation that requires a different part number to be ordered. The corresponding Electrical Symbols List symbol shall be shown on the top of each sheet.
3. Where multiple items and options are shown on one data sheet, the part number and options of the item to be used shall be clearly denoted.

C. Submit CAD Floor Plans as Shop Drawings:

1. The complete layout of the entire system, device addresses, auxiliary equipment, and manufacturer's wiring requirements shall be shown.
2. Indicate the precise routing of notification appliance circuits under the provisions of circuit survivability. Refer to "Wiring" under Part 3 - Execution of this specification section for requirements.
3. A legend or key shall be provided to show which symbols shown on the submittal floor plans correspond with symbols shown on the Contract Documents.

D. About all fire alarm circuits, provide the following: manufacturer's wiring requirements (manufacturer, type, size, etc.) and voltage drop calculations.

E. Provide installation and maintenance manuals under provisions of Section 26 05 00.

F. Submit manufacturer's certificate that system meets or exceeds specified requirements.

G. Provide information on the system batteries as follows: total battery capacity, total capacity used by all devices on this project, total available future capacity.

H. Submit photocopy proof of NICET certification of the person overseeing the preparation of drawings and installation/testing.

I. When required to comply with local or state regulatory reviews, the fire alarm submittal shall have a Professional Engineer's stamp and signature of the state in which the project is completed. NOTE: The Architect/Engineer cannot stamp and seal submittal drawings not prepared under their supervision.

1.6 EXTRA MATERIALS

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

1. Provide quantity equal to 2 percent (2%) of amount of each type installed, but no less than two (2) units of each type.

a. Smoke and heat detectors, manual pull stations, duct smoke detectors, monitor modules, control modules and relays.
b. Notification Appliances: Speakers, speaker strobes, and strobes.

2. Keys: The installing contractor shall collect all equipment spare keys provided with each lockable or resettable device/cabinet minimum of one (1) set each and shall turn over to the Owner upon completion.
3. All spare parts shall be housed in metal cabinet labeled "Fire Alarm Spare Parts."
4. Portable Firefighter Emergency Handset Phones: Provide 10. Locate in the room with the main fire alarm panel .

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Store and protect products under provisions of Section 26 05 00.

1.8 REGULATORY REQUIREMENTS

A. System: UL or FM Global listed.

B. Conform to requirements of NFPA 101.

C. Conform to requirements of Americans with Disabilities Act (ADA).

D. Conform to UL 864 Fire Alarm, UL 1076 Security, UL2017 General Signaling, and UL 2572 Mass Notification Communications.

1.9 SYSTEM DESCRIPTION

A. Performance Statement: This specification section and the accompanying fire alarm specific design documents describe the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the equipment described and the performance required of the system, as presented in these documents, the Vendor and the Contractor are solely responsible for determining all wiring, programming and miscellaneous equipment required for a complete and operational system.

B. This section of the specifications includes the furnishing, installation and connection of the microprocessor controlled, intelligent reporting, fire alarm equipment required to form a complete coordinated system that is ready for operation. It shall include, but is not limited to, alarm initiating devices, emergency communication systems, control panels, auxiliary control devices, annunciators, power supplies, and wiring as indicated on the drawings and specified herein.

C. Fire Alarm System: NFPA 72; Automatic and manual fire alarm system, non-coded, analog-addressable with automatic sensitivity control of certain detectors, multiplexed signal transmission.

D. System Supervision: Provide electrically supervised system, with supervised Signal Line Circuit (SLC) and Notification Appliance Circuit (NAC). Occurrence of single ground or open condition in initiating or signaling circuit places circuit in TROUBLE mode. Component or power supply failure places system in TROUBLE mode.

E. Alarm Reset: Key-accessible RESET function resets alarm system out of ALARM if alarm initiating circuits have cleared.

F. Lamp Test: Manual LAMP TEST function causes alarm indication at each zone at fire alarm control panel and at annunciator panels.

G. Drawings: Only device layouts and some equipment have been shown on the contract drawings. Wiring and additional equipment to make a complete and functioning system has not been shown, but shall be submitted on the shop drawings.

1.10 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 26 05 00.

B. Include location of end-of-line devices.

C. Provide a CAD drawing of each area of the building (minimum scale of 1/16" = 1'-0") showing each device on the project and its address. The devices shall be shown in their installed location and shall be labeled with the same nomenclature as is used in the fire alarm panel programming.

D. Submit test results of sound pressure level (dBA) and intelligibility (STI) with the rooms tested designated on the floor plan. Notification devices shall have the tap wattage designated.

1.11 OPERATION AND MAINTENANCE DATA

A. Submit data under provisions of Section 26 05 00.

B. Include operating instructions, and maintenance and repair procedures.

C. Include results of testing of all devices and functions.

D. Include manufacturer's representative's letter stating that system is operational.

E. Include the CAD floor plan drawings.

F. Include shop drawings as reviewed by the Architect/Engineer and the local Authority Having Jurisdiction.

1.12 DOCUMENT STORAGE CABINET

A. The cabinet shall have all fire alarm system documents, including record drawings, wiring diagrams, operation manuals, etc. A legend sheet permanently attached to the door shall contain system passwords and inspection logs. The enclosure shall also provide two (2) key ring holders for system keys and a location for a standard size business card with service contact information.

1. The cabinet will have, permanently and securely mounted inside, a digital flash memory device with a minimum of 4 GB of storage capacity and a standard USB B connector for uploading and downloading electronic versions of record documents and system programming information.

B. The cabinet shall be red in color with an identification label reading "FIRE ALARM DOCUMENTS". Refer to Identification Section 26 05 53. The cabinet shall be lockable. Minimum cabinet size shall be 14" x 14" x 48".

C. The final version of the system database program shall be stored within the cabinet.

D. Locate cabinet in the Fire Command Room.

1.13 WARRANTY

A. Provide one (1) year warranty on all materials and labor from Date of Substantial Completion.

B. Warranty requirements shall include furnishing and installing all software upgrades issued by the manufacturer during the one (1) year warranty period.

1.14 ANNUAL INSPECTION/TESTING AND SERVICE CONTRACT

A. Provide cost to furnish service, inspect, and test all devices of the fire alarm system per the requirement of NFPA for one (1) year, starting one year after the Date of Substantial Completion. Submit written reports of inspection testing per NFPA 72, Chapter 14.

B. Provide an alternate cost for a complete inspection/testing and service/maintenance contract for the fire alarm system for one (1) year two (2) years, starting one year after the Date of Substantial Completion. Submit sample contract terms and conditions for review with shop drawings.

C. The Owner may enter into a contract directly with the vendor after shop drawing submittals. This specification is not a contract between the Owner and the vendor to perform these services.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Notifier by Honeywell

B. Edwards - EST

C. Gamewell - FCI

2.2 FIRE ALARM CONTROL PANEL (FAP)

A. Control Panel: Modular, power-limited electronic design. Provide surface wall-mounted enclosure as shown on plans. Enclosure shall be minimum 0.060 steel with provisions for electrical conduit connections into the sides and top. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators.

B. Each Signaling Line Circuit (SLC loop) shall not be loaded over 80% of the maximum device capacity. For example, in the minimum system capacity column listed below, if the fire alarm manufacturer's system capacity of analog sensors per loop is 99 devices, then no more than 79 devices shall be wired on that loop. The minimum system capacity shall be as follows:

1. Minimum Total SLC Loops (including board, ready for field connections): 10
2. Panel Expansion Capability, Minimum Total SLC Loops: 10
3. Minimum Node Capacity for Network System: 100

C. Central Processing Unit:

1. The central processing unit (CPU) shall communicate with the monitor and control all other modules in the panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the CPU.

2. The CPU shall execute all control-by-event programs for specific action to be taken if a designated situation is detected in the system. A real-time system clock for time annotations on the display and printer shall be included.
3. All power for the unit shall be supervised and supplied by the FAP.

D. Display:

1. The board shall provide all controls and indicators used by the system operator and may also be used to program all control panel parameters.
2. The board shall provide an alphanumeric array for display of custom alphanumeric labels for all addressable points. It shall also provide indicators for AC Power, System Alarm, System Trouble, Display Trouble and Signal Silence.
3. Displayed descriptions of addressable points shall include actual room names/numbers selected by the Owner. This information shall be obtained prior to programming. Room names/numbers shown on floor plans shall not be used.
4. The board shall provide a touch key-pad with control capability to command all system functions and entry of any alphanumeric information. Twenty different passwords with four levels of security shall be supported to prevent unauthorized manual control or programming.

E. Memory: The CPU and display interface board shall be augmented by non-volatile field programmable memory. EPROM memory will also be allowed provided the memory is burned in with minimum expansion capability equal to the total system capacity of the panel. Memory shall not be lost upon primary and secondary power failure.

F. Serial Interface Board: The board shall provide interfaces to a printer, LCD display and other monitoring devices through RS-232 connections. The minimum operational distance between the board and the peripheral devices shall be 500 feet. Up to three (3) RS-232 outputs shall be supported.

G. Power Supply:

1. Input power shall be 120 VAC, 60 Hertz. Output power shall be as noted on the device specifications and drawings. Each component of the fire alarm system requiring 120 VAC input power shall be served from a dedicated emergency branch circuit. Provide two #12 conductors and one #12 ground in 3/4" conduit to a dedicated 20A/1P circuit breaker with a red handle and a manufacturer's standard handle lock-on device. Identify/label breaker and branch circuit in accordance with NFPA requirements and Specification Section 26 05 53.
2. Adequate to supply 125% of all control panel and peripheral power needs as well as 125% of power required for all external audio-visual devices. The power supply may be increased as needed by adding additional modular expansion power supplies. Over-current protections shall be provided on all power outputs.
3. All power supplies shall be designed and installed to meet UL and NFPA requirements for power-limited operation on all external initiating and indicating circuits.
4. The power supply shall provide integral charger for use with internal batteries. Battery capacity shall be sufficient for operation of the entire system for 24 hours in a non-alarm state followed by alarm mode for 15 minutes, plus 25% spare capacity for future devices.

H. Surge Protection:

1. All fire alarm control panels, NAC panels, etc. shall be provided with a surge protection device (SPD). The SPD shall be UL listed to Standard 1449 Rev 3. The unit should be clearly labeled in accordance with Identification Section 26 05 53. The SPD shall have thermal fuses to protect against fire in short circuit conditions. The unit shall provide visual indication that the unit is protecting and functioning.
2. Any communications or signaling circuits associated with the fire alarm system, which leave or enter a facility, shall be provided with a surge protection device. The devices shall be as recommended by the fire alarm system manufacturer.

2.3 FIRE ALARM PATHWAY CLASS AND SURVIVABILITY LEVEL

A. Pathway Class:

1. Pathway Class B: Circuits NOT capable of transmitting an alarm beyond the location of the fault condition. Wiring of outgoing and return conductors is permitted to be run in the same conduit or cable.
2. Pathway Class: SLC for addressable devices with less than 50 devices can be Class A or B, and more than 50 devices shall be Class A.

B. Interconnection of Multiple Fire Alarm Panels:

1. The pathways of interconnected fire alarm panels or systems shall be as follows:
2. Pathway Survivability Level 2: Pathway survivability includes one or more of the following:

a. Listed 2-hour fire-rated circuit integrity (CI) or fire-resistive cable.
b. Pathway installed in a 2-hour fire-rated enclosure or assembly.

2.4 FIRE ALARM TERMINAL CABINET (FATC)

A. Fire Alarm Terminal Cabinet with locked hinged door. Provide as an extension of the main fire alarm system.

2.5 SIGNALING LINE CIRCUIT DEVICES

A. Combination Devices: Subscripts identify combination type devices when applicable. Contractor shall provide the combination device or provide multiple device(s) to meet the functionality when the manufacturer does not offer the required functionality with a single device.

B. Signal Line Device(s):

1. Subscripts: Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

a. Device type as follows:

1) W = Weather Proof
2) WG = Wire guard is required
3) Candela Ratings:

a) ## = 15 Candela, 30 Candela; 75 Candela; 110 Candela; 177 Candela
b) CD = NICET designer shall select Candela rating as required to provide full coverage of the space.

b. Sequence of operation as follows:

1) A = Atrium
2) CR = Computer Room
3) E = Elevator Recall
4) D = HVAC Control
5) SW = Stairwell

C. FA-120; Smoke Detectors:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

a. Device types as follows:

1) Blank = Photoelectric
2) AT = Attic (located in)
3) H = Combination Smoke / Heat Detectors
4) ION = Ionization Type
5) ID = In-Duct Detector
6) SA = Stand Alone with Sounder
7) SB = Sounder Base
8) SV = Stand Alone with Sounder and 177 Candela Strobe

2. (BLANK) Analog Photoelectric Type Sensor: Shall use the photoelectric principle to measure smoke density and send data to the control panel representing the analog level of smoke density measured.

3. (ION) Analog Ionization Type Sensor: Shall use the dual chamber ionization principle to measure smoke density and send data to the control panel representing the analog level of smoke density measured.
4. (IN) In-Duct Smoke Detectors:

a. Analog Photoelectric Type Sensor: Shall use the photoelectric principle to measure smoke density and send data to the control panel representing the analog level of smoke density measured.
b. Analog Ionization Type Sensor: Shall use the dual chamber ionization principle to measure smoke density and send data to the control panel representing the analog level of smoke density measured.
c. Low Flow Type: Listed for use in duct with 0-2000 feet per minute velocity.
d. Each smoke detector shall connect directly to an SLC loop.

e. Each detector shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided to match the duct application. Provide a two-piece head/base design.
f. Each detector shall have a manual switching means to set the internal identifying code (address) of that detector, which the control panel shall use to identify its address with the type of sensor connected.
g. Provide a remote LED indicator device (FA-240/241), mounted in ceiling directly below detector with a single-gang faceplate labeled: Duct Smoke Detector.

5. Each smoke detector shall connect directly to an SLC loop, unless listed as stand alone.
6. Each detector shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided. Provide a two-piece head/base design.
7. Each detector shall have a manual switching means to set the internal identifying code (address) of that detector, which the control panel shall use to identify its address with the type of sensor connected.
8. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. Remote indicator terminals shall be provided. Provide a remote LED indicator device if detector is not visible from a floor standing position.
9. A test means shall be provided to simulate an alarm condition.
10. Where operation is noted as required below 32°F and/or above 120°F, a conventional device shall be installed with a unique monitor module located in the nearest available location with maintained temperatures between 32°F and 120°F.

D. FA-122; Duct Smoke Detectors, Sampling Tube Type:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

a. Device types as follows:

1) # = Equipment or system

b. Duct-type smoke detectors shall use the same analog photoelectric sensor technology, with the same features specified for standard smoke detectors, except with additional features as specified below.
c. Provide sampling tubes and mounting hardware to match the duct to which it is attached. Where the detector housing is larger than the duct height, Contractor shall fabricate a mounting bracket for the detector and attach according to the fire alarm manufacturer's recommendations.
d. Provide a remote alarm LED indicator device (FA-241) or (FA-242) if detector is not visible from a floor-standing position. If detector is located above a suspended ceiling, mount remote indicator in ceiling directly below detector with a white single-gang faceplate labeled: Duct Smoke Detector.

E. FA-130; Manual Pull Stations:

1. Manual pull station, addressable, single action with plastic breakrod, reset key lock, semi-flush mount, red high abuse plastic or cast metal construction with white lettering. Provided with all necessary mounting hardware. Use surface mount only on precast concrete or structure.
2. Manual stations shall connect directly to an SLC loop. Stations shall provide address setting means using rotary decimal or DIP switches.
3. Where operation is noted as required below 32°F and/or above 120°F, a conventional device shall be installed with a unique monitor module located in the nearest available location, with maintained temperatures between 32°F and 120°F.

F. FA-131; Manual Pull Stations with Cover:

1. Manual pull station, addressable, single action with plastic breakrod, reset key lock, semi-flush mount, red high abuse plastic or cast metal construction with white lettering. Provide device with clear Lexan tamper resistant cover with integral 9V battery powered alarm that sounds when shield is lifted. Provided with all necessary mounting hardware. Use surface mount only on precast concrete or structure.
2. Manual stations shall connect directly to an SLC loop. Stations shall provide address setting means using rotary decimal or DIP switches.
3. Where operation is noted as required below 32°F and/or above 120°F, a conventional device shall be installed with a unique monitor module located in the nearest available location, with maintained temperatures between 32°F and 120°F.

G. FA-140; Heat Detectors:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

    a. Device types as follows:

        1) Blank = Combination Rate of Rise / Fixed Temp
        2) AT = Attic (located in)
        3) F = Fixed Temp
        4) RC = Rate Compensated
        5) X = Explosion Proof

2. (BLANK) Combination rate of rise and 135°F fixed temperature analog thermal type sensor. Factory programmed to alarm at 135°F and at 15°F per minute rate-of-rise. Sensor shall measure heat level and send data to the control panel representing the analog level of thermal measurement and rate-of-rise.

3. (F) 200°F fixed temperature. Provide a remote addressable monitor module to interface with addressable system as shown on the plans.
4. (RC) Rate Compensated

5. Provide a two-piece head/base design, with a manual switching means to set the internal identifying code (address) of that detector, which the control panel shall use to identify its address with the type of sensor connected.
6. Heat detectors shall connect directly to SLC loops. Where fixed temperature or explosion proof detectors are used, one monitor module may be used to monitor all detectors in one room/area as shown on the drawings.
7. Detectors shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided.
8. Provide a remote LED indicator device if detector is not visible from a floor-standing position.
9. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. A connection for attachment of a remote indicator shall be provided.
10. A test means shall be provided to simulate an alarm condition.
11. Where operation is noted as required below 32°F and/or above 120°F, a conventional device shall be installed with a unique monitor module located in the nearest available location with maintained temperatures between 32°F and 120°F.

H. FA-160; Monitor Modules:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

    a. Device types as follows:

        1) Blank = Refer to Plans
        2) KB = Knox Box Monitor

2. Monitor Module shall connect directly to an SLC loop and receive power from a separate 24 VDC circuit. It shall interface initiating devices with the control panel using Style D or Style B circuits. Contractor Option: Use an interface module (2-wire operation) for Style B circuits connected to normally-open dry contacts, such as a flow switch.
3. The module shall be mounted in an enclosure located in an accessible service location as near as possible to the device(s) being monitored, or where shown on the drawings. All mounting hardware shall be provided.
4. The module shall supply the required power to operate the monitored device(s).
5. The module shall provide address setting means using rotary decimal or DIP switches.

I. FA-161; Addressable Control Module:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

    a. Device types as follows:

        1) Blank = Refer to Plans
        2) DH = Door Hold Open

3) PD = Hold Open Override

2. Relay that represents an addressable control point used primarily for the control of auxiliary devices as indicated on the drawings. Contractor to provide additional child relay(s), as required, rated for the electrical load being controlled (Contractor to match voltage, amps, etc.).
3. Relay shall connect directly to an SLC loop and receive power from a separate 24 VDC circuit.
4. The relay shall be mounted in an enclosure located in an accessible service location as near as possible to the device(s) being controlled, unless otherwise shown on the drawings. All mounting hardware shall be provided.
5. The relay shall supply 24 VDC power to the device(s) being controlled, unless otherwise indicated on the drawings.

2.6 NOTIFICATION APPLIANCE DEVICES

A. Combination Devices: Subscripts identify combination type devices when applicable. Contractor shall provide the combination device or provide multiple device(s) to meet the functionality when the manufacturer does not offer the required functionality with a single device.

B. Notification Appliance Device(s):

1. Subscripts: Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

a. Device types as follows:

1) W = Weather Proof
2) WG = Wire guard is required
3) Candela Ratings:

a) ## = 15 Candela; 30 Candela; 75 Candela; 110 Candela; 177 Candela
b) CD = NICET designer shall select Candela rating as required to provide full coverage of the space.

C. Notification Device(s):

1. Wall Mounted: Red housing with white lettering or pictogram.
2. Ceiling Mounted: Red housing with white lettering or pictogram.

D. FA-200; Visual Alarm Devices:

1. Wall or ceiling mounted, refer to plans.
2. High intensity (Candela rating as scheduled on the drawings) xenon strobe or equivalent under a lens. Candela rating shall be visible from exterior of the device.

3. The maximum pulse duration shall be 0.2 seconds with a maximum duty cycle of 40%. The flash rate shall be 1 Hz. Where more than two strobes are visible from any one location, the fire alarm visual devices shall be synchronized.
4. Device, housing, and backbox shall be UL listed for fire alarm/emergency applications.
5. (W) Weatherproof Visual Notification Device: High intensity strobe, square housing, 75 Candela rating, suitable for wet locations. Provide with weatherproof back box.

    a. Mounting: Semi-flush wall.
    b. Conduit shall not be exposed.

E. FA-210; Audio Horn Alarm Devices:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.
2. Device types as follows:

    a. M = Mini-Horn

3. Wall or ceiling mounted, refer to plans.
4. Sound Rating: 85 dB at 10 feet. Sound levels for alarm signals shall not exceed 120 dBA in the occupied area.
5. Device shall be capable of a high and low dB level setting. Unless noted otherwise, the device shall be set to the high setting at building completion.
6. Device, housing, and backbox shall be UL listed for fire alarm/emergency applications.
7. (M) Mini-Horn Audio Notification Device: Electronic Horn.

    a. Mounting: Single-gang flush wall.

2.7 NOTIFICATION APPLIANCE CIRCUIT PANEL (NAC)

A. As shown on the plans or as a Contractor's option if not shown, furnish and install NAC extender panels as necessary to provide remote power supply for notification appliance circuits (NAC). Contractor shall indicate quantity and locations of each NAC on the shop drawing submittals.

B. Each NAC shall be self-contained remote power supply with batteries, and battery charger mounted in a surface lockable cabinet. Battery capacity shall be sufficient for operation for 24 hours in a non-alarm state followed by alarm for 15 minutes, plus 25% spare capacity for future devices. Each NAC provides a minimum of up to 4 outputs, 2A continuous, or 6A full load total capacity.

C. Power for each NAC shall be from a local 120 VAC emergency circuit. Provide two #12 conductors and one #12 ground in 1/2" conduit to each NAC from a dedicated 20A/1P circuit breaker with a red handle and a manufacturer's standard handle lock-on device. Coordinate panel and circuit number with the Architect/Engineer prior to installation.

D. NAC extender panels may be installed only where shown on drawings.

E. Mounting: Surface.

2.8 ANNUNCIATION

A. Printer:

1. Printer shall be UL 864 listed and shall be the automatic type with code, time, date, location, category and condition.
2. The printer shall provide hard copy printout of all changes in status of the system and shall time-stamp such printouts with the current time of day and date. The printer shall be standard carriage with 80 characters per line and shall use standard bond paper. The printer shall be enclosed in a separate enclosure, suitable for placement on desk or countertop. The printer shall communicate with the control panel using an interface complying with Electrical Industries Association Standard EIA-232D. Power to the printer shall be 120 VAC, 60 Hertz.
3. The printer shall be connected to the graphics annunciator PC and shall have all interfaces in place to be connected to the Fire Command Center and all transponders in case of network or hardware failure.

B. FAA; Remote LCD Annunciators:

1. Auxiliary annunciators shall indicate alarm and trouble conditions visually and audibly as shown on the drawings. Provide local TROUBLE ACKNOWLEDGE, TEST, and ALARM SILENCE capability. Minimum 80-character display.
2. Communications and power to the annunciators shall be supervised. The annunciator shall receive power from the fire alarm control panel.
3. A single key switch shall enable all switches on the annunciator.
4. Mounting:.

2.9 ETHERNET NETWORK

A. The IP network shall be fiber optic cable, single or multi-mode fiber. The TCP/IP network switches shall be industrial grade managed switching hubs. Network switches shall be UL864 listed, shall provide a minimum of four (4) or a maximum of eight (8) 10/100 Mbps shielded RF-45 connectors for Ethernet connections, and selectable multi-mode or single-mode fiber ports. The switches shall operate on a nominal 24 VDC supplied from a battery backed up fire alarm control panel or booster power supply to ensure power to the switch is always available. Switches shall provide LED indicators for data rate, activity/link integrity, power, and loop detection.

2.10 CONNECTIONS TO AUXILIARY DEVICES PROVIDED BY OTHERS

A. FA-260; Flow Switch:

1. (FA-260) Connection to flow switch to monitor fire protection flow switch or discharge output contacts. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC.
2. Provide a dedicated monitor switch for each sprinkler flow switch.

B. FA-261; Tamper / Monitor Switch:

1. (FA-261) Connection to monitor switch to monitor fire protection system supervisory switches or output contacts. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC.
2. Tamper switches in the same room or system may be monitored by a single monitor switch when shown grouped on the plans.
3. Subscripts: Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.
4. Device types as follows:

    a. Blank = Refer to Plans
    b. PIV = Post Indicator Valve

5. (PIV) Post Indicator Valve. Connection to post indicator valve for sprinkler system supervisory notification. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC. Provide surge protection device as recommended by the fire alarm system manufacturer on line entering/leaving the facility.

C. FA-263; Electronic Bell:

1. Electronic bell for sprinkler alarm, electro-mechanical type, 120 VAC. Furnished and installed by MC. Fire alarm control and power connections by EC.

D. FA-160; Knox Box Monitor:

1. Subscript: Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

    a. KB = Knox Box

2. Monitored Knox box furnished and installed by GC. Provide addressable monitor module (FA-160) for Knox box monitoring. Refer to architectural plans for requirements and location.

2.11 WIRING

A. Fire alarm wiring/cabling shall be furnished and installed by the Contractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes. Cabling shall be UL listed and labeled as complying with the Electrical Code for power-limited fire alarm signal service.

B. Fire Alarm Cable:

1. Manufacturers:

    a. Comtran Corp.
    b. Helix/HiTemp Cables, Inc.
    c. Rockbestos-Suprenant Cable Corp.

d. West Penn Wire/CDT.
e. Radix.

PART 3 - EXECUTION

3.1 SEQUENCES OF FIRE ALARM OPERATION

A. General:

1. Refer to the Fire Alarm Operation Matrix on the drawings for basic requirements and system operation.
2. All system output programs assigned via control-by-event equations to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.

B. Access Control Override Sequence:

1. The fire alarm shall use addressable output relay(s) to signal the access control panel.
2. Refer to the access control specifications for requirement upon fire alarm signal. The fire alarm shall initiate an override of delayed egress doors.

3.2 INSTALLATION

A. Install system in accordance with manufacturer's instructions and referenced codes.

B. Fire Alarm Control Panel:

1. Install the control panel where shown on the drawings.
2. All expansion compartments, if required, shall be located at the control panel.
3. Install the voice command center and fire command center in the location as indicated on the drawings. This location should be primary fire department "attack" location. Coordinate with the local fire department prior to submitting shop drawings.

C. Devices:

1. General:

a. All ceiling-mounted devices shall be located where shown on the reflected ceiling and floor plans. If not shown on the reflected ceiling or reflected floor drawings, the devices shall be installed in the relative locations shown on the floor drawings in a neat and uniform pattern.
b. All devices shall be coordinated with luminaires, diffusers, sprinkler heads, piping and other obstructions to maintain a neat and operable installation. Mounting locations and spacing shall not exceed the requirements of NFPA 72.
c. Where the devices are to be installed in a grid type ceiling system, the detectors shall be centered in the ceiling tile.

d. The location of all fire alarm devices shall be coordinated with other devices mounted in the proximity. Where a conflict arises with other items or with architectural elements that will not allow the device to be mounted at the location or height shown, the Contractor shall adjust location of device so that new location meets all requirements in NFPA 72 and all applicable building codes.

2. Per the requirements of NFPA, detector heads shall not be installed until after the final construction cleaning unless required by the local Authority Having Jurisdiction (AHJ). If detector heads must be installed prior to final cleaning (for partial occupancy, to monitor finished areas or as otherwise required by the AHJ), they shall not be installed until after the fire alarm panel is installed, with wires terminated, ready for operation. Any detector head installed prior to the final construction cleaning shall be removed and cleaned prior to closeout.
3. Protection of Fire Alarm System:

   a. A smoke detector shall be installed within the vicinity of the main fire alarm panel and every NAC extender panel per NFPA 72. A heat detector may be substituted when a smoke detector is not appropriate for the environment of installation.

4. Duct-type Analog Smoke Detectors:

   a. Duct-type analog smoke detectors shall be installed on the duct where shown on the drawings and details. The sampling tubes shall be installed in the respective duct at the approximate location where shown on the electrical drawings to meet the operation requirements of the system.
   b. All detectors shall be accessible.
   c. Duct-type detectors shall be installed according to the manufacturer's instructions.

5. In-Duct Analog Smoke Detectors:

   a. In-duct analog smoke detectors shall be installed in the duct where shown on the drawings and details. The devices shall be installed in the respective duct at the approximate location where shown on the electrical drawings to meet the operation requirements of the system.
   b. All detectors shall be accessible.

6. Heat Detector, Linear Wire Type:

   a. Install detection wire within 20 inches of the underside of building roof, floor, or as recommended by the manufacturer.
   b. The protected area shall not exceed 4,000 square feet per zone. Provide a separate zone for areas divided by fire/smoke rated walls.

7. Manual Pull Stations:

   a. Stations shall be located where shown and at the height noted on the drawings.

8. Addressable Relays and Monitor Modules:

    a. Modules shall be located as near to the respective monitor or control devices as possible, unless otherwise indicated on the drawings.
    b. All modules shall be mounted in or on a junction box in an accessible location.
    c. Where not visible from a floor standing position, a remote indicator shall be installed to allow inspection of the device status from a local floor standing location.

9. SLC Loop Isolation Modules:

    a. Isolation modules shall be installed to limit the number of addressable devices that are incapacitated by a circuit fault.
    b. Install all Isolation Modules within the fire alarm control panel, unless otherwise indicated on the drawings. Refer to the fire alarm riser diagram for requirements. Refer to the floor plans for areas served by separate isolation modules.

10. Notification Appliance Devices:

    a. Devices shall be located where shown on the drawings.
    b. Wall-mounted audio, visual and audio/visual alarm devices shall be mounted as denoted on the drawings.
    c. Where ceiling mounted visual alarm devices or combination audio/visual alarm devices are shown where the ceiling is greater than 30'-0" high, they shall be stem mounted so that the entire unit is below 30'-0". This does not apply to audio-only alarm devices.

D. Wiring:

1. Fire alarm wiring/cabling shall be provided by the Contractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes.
2. Wiring shall be installed in conduit.
3. Wiring shall be installed in conduit from device to above accessible ceilings. Exposed plenum-rated cable (FPLP) shall be used above accessible ceilings supported every 4 feet or run in cable trays (if applicable) maintaining a minimum of 5-inches clearance from all lighting ballasts. Fire alarm cabling shall not be installed in the same bridle rings or cable trays designated for the cabling of other systems.
4. All junction boxes with SLC and NAC circuits shall be identified on cover. Refer to Identification Section 26 05 13 for color and identification requirements.
5. Partial evacuation or relocation of occupants is the standard operating procedure for this facility in the event of an alarm. Therefore, all notification appliance circuits (NAC), including circuits serving NAC extender panels and other network communication circuits, must be installed and protected in accordance with the "circuit survivability" requirements described in NFPA 72. Contractor shall maintain the following:

a. NACs serving separate evacuation signaling zones shall be routed separately such that they are no less than 4 feet apart when run horizontally and 1 foot apart when run vertically. They may come simultaneously only within 10 feet of the control panel. Evacuation signaling zones are identified on the drawings.
b. NACs passing through other evacuation signaling zone(s) shall be installed in conduit and routed through the 2-hour fire-rated chase(s) or enclosure(s) identified on the drawings.
c. NACs passing through other evacuation signaling zone(s) shall be Electrical Code classified CIC cable (Fire Alarm Circuit Integrity) installed in conduit. Provide CIC cable meeting UL requirements for 2-hour listing.

1) The CIC cable system shall be installed in a conduit system meeting all requirements of its UL-listed installation system (conduit, boxes, connectors, etc.).

6. Fire Alarm Power Branch Circuits: Building wiring as specified in Section 26 05 13.
7. Notification Appliance Circuits shall provide the features listed below. These requirements may require separate circuits for visual and audible devices.

a. Fire alarm temporal audible notification for all audio appliances.
b. Synchronization of all visual devices where two or more devices are visible from the same location.
c. Ability to silence audible alarm while maintaining visual device operation.
d. Emergency communication alert and textual visible appliance notification.

8. Notification Appliance Circuits shall not span floors or smoke compartments. Refer to architectural drawings for smoke compartments.
9. Signal line circuits connecting devices shall not span floors or 2-hour smoke compartments.
10. Signal line circuits connecting devices shall be provided with an isolation module at each floor separation or as otherwise shown on the drawings.
11. No wiring other than that directly associated with fire alarm detection, alarm or auxiliary fire protection functions shall be in fire alarm conduits. Wiring splices shall be avoided to the extent possible, and if needed, they shall be made only in junction boxes, and enclosed by plastic wire nut type connectors. Transposing or changing color coding of wires shall not be permitted. All conductors in conduit containing more than one wire shall be labeled on each end, in all junction boxes, and at each device with "E-Z Markers" or equivalent. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals shall be numbered and coded, and no unterminated conductors are permitted in cabinets or control panels. All controls, function switches, etc. shall be clearly labeled on all equipment panels.

E. Fire Alarm Cabling Color Code: Provide circuit conductors with insulation color coding as follows, or using colored tape at each conductor termination and in each junction box.

1. Power Branch Circuit Conductors: In accordance with Section 26 05 53.

2. Signaling Line Circuit: Overall red jacket with black and red conductors.
3. DC Power Supply Circuit: Overall red jacket with violet and brown conductors.
4. Notification Appliance Circuit: Overall red jacket with blue and white conductors.
5. Door Release Circuit: Gray conductors.
6. Central Station Trip Circuit: Orange conductors.
7. Central Station Fire Alarm Loop: Black and white conductors.

F. Devices surface mounted in finished areas shall be mounted on surface backboxes furnished by fire alarm equipment supplier. Backboxes shall be painted to match device, shall be the same shape and size as the device shall not have visible knockouts.

G. Make conduit and wiring connections to door release devices, sprinkler flow and pressure switches, sprinkler valve monitor switches, fire suppression system control panels, duct analog smoke detectors and all other system devices shown or noted on the Contract Documents or required in the manufacturer's product data and shop drawings.

3.3 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 05 00.

B. Test in accordance with NFPA 72, Chapter 14 and local fire department requirements. Submit documentation with O & M manuals in accordance with Section 14.6 of the Code.

C. Contractor shall test and adjust the fire alarm system as follows:

1. Speaker taps shall be adjusted to the lowest tap setting which achieves a sound level higher than or equal to the greatest of the following:

   a. 70dBA.
   b. 15 dBA above ambient levels as indicated in NFPA 72 Table A.18.4.3.
   c. 15 dBA above measured ambient. 5 dBA above the maximum measured sound level with duration of more than 60 seconds.
   d. As specified on the drawings.

2. Sound level measurement procedure shall meet the following requirements:

   a. All measurements shall use the 'A' weighted, dBA, sound measurement scale.
   b. All measurements shall be taken after furnishings, wall coverings and floor coverings are in place.
   c. All measurements shall be taken after fixed equipment (HVAC units, etc.) producing ambient noise is installed and is in operation.
   d. Final ambient sound measurements shall be taken during occupancy and the units shall be re-adjusted at that time, if necessary.
   e. All sound level measurements shall be taken at a height of 5' above the finished floor level.

f. Measurements shall be taken in every unique room. If there are multiple rooms, which have the identical dimensions and function, 10%, or a minimum of two (2) rooms shall be tested. The results from the rooms tested shall be averaged and the remaining rooms may be adjusted per the average.
g. Measurements shall be taken on a 20' x 20' grid and the results for all points taken shall be averaged. If the room is smaller than 20' x 20' a minimum of two measurements are required.
h. Measurements shall be taken halfway between speakers or halfway between a speaker and the wall. No measurements shall be taken at the extreme edges of the room, nor directly under speakers.

3.4 MANUFACTURER'S FIELD SERVICES

A. Provide manufacturer's field services under provisions of Section 26 05 00.

B. Include services of the manufacturer's software programmer to write initial custom-user program (for Color Graphics Annunciation System).

C. Include services of certified technician to supervise installation, adjustments, final connections, and system testing.

D. Note that room numbers depicted on the architectural/engineering drawings will not necessarily reflect the actual room (signage) numbers that the Owner selects. Contractor and fire alarm manufacturer shall coordinate the actual room numbers as the Owner directs to identify each device. This list shall be a part of the floor plan record drawing to be turned in at the project closeout.

E. Include the services to train up to three of the Owner's staff in operation, maintenance, and programming of the fire alarm system at the manufacturer's factory. Airfare and lodging expenses for the Owner's staff will be by the Owner.

F. System Occupancy Adjustments: When requested by Owner within 12 months of date of Substantial Completion, provide on-site system adjustments to suit actual occupied conditions. For this purpose, provide up to two (2) site visits, four (4) hours each visit, outside normal occupancy hours.

3.5 SYSTEM TRAINING

A. System training shall be performed under provisions of Section 26 05 00.

B. Minimum on-site training times shall be:

1. System Operators: One (1) day.
2. GUI Operation and Editing: One (1) day.

END OF SECTION

**SECTION 31 0501**

**COMMON EARTHWORK REQUIREMENTS**

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Includes but Not Limited to:
   1. General procedures and requirements for earthwork.

B. Related Requirements:
   1. Pre-Installation conferences held jointly with Section 31 0501 as described in Administrative Requirements on Part 1 of this specification section:
   2. Section 32 9300: 'Landscape Planting':
      a. Pre-installation conference held jointly with other landscape related sections.

### 1.2 REFERENCES

A. Definitions:
   1. Aggregate Base: Layer of granular material immediately below concrete and asphalt paving or miscellaneous site concrete (sidewalks, curbs, etc) and below interior concrete slabs on grade.
   2. Base: See aggregate base.
   3. Building Grading: sloping of grounds immediately adjacent to building. Proper grading causes water to flow away from a structure. Grading can be accomplished either with machinery or by hand.
   4. Compacted Fill: Placement of soils on building site placed and compacted per Contract Documents. Used to replace soils removed during excavation or to fill in low spot on building site.
   5. Excavation: Removal of soil from project site or cavity formed by cutting, digging or scooping on project site.
   6. Fine Grading (FG): Preparation of subgrade preceding placement of surfacing materials (aggregate base, asphalt or concrete paving, and topsoil) for contour of building site required. Fine Grading is conducted to ensure that earth forms and surfaces have been properly shaped and subgrade has been brought to correct elevations. It is performed after rough grading and placement of compacted fill but before placement of aggregate base or topsoil.
   7. Finish Grading: Completed surface elevation of landscaping areas for seeding, sodding, and planting on building site.
   8. Natural Grade: Undisturbed natural surface of ground.
   9. Rough Grading (RG): Grading, leveling, moving, removal and placement of existing or imported soil to its generally required location and elevation. Cut and fill is part of rough grading.
   10. Subgrade (definition varies depending upon stage of construction and context of work being performed):
       a. Prepared natural soils on which fill, aggregate base, or topsoil is placed.
          or
       b. Prepared soils immediately beneath paving or topsoil.
   11. Topsoil Placement and Grading: Topsoil placement and finish grading work required to prepare site for installation of landscaping.

### 1.3 ADMINISTRATIVE REQUIREMENTS

A. Pre-Installation Conference:
   1. Participate in MANDATORY pre-installation conference for common earthwork sections:
      a. Schedule conference after completion of site clearing but before beginning grading work.
      b. In addition to agenda items specified above, review following. These are items that will occur before pre-installation conference for landscape sections:

1) Review clearing and grubbing requirements.
2) Review topsoil stripping and stockpiling requirements.
3) Review landscape grading requirements.
4) Review landscape finish grade tolerance requirements.
5) Review landscape and plant tolerances.
6) Review surface preparation of landscape and planting areas.
7) Review additional agenda items as specified in related sections listed above.

2. Participate in pre-installation conference for landscape sections:
   a. Schedule pre-installation conference after completion of Fine Grading specified in Section 31 2216, but one (1) week minimum before beginning landscape.

B. Sequencing:
1. General Earthwork:
   a. Excavation.
   b. Rough Grading.
   c. Fill.
   d. Fine Grading.
   e. Aggregate Base or Topsoil Grading.

## 1.4 QUALITY ASSURANCE

A. Testing And Inspection:
1. Owner is responsible for Quality Assurance. Quality assurance performed by Owner will be used to validate Quality Control performed by Contractor.
   a. Owner will employ testing agencies to perform testing and inspection as specified in Field Quality Control in Part 3 of this specification:
      1) Owner's employment of an independent Testing Agency does not relieve Contractor of Contractor's obligation to perform the Work in strict accordance with requirements of Contract Documents and perform contractor testing and inspection.
      2) See Section 01 1200: 'Multiple Contract Summary'.

## PART 2 - PRODUCTS: Not Used

## PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verification of Conditions:
1. Forty-eight (48) hours minimum before performing any work on site, contact Underground Service Alert to arrange for utility location services: 1-800-422-4133
2. Perform minor, investigative excavations to verify location of various existing underground facilities at sufficient locations to assure that no conflict with the proposed work exists and sufficient clearance is available to avoid damage to existing facilities.
3. Perform investigative excavating ten (10) days minimum in advance of performing any excavation or underground work.
4. Upon discovery of conflicts or problems with existing facilities, notify Architect by phone or fax within twenty-four (24) hours. Follow telephone or fax notification with letter and diagrams indicating conflict or problem and sufficient measurements and details to evaluate problem.

## 3.2 PREPARATION

A. Protection:
1. Spillage:

a. Avoid spillage by covering and securing loads when hauling on or adjacent to public streets or highways.
b. Remove spillage and sweep, wash, or otherwise clean project, streets, and highways.

2. Dust Control:
   a. Take precautions necessary to prevent dust nuisance, both on-site and adjacent to public and private properties.
   b. Correct or repair damage caused by dust.

## 3.3 FIELD QUALITY CONTROL

A. Field Tests And Inspections:
   1. Civil and structural field tests, laboratory testing, and inspections are provided by Owner's independent Testing Agency as specified in Section 01 400 'Quality Requirements':
      a. Quality Control is sole responsibility of Contractor. Owner's employment of an independent Testing Agency does not relieve Contractor of Contractor's obligation to perform The Work or Contractors own Testing and Inspection services.
   2. Testing and inspection of earthwork operations is required.
   3. Field Tests and Laboratory Tests:
      a. Owner reserves right to require additional testing to re-affirm suitability of completed work including compacted soils that have been exposed to adverse weather conditions.
   4. Field Inspections:
      a. Notify Architect forty-eight (48) hours before performing excavation or fill work.
      b. If weather, scheduling, or any other circumstance has interrupted work, notify Architect twenty-four (24) hours minimum before intended resumption of grading or compacting.

B. Non-Conforming Work:
   1. If specified protection precautions are not taken or corrections and repairs not made promptly, Owner may take such steps as may be deemed necessary and deduct costs of such from monies due to Contractor. Such action or lack of action on Owner's part does not relieve Contractor from responsibility for proper protection of The Work.

**END OF SECTION**

**SECTION 31 1100**

**CLEARING AND GRUBBING**

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Includes but Not Limited To:
   1. Perform clearing and grubbing as necessary to prepare site for rough grading and structure excavation as described in Contract Documents.

B. Related Requirements:
   1. Section 31 0501: Common Earthwork Requirements:
      a. General procedures and requirements for earthwork.
      b. Pre-installation conference held jointly with other common earthwork related sections.
      c. Pre-installation conference held jointly with other landscape related sections.

### 1.2 ADMINISTRATIVE REQUIREMENTS

A. Pre-Installation Conference:
   1. Participate in pre-installation conferences as specified in Section 31 0501.

## PART 2 - PRODUCTS: Not Used

## PART 3 - EXECUTION

### 3.1 PERFORMANCE

A. Tree and Brush Removal:
   1. Cut off trees, shrubs, brush, and vegetative growth 12 inches (300 mm) maximum above ground.
   2. Do not pull up or rip out roots of trees and shrubs that are to remain. If excavation through roots is required, excavate by hand and cut roots with sharp axe. Make clean, smooth, sloping cuts.
   3. Cut roots 6 inches (150 mm) or larger in diameter only with Architect's written permission.

B. Grubbing:
   1. Grub out stumps and roots 12 inches (300 mm) minimum below original ground surface, except as follows:
      a. Under buildings, remove roots one inch and larger entirely.
      b. Entirely remove roots of plants that normally sprout from roots or as specified by Landscape Architect, stumps, vegetative layer, and surface debris and dispose of legally.

C. Do not bury cuttings, stumps, roots, and other vegetative matter or burnt waste material on site.

**END OF SECTION**

**SECTION 31 2213**

**ROUGH GRADING**

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Includes But Not Limited To:
   1. Perform rough grading work required to prepare site for construction as described in Contract Documents.

B. Related Requirements:
   1. Section 03 3053: Miscellaneous Exterior Cast-In-Place Concrete.

### 1.2 ADMINISTRATIVE REQUIREMENTS

A. Pre-Installation Conference:
   1. Participate in MANDATORY pre-installation conference as specified in Section 31 0501:
   2. In addition to agenda items specified in Section 31 0501, review following:
      a. Identify benchmark to be used in establishing grades and review Contract Document requirements for grades, fill materials, and topsoil.
      b. Examine site to pre-plan procedures for making cuts, placing fills, and other necessary work.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

A. Materials used for fill shall be as specified for backfill in Section 31 2323 'Fill'.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions:
   1. Verify elevations of rough grading are correct before compacted fill, fine grading or landscape grading are placed.

### 3.2 PREPARATION

A. Surface Preparation:
   1. Before making cuts, remove topsoil over areas to be cut and filled that were not previously removed by stripping. Stockpile this additional topsoil with previously stripped topsoil.

### 3.3 PERFORMANCE

A. Subgrade (Natural Soils):
   1. Subgrade beneath compacted fill or aggregate base under asphalt or concrete paving shall be constructed smooth and even.

B. Special Techniques:
   1. Compact fills as specified in Section 31 2323 'Fill'.
   2. If soft spots, water, or other unusual and unforeseen conditions affecting grading requirements are encountered, stop work and notify Architect.

C. Tolerances:
   1. Maximum variation from required grades shall be 1/10 of one foot (28 mm).

**END OF SECTION**

**SECTION 31 2216**

**FINE GRADING**

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Includes but Not Limited To:
   1. Perform fine grading of subgrade work required to prepare site for paving finish grading and for placement of topsoil as described in Contract Documents.
   2. Asphalt Paving:
      a. Prepare natural soil subgrade as described in Section 31 2213 'Rough Grading' or prepare fill subgrade as described in this specification section for asphalt paving.
   3. Concrete Paving:
      a. Prepare natural soil subgrade as described in Section 31 2213 'Rough Grading' or prepare fill subgrade as described in this specification section for concrete paving.

B. Related Requirements:
   1. Section 31 0501: 'Common Earthwork Requirements' for:
      a. General procedures and requirements for earthwork.
      b. Pre-installation conference held jointly with other common earthwork related sections.
   2. Section 31 2213: 'Rough Grading' for grading and preparation of natural soil subgrades below fill and aggregate base materials.
   3. Section 31 2316: 'Excavation'.
   4. Section 31 2323: 'Fill' for compaction procedures and tolerances for base.
   5. Section 32 1216: 'Asphalt Paving' for finish grading for asphalt paving.
   6. Section 32 1313: 'Concrete Paving' for finish grading for concrete paving.

### 1.2 ADMINISTRATIVE REQUIREMENTS

A. Pre-Installation Conference:
   1. Participate in MANDATORY pre-installation conference as specified in Section 31 0501.
   2. In addition to agenda items, review following:
      a. Review backfill requirements.
      b. Review Geotechnical report dated May 30, 2019 by Patel and Associates, Inc..
      c. Testing and Inspection administrative requirements and responsibilities and Field Quality Control tests and inspections required of this section.
         1) Review requirements and frequency of testing and inspections from Geotechnical report.

B. Scheduling:
   1. Notify Testing Agency, Geotechnical Engineer and Architect twenty-four (24) hours minimum before installation of fill to allow inspection.
   2. Allow special inspector to review all subgrades and excavations to determine if site has been prepared in accordance with geotechnical report prior to placing any fill, aggregate base or concrete.
   3. Allow inspection and testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after inspections and test results for previously compacted work comply with requirements.

### 1.3 SUBMITTALS

A. Closeout Submittals:
   1. Include the following in Operations and Maintenance Manual:

a. Record Documentation:
    1) Testing and Inspection Reports:
        a) Testing Agency Testing and Inspecting Reports of fill.

## 1.4 QUALITY ASSURANCE

A. Testing and Inspection:
    1. Owner is responsible for Quality Assurance. Quality assurance performed by Owner will be used to validate Quality Control performed by Contractor.
    2. Owner will provide Testing and Inspection for fill:
        a. Owner will employ testing agencies to perform testing and inspection for fill / engineering fill as specified in Field Quality Control in Part 3 of this specification.
            1) Owner's employment of an independent Testing Agency does not relieve Contractor of Contractor's obligation to perform the Work in strict accordance with requirements of Contract Documents and perform contractor testing and inspection.

## PART 2 - PRODUCTS: Not Used

## PART 3 - EXECUTION

## 3.1 PREPARATION

A. Protection of In-Place Conditions: Protect utilities and site elements from damage.

B. Surface Preparation:
    1. Asphalt Paving:
        a. Survey and stake parking surfaces to show grading required by Contract Documents.
        b. Subgrade (material immediately below aggregate base):
            1) Compact subgrade as specified in Section 31 2213 (natural soils) and Section 31 2323 (fill).
            2) Fine grade parking surface area to grades required by Contract Documents.
            3) Subgrade to be constructed smooth and even.
    2. Concrete Paving:
        a. Survey and stake parking surfaces to show grading required by Contract Documents.
        b. Subgrade (material immediately below aggregate base):
            1) Compact subgrade as specified in Section 31 2213 (natural soils) and Section 31 2323 (fill).
            2) Fine grade parking surface area to grades required by Contract Documents.
            3) Subgrade to be constructed smooth and even.

## 3.2 PERFORMANCE

A. Interface With Other Work: Do not commence work of this Section until grading tolerances specified in Section 31 2213 are met.

B. General:
    1. Do not expose or damage existing shrub or tree roots.

C. Tolerances:
    1. Site Tolerances:
        a. Subgrade (material immediately below aggregate base):
            1) 0.00 inches (0.00 mm) high.
            2) Measure using string line from curb to curb, gutter, flat drainage structure, or grade break.

b. Maximum variation from required grades shall be 1/10 of one foot (28 mm).

2. Aggregate Base (Asphalt Paving) Tolerances:
   a. Aggregate base shall be 6 inches (150 mm) thick minimum after compaction, except where shown thicker on Drawings.
   b. Measure using string line from curb to curb, gutter, flat drainage structure, or grade break.
3. Aggregate Base (Concrete Paving) Tolerances:
   a. Finished base course shall be 4 inches (100 mm) thick minimum after compaction and true to line and grade within plus or minus 1/4 inch in 10 feet (6 mm in 3 m).

## 3.3 FIELD QUALITY CONTROL

A. Field Tests and Inspections:
   1. Civil and structural field tests, laboratory testing, and inspections are provided by Owner's independent Testing Agency:
      a. Quality Control is sole responsibility of Contractor:
         1) Owner's employment of an independent Testing Agency does not relieve Contractor of Contractor's obligation to perform testing and inspection as part of his Quality Control:
            a) Testing and inspections, if performed by Contractor, will be responsibility of Contractor to be performed by an independent entity.
   2. Site Preparation:
      a. Prior to placement of fill, inspector shall determine that site has been prepared in accordance with geotechnical report.
      b. Footing subgrade: At footing subgrades, Certified Inspector is to verify that soils conform to geotechnical report.
   3. Fill:
      a. Testing Agency shall provide testing and inspection for fine grading.
      b. Number of tests may vary at discretion of Architect and Geotechnical Engineer.
      c. Testing Agency is to provide one (1) moisture-maximum density relationship test for each type of fill material.

**END OF SECTION**

**SECTION 31 2316**

**EXCAVATION**

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Includes but Not Limited To:
   1. Perform Project excavating and trenching as described in Contract Documents, except as specified below.
   2. Procedure and quality for excavating and trenching performed on Project under other Sections unless specifically specified otherwise.

B. Related Requirements:
   1. Section 31 0501: 'Common Earthwork Requirements' for:
      a. General procedures and requirements for earthwork.
      b. Pre-installation conference held jointly with other common earthwork related sections.
   2. Section 31 1100: Clearing and Grubbing.
   3. Section 31 2213: 'Rough Grading' for rough grading and preparation of natural soil subgrades below fill and aggregate base materials.
   4. Section 31 2216: 'Fine Grading' for grading of subgrade below aggregate base and topsoil.
   5. Section 31 2323: 'Fill' for compaction procedures and tolerances for base.
   6. Performance of excavating inside and outside of building required for electrical and mechanical work is responsibility of respective Section doing work unless arranged differently by Contractor.

### 1.2 ADMINISTRATIVE REQUIREMENTS

A. Pre-Installation Conference:
   1. Participate in MANDATORY pre-installation conference as specified in Section 31 0501:
   2. In addition to agenda items specified, review following:
      a. Review protection of existing utilities requirements.

## PART 2 - PRODUCTS: Not Used

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions:
   1. Carefully examine site and available information to determine type soil to be encountered.
   2. Discuss problems with Architect before proceeding with work.

### 3.2 PREPARATION

A. Protection of Existing Utilities:
   1. Protect existing utilities identified in Contract Documents during excavation.
   2. If existing utility lines not identified in Contract Documents are encountered, contact Architect before proceeding.

## 3.3 PERFORMANCE

A. Interface with Other Work:
   1. Section 31 2213: 'Rough Grading' for rough grading and preparation of natural soil subgrades below fill and aggregate base materials.
   2. Section 31 2216: 'Fine Grading' for grading of subgrade below aggregate base and topsoil.

B. Excavation:
   1. Building Footings and Foundations:
      a. Under Building:
         1) Excavate at least 18-inches and up to 24-inches below existing grade and 5 feet (1.50 m) beyond perimeter of buildings and structures and as necessary for proper placement and forming of footings and foundations so that final grade allows for 8-inch of select fill below slab.
      b. Under Paving:
         1) Excavate at least 12-inches and up to 12-inches below existing grade so final grade allows for 8-inch of compacted fill below paving.
      c. Bottom of excavations to receive footings shall be undisturbed soil.
      d. Excavation Carried Deeper Than Required:
         1) Under Footings: Fill with concrete specified for footings.
         2) Under Slabs: Use specified compacted backfill material.
   2. Pavement and Miscellaneous Cast-In-Place Concrete:
      a. Excavate as necessary for proper placement and forming of concrete site elements and pavement structure. Remove vegetation and deleterious material and remove from site.
      b. Remove and replace exposed material that becomes soft or unstable.
   3. Utility Trenches:
      a. Unless otherwise indicated, excavation shall be open cut. Short sections of trench may be tunneled if pipe or duct can be safely and properly installed and backfill can be properly tamped in tunnel sections and if approved by Architect.
      b. Excavate to proper alignment, depth, and grade. Excavate to sufficient width to allow adequate space for proper installation and inspection of utility piping.
      c. If trenches are excavated deeper than required, backfill until trench bottom is proper depth with properly compacted native material.
      d. Pipe 4 Inches (100 mm) In Diameter Or Larger:
         1) Grade bottom of trenches to provide uniform bearing and support for each section of pipe on undisturbed soil at every point along its length.
         2) Except where rock is encountered, take care not to excavate below depths indicated.
            a) Where rock excavations are required, excavate rock with minimum over-depth of 4 inches (100 mm) below required trench depths.
            b) Backfill over-depths in rock excavation and unauthorized over-depths with loose, granular, moist earth, thoroughly compacted.
         3) Whenever wet or unstable soil incapable of properly supporting pipe, as determined by Geotechnical Engineer, occurs in bottom of trench, remove soil to depth required and backfill trench to proper grade with coarse sand, fine gravel, or other suitable material acceptable to Architect.
   4. If unusual excavating conditions are encountered, stop work and notify Architect.

## 3.4 REPAIR / RESTORATION

A. Repair damage to other portions of the Work resulting from work of this Section at no additional cost to Owner. On new work, arrange for damage to be repaired by original installer.

## 3.5 CLEANING

A. Debris and material not necessary for Project are property of Contractor and are to be removed before completion of Project. However, if material necessary for Project is hauled away, replace with specified fill / backfill material.

**END OF SECTION**

**SECTION 31 2323**

**FILL**

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Includes But Not Limited To:
   1. Perform Project backfilling and compacting as described in Contract Documents, except as specified below.
   2. Procedure and quality for backfilling and compacting performed on Project under other Sections unless specifically specified otherwise.

B. Related Requirements:
   1. Section 31 0501: 'Common Earthwork Requirements' for:
      a. General procedures and requirements for earthwork.
      b. Pre-installation conference held jointly with other common earthwork related sections.
   2. Section 31 1100: 'Clearing and Grubbing'.
   3. Section 31 2213: 'Rough Grading' for grading and preparation of natural soil subgrades below fill and aggregate base materials.
   4. Section 31 2216: 'Fine Grading' for grading of subgrade below aggregate base and topsoil.
   5. Section 31 2316: 'Excavation'.
   6. Division 32: Compaction of subgrade under walks and paving.
   7. Performance of backfilling and compacting inside and outside of building required for electrical and mechanical work is responsibility of respective Section doing work unless arranged differently by Contractor.

### 1.2 REFERENCES

A. Reference Standards:
   1. ASTM International (Following are specifically referenced for fill and aggregate base testing):
      a. ASTM D698-12, 'Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3))'.
      b. ASTM D1556/D1556M-15, 'Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method'.
      c. ASTM D1557-12, 'Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))'.
      d. ASTM D2167-15, 'Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method'.
      e. ASTM D2487-11, 'Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)'.
      f. ASTM D6938-15, 'Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)'.

### 1.3 ADMINISTRATIVE REQUIREMENTS

A. Pre-Installation Conferences:
   1. Participate in MANDATORY pre-installation conference as specified in Section 31 0501.
   2. In addition to agenda items specified in Section 01 3100, Section 31 0501, and Section 31 2324 if Flowable Fill is included, review following:
      a. Review backfill requirements.
      b. Review Section 01 4523 for Testing and Inspection administrative requirements and responsibilities and Field Quality Control tests and inspections required of this section.
         1) Review requirements and frequency of testing and inspections.

B. Scheduling:
   1. Notify Testing Agency and Architect seventy-two (72) hours minimum before installation of fill / engineered fill to perform proctor and plasticity index tests on proposed fill or subgrade.
   2. Notify Testing Agency and Architect twenty-four (24) hours minimum before installation of fill / engineered fill to allow inspection.
   3. Allow special inspector to review all subgrades and excavations to determine if site has been prepared in accordance with geotechnical report prior to placing any fill (or concrete).
   4. Allow inspection and testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after inspections and test results for previously compacted work comply with requirements.

## 1.4 SUBMITTALS

A. Closeout Submittals:
   1. Include following in Operations And Maintenance Manual specified in Section 01 7800:
      a. Record Documentation:
         1) Testing and Inspection Reports:
            a) Testing Agency Testing and Inspecting Reports of fill / engineered fill.

## 1.5 QUALITY ASSURANCE

A. Testing and Inspection:
   1. Owner is responsible for Quality Assurance. Quality assurance performed by Owner will be used to validate Quality Control performed by Contractor.
   2. Owner will provide Testing and Inspection for fill / engineering fill:
      a. Owner will employ testing agencies to perform testing and inspection for fill / engineering fill as specified in Field Quality Control in Part 3 of this specification.
         1) Owner's employment of an independent Testing Agency does not relieve Contractor of Contractor's obligation to perform the Work in strict accordance with requirements of Contract Documents and perform contractor testing and inspection.
         2) See Section 01 1200: 'Multiple Contract Summary'.

## 1.6 FIELD CONDITIONS

A. Ambient Conditions:
   1. Do not perform work during unfavorable conditions as specified below:
      a. Aggregate Base:
         1) Presence of free surface water.
         2) Over-saturated subbase materials.

# PART 2 - PRODUCTS

## 2.1 MATERIALS

A. Site Material:
   1. Existing excavated material on site is suitable for use as fill and backfill to meet Project requirements.

B. Imported Fill / Backfill:
   1. Well graded material conforming to ASTM D2487 free from debris, organic material, frozen materials, brick, lime, concrete, and other material which would prevent adequate performance of backfill.
      a. Under Building Footprint and Paved Areas: Fill shall comply with soil classification groups GW, CL, GP, GM, SW, SP, or SM. Fill may not contain stones over 6 inches (150 mm)

diameter and ninety-five (95) percent minimum of fill shall be smaller than 1-1/2 inch (38 mm) in any direction.

b. Under Landscaped Areas:
   1) Fill more than 36 inches (900 mm) below finish grade shall comply with soil classification groups GW, CL, GP, GM, SW, SP, or SM. Fill may not contain stones over 6 inches (150 mm) diameter and ninety (90) percent minimum of fill shall be smaller than 1-1/2 inch (38 mm) in any direction.
   2) Fill less than 36 inches (900 mm) below finish grade shall comply with soil classification groups SW, SP, SM, or SC. Fill may not contain stones larger than 1-1/2 inches (38 mm) in any direction and ninety (90) percent minimum of fill shall be smaller than 3/8 inch (4.7 mm) in any direction.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Before placing fill, aggregate base, or finish work, prepare existing subgrade as follows:
   1. Do not place fill or aggregate base over frozen subgrade.
   2. Under Building Slab and Equipment Pad Areas:
      a. Scarify subgrade 6 inches (150 mm) deep, moisture condition to uniform moisture content of between optimum and four (4) percent over optimum, and mechanically tamp 6 inches (150 mm) deep to ninety-five (95) percent minimum of relative compaction.
   3. Under Driveways And Parking Areas:
      a. Scarify subgrade 6 inches (150 mm) deep, moisture condition to uniform moisture content between optimum and four (4) percent over optimum, and mechanically tamp to ninety-five (95) percent minimum of relative compaction.
   4. Under Miscellaneous Concrete Site Elements And Outside Face of Foundation Walls
      a. Scarify subgrade 6 inches (150 mm) deep, moisture condition to uniform moisture content between optimum and four (4) percent over optimum, and mechanically tamp to ninety-five (95) percent minimum of relative compaction.
   5. Landscape Areas:
      a. Compact subgrade to eighty-five (85) percent relative compaction.

### 3.2 PERFORMANCE

A. Interface with Other Work:
   1. Section 31 2213: 'Rough Grading' for rough grading and preparation of natural soil subgrades below fill and aggregate base materials.
   2. Section 31 2216: 'Fine Grading' for grading of subgrade below aggregate base and topsoil.

B. Fill / Backfill:
   1. General:
      a. Around Buildings and Structures: Slope grade away from building as specified in Section 31 2216. Hand backfill when close to building or where damage to building might result.
      b. Site Utilities:
         1) In Landscape Areas: Use backfill consisting of on-site soil.
         2) Under Pavement and Concrete Site Elements: Extend excavatable flowable fill / backfill to elevation of subgrade. Do not place aggregate base material until excavatable flowable fill / backfill has cured seventy-two (72) hours.
      c. Do not use puddling or jetting to consolidate fill areas.
   2. Compacting:
      a. Fill / Backfill:
         1) All fill material shall be well-graded granular material with maximum size less than 3 inch (76 mm) and with not more than fifteen (15) percent passing No. 200 sieve.
         2) Under Building Slab and Equipment Pad Areas:

a) Place in 8 inch (200 mm) maximum layers, moisture condition to plus or minus two (2) percent of optimum moisture content, and mechanically tamp to ninety five (95) percent minimum of maximum laboratory density as established by ASTM D1557.

3) Under Driveways And Parking Areas:
   a) Place in 8 inch (200 mm) maximum layers, dampen but do not soak, and mechanically tamp to ninety five (95) percent minimum of maximum laboratory density as established by ASTM D1557.
4) Under Miscellaneous Concrete Site Elements And Outside Face of Foundation Walls:
   a) Place in 8 inch (200 mm) maximum layers, dampen but do not soak, and mechanically tamp to ninety five (95) percent minimum of maximum laboratory density as established by ASTM D1557.
5) Utility Trenches:
   a) Site:
      (1) Place fill in 12 inch (300 mm) layers and moisture condition to plus or minus two (2) percent of optimum moisture content.
      (2) Compact fill to ninety-five (95) percent minimum relative compaction to within 12 inches (300 mm) of finish grade.
      (3) Compact fill above 12 inches (300 mm) to eighty-five (85) percent relative compaction.
   b) Under Slabs:
      (1) Under Slabs: Place fill in 6 inch (150 mm) layers, moisture condition to plus or minus two (2) percent of optimum moisture content, and compact to ninety five (95) percent minimum relative compaction to within 4 inches (100 mm) of finish grade.
      (2) Final 4 inches (100 mm) of fill shall be aggregate base as specified in Section 31 1123.
6) Fill Slopes: Compact by rolling or using sheepsfoot roller.
7) Backfill Under Footings if required by Geotechnical Evaluation Report.
8) Landscape Areas:
   a) Compact fill to eighty-five (85) percent minimum relative compaction.
9) Other Backfills: Place other fills in 12 inch (300 mm) layers and compact to ninety five (95) percent relative compaction.
10) Loose material from compacted subgrade surface shall be immediately removed before placing compacted fill or aggregate base course.

## 3.3 REPAIR / RESTORATION

A. Repair damage to other portions of the Work resulting from work of this Section at no additional cost to Owner. On new work, arrange for damage to be repaired by original installer.

## 3.4 FIELD QUALITY CONTROL

A. Field Tests and Inspections:
   1. Civil and structural field tests, laboratory testing, and inspections are provided by Owner's independent Testing Agency:
      a. Quality Control is sole responsibility of Contractor:
         1) Owner's employment of an independent Testing Agency does not relieve Contractor of Contractor's obligation to perform testing and inspection as part of his Quality Control:
            a) Testing and inspections, if performed by Contractor, will be responsibility of Contractor to be performed by an independent entity.
   2. Fill:
      a. Testing Agency shall provide testing and inspection for fill.
      b. Number of tests may vary at discretion of Architect.
      c. Testing Agency is to provide one (1) moisture-maximum density relationship test for each type of fill material.
      d. Prior to placement of engineered fill, inspector shall determine that site has been prepared in accordance with geotechnical report.

e. Footing subgrade: At footing subgrades Certified Inspector is to verify that soils conform to geotechnical report.

f. Testing Agency will test compaction of soils according to ASTM D1556/D1556M, ASTM D2167, and ASTM D6938, as applicable. Lift thicknesses shall comply with geotechnical report. Inspector shall determine that in-place dry density of engineered fill material complies with geotechnical report. Tests will be performed at following locations and frequencies:
   1) Paved Areas: At each compacted fill and backfill layer, at least one (1) test for every 10,000 sq. ft. (930 sq. m) or less of paved area but in no case less than three (3) tests.
   2) Building Slab Areas: At each compacted fill and backfill layer, at least on test for every 2,500 sq. ft. (232 sq. m) or less of building slab area but in no case less than three (3) tests.
   3) Foundation Wall/Continuous Footing Backfill: At each compacted backfill layer, at least one (1) test for each 40 linear feet (12 linear m) or less of wall length, but no fewer than two (2) tests.
   4) Trench Backfill: At each 12 inch (305 mm) compacted lift for each 100 linear feet (30.5 linear m) or less of trench length but no fewer than two (2) tests.
   5) Sidewalks, Curbs, Gutters, Exterior Pads: Minimum of one (1) test for each lift for each 40 lineal feet (12 linear m) or one (1) test for every 5,000 sq. ft. (465 sq. m) or less of pad area but no fewer than three (3) tests.

g. Required verification and inspection of soils as referenced in 2015 IBC (or latest approved edition) Table 1704.7 'Required Verification And Inspection Of Soils'. Periodic and continuous inspections include:
   1) Verify materials below shallow foundations are adequate to achieve design bearing capacity (periodic).
   2) Verify excavations are extended to proper depth and have reached proper material (periodic).
   3) Perform classification and testing of compacted fill materials (periodic).
   4) Verify use of proper materials, densities and lift thicknesses during placement and compaction of compacted fill (continuous).
   5) Prior to placement of compacted fill, observe subgrade and verify that site has been prepared properly (periodic).

## 3.5 CLEANING

A. Debris and material not necessary for Project are property of Contractor and are to be removed before completion of Project. However, if material necessary for Project is hauled away, replace with specified fill / backfill material.

**END OF SECTION**

**SECTION 32 1216**

**ASPHALT PAVING**

## 1.1 SUMMARY

A. Includes but Not Limited To:
1. Furnish and install asphalt paving in driveways and parking areas as described in Contract Documents including the following, but not limited to:

| | | |
|---|---|---|
| 1) | Asphalt Binder: | PG 64-28 |
| 2) | Nominal maximum size aggregate (Nmas): | 9.5 mm (3/8 inch) |
| 3) | Maximum size aggregate: | 12.5 mm (1/2 inch) |
| 4) | Mix Designator (compaction effort); Ndesign: | 75 |
| 5) | Antistrip Agent: | If required by supplier's mix design (use 1 percent or greater lime slurry when required |
| 6) | Asphalt Reinforcement Fibers: | Specified in Section 32 1217 as Alternate 'A' |
| 7) | Reclaimed Asphalt Pavement (RAP): | Allowed up to 25 percent. Asphalt binder shall be one grade softer when more than 15 percent RAP is used |
| 8) | ROSP | Not allowed. |
| 9) | Warm Mix Additive | If required by supplier's mix design |
| 10) | Recycle Agent: | If required by supplier's mix design |

b. Design Air Voids:
1) Three and one-half percent (3.5 percent).
c. Tack coat: Application of asphaltic material to existing asphalt concrete or Portland concrete surfaces before asphalt concrete pavement.
d. Blotter materials and procedures for absorbing excess asphalt as required.

B. Related Requirements:
1. Section 31 0501: 'Common Earthwork Requirements' for:
a. General procedures and requirements for earthwork.
b. Pre-installation conference held jointly with other common earthwork related sections.
2. Section 31 2213: 'Rough Grading' for rough grading and preparation of natural soil subgrades below fill and aggregate base materials.
3. Section 31 2216: 'Fine Grading' for grading of subgrade below aggregate base and topsoil.
4. Section 31 2323: 'Fill' for compaction procedures and tolerances for base.
5. Section 32 1723: 'Pavement Markings'.

## 1.2 REFERENCES

A. Association Publications:
1. Asphalt Institute, 2696 Research Park Dr., Lexington, KY www.asphaltinstitute.org:
a. MS-2, *'Mix Design Methods'* (7th Edition 2015).

B. Definitions:
1. Aggregate: Hard inert mineral material, such as gravel, crushed rock, slag, or sand.
a. Coarse Aggregate: Aggregate retained on or above No. 4 (4.75 mm) sieve.
b. Coarse-Graded Aggregate: Aggregate having predominance of coarse sizes.
c. Dense-Graded Aggregate: Aggregate that is graded from maximum size down through filler with object of obtaining an asphalt mix with controlled void content and high stability.
d. Fine Aggregate: Aggregate passing No. 4 (4.75 mm) sieve.
e. Fine-Graded Aggregate: Aggregate having predominance of fine sizes.
f. Mineral Filler: Fine mineral product at least 70 percent of which passes a No. 200 (75µm) sieve.

2. Air Voids: Total volume of small air pockets between coated aggregate particles in asphalt cement concrete (ACC); expressed as percentage of bulk volume of compacted paving mixture.
3. Anti-Stripping Agent: Chemicals added to bitumen to improve the adhesion of the bitumen to hydrophilic aggregates
4. Asphalt Binder: Asphalt cement or modified asphalt cement that binds aggregate particles into dense mass.
    a. Asphalt Cement used in paving applications that has been classified according to the Standard Specification for Performance Graded Asphalt Binder, AASHTO Designation MP 320. It can be either unmodified or modified Asphalt Cement, as long as it complies with specifications.
5. Asphalt-Aggregate Designator: Alpha-numeric code that indicates nominal maximum size of aggregate, and type and grade of asphalt in aggregate-asphalt mix.
    a. Example: “12.5 PG70-28” means aggregate asphalt mix shall be composed of aggregate gradation with 12.5 mm (1/2 inch) nominal maximum size and performance grade asphalt binder designed to perform between temperatures of 70 deg C and -28 deg C (158 deg F and -18.4 deg F).
6. Equivalent Single Axle Load (ESAL): Effect on pavement performance of any combination of axle loads of varying magnitude equated to number of 18,000-lb. (80-kN) single-axle loads that are required to produce an equivalent effect.
7. Maximum Size (Superpave): One sieve larger than the nominal maximum size.
8. Ndesign (Superpave): Design number of gyrations used for design of Hot Mix Asphalt (HMA).
9. Nominal Maximum Size: One sieve size larger than first sieve size retaining more than 10 percent of Sample. Nominal maximum size sieve will retain minimum of 0 and maximum of 10 percent of sample. Maximum size is one sieve size larger than nominal maximum size.
10. Performance Graded Asphalt Binder (PGAB): Asphalt binder designed to produce HMA that meets certain performance standards. Designations for performance-graded asphalt binders are prefixed with PG. Each grade designation also includes two sets of numbers that denote temperature range. This is a range of climate temperatures to which road may be exposed and still be expected to give superior performance. PG numbers do not indicate viscosity as in conventional liquid asphalt designations.
11. Pre-emergent Herbicide: Chemical that is applied before weeds emerge. It acts by killing weed seedlings and /or establishing layer of chemical on or near soil surface that is toxic to germinating seeds and young seedlings.
12. Reclaimed Asphalt Pavement (RAP): Existing asphalt mixture that has been pulverized, usually by milling, and is used like aggregate in recycling of asphalt pavements.
13. Subgrade (definition varies depending upon stage of construction and context of work being performed):
    a. Prepared natural soils on which fill, aggregate base, or topsoil is placed.
    or
    b. Prepared soils immediately beneath paving.
14. Tack Coat: Very light application of liquid asphalt, or asphalt emulsion diluted with water.

C. Reference Standards:
1. American Association of State and Highway Transportation Officials:
    a. AASHTO T 304-11: ‘Standard Method of Test for Uncompacted Void Content of Fine Aggregate’.
    b. AASHTO T 322-07(2011), ‘Standard Method of Test for Determining the Creep Compliance and Strength of Hot-Mix Asphalt (HMA) Using the Indirect Tensile Test Device.
2. ASTM International:
    a. ASTM C29/C29M-16, ‘Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate'.
    b. ASTM C88-13, ‘Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate'.
    c. ASTM C117-13, ‘Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing'.
    d. ASTM C131/C131M-14, 'Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine’.
    e. ASTM C142/C142M-10, ‘Standard Test Method for Clay Lumps and Friable Particles in Aggregates'.

f. ASTM D242/D242M-09(2014), ‘Standard Specification for Mineral Filler for Bituminous Paving Mixtures'.
g. ASTM D977-13, 'Standard Specification for Emulsified Asphalt’.
h. ASTM D979/D979M-15, 'Practice for Sampling Bituminous Paving Mixtures'.
i. ASTM D2041/D2041M-11, 'Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures’.
j. ASTM D2172/D2172M-11, ‘Standard Test Methods for Quantitative Extraction of Bitumen From Bituminous Paving Mixtures’.
k. ASTM D2256/ D2256M-10, ‘Standard Test Method for Tensile Properties of Yarns by the Single-Strand Method’.
l. ASTM D2397/D2397M, 'Standard Specification for Cationic-Emulsified Asphalt’.
m. ASTM D2419-14, ‘Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate'.
n. ASTM D2950/D2950M-14, ‘Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods'.
o. ASTM D3203/D3203M-11, ‘Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures'.
p. ASTM D3549/D3549M-11, ‘Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens’.
q. ASTM D3665-12, ‘Standard Practice for Random Sampling of Construction Materials’.
r. ASTM D4318-10, ‘Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils'.
s. ASTM D4552/D4552M-10, ‘Standard Practice for Classifying Hot-Mix Recycling Agents'.
t. ASTM D4759-11, ‘Standard Practice for Determining the Specification Conformance of Geosynthetics'.
u. ASTM D4791-10, ‘Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
v. ASTM D5444-15, ‘Standard Method for Mechanical Size Analysis of Extracted Aggregate'.
w. ASTM D5821-13, ‘Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate’.
x. ASTM D6307-10, ‘Standard Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method'.
y. ASTM D6932/D6932M-08(2013), ‘Standard Guide for Materials and Construction of Open-Graded Friction Course Plant Mixtures’.

## 1.3 ADMINISTRATIVE REQUIREMENTS

A. Pre-Installation Conferences:
1. Participate in MANDATORY pre-installation conference as specified in Section 31 0501 ‘Common Earthwork Requirements’:
2. In addition to agenda items specified, review the following:
a. Review surveying and staking of parking areas and installation of sleeves.
b. Review proposed aggregate base schedule.
c. Review rough grading elevations before placing paving fill.
d. Review fine grading elevations of subgrade fine grading operations before placing aggregate base and paving.
e. Review proposed asphalt paving schedule.
f. Review asphalt paving mix design.
g. Review pre-emergent herbicide protection of adjoining property and planting area on site requirements, schedule and application requirements.
h. Review schedule of mandatory asphalt paving surface treatment to be applied after placement of asphalt paving.
i. Review schedule of paint stripes to be applied after asphalt paving surface treatment.
j. Review safety issues.
k. Field Quality Control tests and inspections of this section.
1) Review requirements and frequency of testing and inspections.
2) Review Contractor Testing Agency Qualifications.

B. Scheduling:Notify Testing Agency, Geotechnical Engineer and Architect twenty-four (24) hours minimum before placing asphalt paving.

## 1.4 SUBMITTALS

A. Action Submittals:
1. Product Data:
a. Pre-Emergent Herbicide:
1) Manufacturer's published product data on pre-emergent herbicide.

B. Informational Submittals:
1. Certificates:
a. Require mix plant to furnish delivery/load tickets for each batch of asphalt. Keep delivery tickets at job-site for use of Owner's Representative. Tickets shall show following:
1) Name of mix plant.
2) Date.
3) Name of contractor.
4) Name and location of Project.
5) Serial number of ticket.
6) Asphalt mix type.
7) Time loaded.
8) Identity of truck.
b. Installer to provide Manufacturer's Certificate of Compliance stating material authenticity and properties for review and acceptance by Architect before product use.
2. Design Data:
a. Hot Mix Asphalt:
1) Design Criteria:
a) Develop mix design according to current Asphalt Institute MS-2 'Asphalt Mix Design Methods' for Superpave Method.
b) Submittal format:
(1) Design mix submittal shall follow format as indicated in current Asphalt Institute MS-2, *'Mix Design Methods.*
2) Mix design of asphalt paving must meet Design Criteria minimum requirements and show conformance to the following:
a) Location and name of hot mix asphalt concrete production facility.
b) Date of mix design. If older than two (2) years, recertify mix design.
c) Asphalt mix type.
d) Mix design method used.
e) Mix density.
f) Design air voids (three and one half (3.5) percent.
g) Asphalt content in percent.
h) Performance grade of asphalt binder.
i) Nominal maximum size of aggregate.
j) Maximum size of aggregate.
k) Aggregate source and gradation.
l) Mix properties and design parameters.
m) Temperature of mix at plant and in the field for optimum field compaction.
n) Amount of recycled asphalt pavement (RAP).
o) Mineral fillers, antistrip, and recycle agent percentages.
p) Identify if warm mix technologies will be used and how much warm mix additive will be used.
3) Within thirty (30) days prior to asphalt construction, submit actual design mix to Architect, Civil Engineering Consultant of Record and Independent Testing Laboratory for review and approval.
3. Test and Evaluation Reports:
a. Hot Mix Asphalt:
1) Contractor's Testing Agency copies of Field Test results to show compliance with all contract requirements and quality control for quality of asphalt mixture and asphalt installation.

2) Owner's Testing Agency copies of Field Tests and Inspections used to validate or determine discrepancies with testing by Contractor.

4. Manufacturer Instructions:
   a. Pre-Emergent Herbicide:
      1) Application instructions for pre-emergent herbicide.
5. Qualification Statement:
   a. Installer:
      1) Provide Qualification documentation if requested by Owner's Representative.

C. Closeout Submittals:
1. Include following in Operations and Maintenance Manual specified in Section 01 7800 'Closeout Submittals':
   a. Record Documentation:
      1) Manufacturer's documentation:
         a) Pre-emergent herbicide documentation.
         b) Asphalt paving design.
         c) Test reports.
         d) Certificates from mix plant of delivery/load tickets.
         e) Manufacturer's Certificate of Compliance.
      2) Testing and Inspection Reports:
         a) Testing Agency Testing and Inspecting Reports of asphalt paving.

## 1.5 QUALITY ASSURANCE

A. Qualifications. Requirements of Section 01 4301 'Quality Assurance - Qualifications' applies but not limited to following:
1. Asphalt Paving:
   a. Foreman of asphalt paving crew has completed at least three (3) projects of similar size and nature.
   b. Upon request, submit documentation.
2. Pre-emergent herbicide:
   a. Applicator:
      1) Pre-emergent herbicide shall be applied by applicator certified by State in which Project is located as an applicator of agricultural chemicals.

B. Testing and Inspection:
1. Owner is responsible for Quality Assurance. Quality assurance performed by Owner will be used to validate Quality Control performed by Contractor.
2. Owner will provide Testing and Inspection for asphalt paving:
   a. Owner will employ testing agencies to perform testing and inspection for asphalt paving as specified in Field Quality Control in Part 3 of this specification.
      1) Owner's employment of an independent Testing Agency does not relieve Contractor of Contractor's obligation to perform the Work in strict accordance with requirements of Contract Documents and perform contractor testing and inspection.
      2) See Section 01 1200: 'Multiple Contract Summary'.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:
1. Asphalt Material:
   a. Each shipment must:
      1) Be uniform in appearance and consistency.
      2) Show no foaming when heated to specified loading temperature.
   b. Do not supply shipments contaminated with other asphalt types or grades than those specified:
      1) Do not use petroleum distillate as a release agent.
2. Pre-emergent herbicide:
   a. Materials shall be delivered in original, unopened packages with labels intact.

B. Storage and Handling Requirements:
   1. Pre-emergent herbicide:
      a. Do not freeze. Store in at temperatures above 41 deg F (5 deg C).
      b. Follow Manufacturer's storage and handling requirements.

## 1.7 FIELD CONDITIONS

A. Ambient Conditions:
   1. Pre-emergent herbicide:
      a. Follow printed Manufacturers instruction for environmental hazards:
      b. Follow printed Manufacturers instruction ambient conditions for application of product.
   2. Tack Coat:
      a. Apply only when air and roadbed temperatures in shade are greater than 40 deg F (4.4 deg C). Temperature restrictions may be waived only upon written authorization from Architect or Civil Engineer.
      b. Do not apply to wet surfaces.
      c. Do not apply when weather conditions prevent tack coat from adhering properly.
   3. Asphalt paving:
      a. Do not perform work during following conditions:
         1) Ambient temperature is below 45 deg F (7.2 deg C) or will fall below 45 deg F (7.2 deg C) during placement.
         2) Temperature of aggregate base below 50 deg F (10 deg C).
         3) Cold Weather Asphalt Paving Plan: If asphalt pavement is placed outside of these temperature limits or those identified in MINIMUM Temperature Degrees, a plan is required which includes:
            a) Haul times.
            b) Placement details.
            c) Compaction aids used in production.
            d) Owner does not assume responsibility for asphalt when placed outside temperature limits.
         4) Presence of free surface water or weather is unsuitable.
         5) Wind or ground cools mix material before compaction.

# PART 2 - PRODUCTS

## 2.1 DESIGN CRITERIA

A. General:
   1. Follow current Asphalt Institute MS-2 'Asphalt Mix Design Methods' for Superpave Method.

B. Asphalt Mix:
   1. Asphalt Binder:
      a. Performance Graded Asphalt Binder:
         1) Use performance graded asphalt binder identified under Asphalt Mix Design Criteria.
   2. Aggregates:
      a. Use clean, hard, durable, angular, sound, consisting of crushed stone, crushed gravel, slag, sand, or combination.
      b. Use nominal maximum size aggregate and maximum size aggregate per Asphalt Mix Design Criteria. Aggregate gradation to meet **Table 1** - **MASTER GRADING BANDS** requirements:

| Table 1 - MASTER GRADING BANDS | | | |
|---|---|---|---|
| Sieve (mm) | | Nominal Maximum Aggregate Size | |
| | | 12.5 mm | 9.5 mm |
| Control Sieves | 19 | 100 | - |
| | 12.5 | 100 | 100 |
| | 9.5 | < 90 | 90 – 100 |
| | 4.75 | -- | < 90 |
| | 2.36 | 28 – 58 | 32 – 60 |
| | 0.075 | 2 – 10 | 2 – 10 |
| Restricted Zone | 2.36 | 39.1 | 47.2 |
| | 1.18 | 25.6 – 31.6 | 31.6 – 37.6 |
| | 0.6 | 19.1 – 23.1 | 23.5 – 27.5 |
| | 0.3 | 15.5 | 18.7 |

NOTES:
1. It is assumed fine and coarse aggregate have same bulk specific gravity.
2. Gradation is expressed in percent passing by weight, ASTM C136. Percentage of fines passing 0.075 mm control sieve determined by washing, ASTM C117.

c. Provide aggregate material properties to meet **Table 2 – AGGREGATE PHYSICAL PROPERTIES** requirements:

| Table 2 –AGGREGATE PHYSICAL PROPERTIES | | | | | |
|---|---|---|---|---|---|
| **Property** | | **ASTM** | **ESAL** | **Min** | **Max** |
| **Coarse Aggregate (does not pass No. 4 sieve)** | | | | | |
| Angularity (fractured faces), percent | | D5821 | less than 0.3 | 55 | -- |
| | | | 0.3 to 3.0 | 75 | -- |
| | | | greater than 3.0 | 85/80 | -- |
| Wear (hardness or toughness), percent | | C131/C131M | less than 0.3 | -- | 40 |
| | | | 0.3 to 3.0 | -- | 35 |
| | | | greater than 3.0 | -- | 35 |
| Flats or elongates (3:1 length to width), percent, maximum | | D4791 | -- | -- | 20 |
| **Fine Aggregate (passing No. 4 sieve)** | | | | | |
| Angularity (uncompacted void content), percent (AASHTO T304) | | -- | less than 0.3 | -- | -- |
| | | | 0.3 to 3.0 | 40 | -- |
| | | | greater than 3.0 | 45 | -- |
| Sand equivalent, percent | | D2419 | less than 0.3 | 40 | -- |
| | | | 0.3 to 3.0 | 40 | -- |
| | | | greater than 3.0 | 45 | -- |
| Friable particles, percent | | C142 | -- | -- | 2 |
| Plastic limit, maximum | Liquid limit | D4318 | -- | -- | 25 |
| | Plastic limit | D4318 | -- | -- | 6 |
| Notes:<br>1. ESAL in millions.<br>2. Angularity by weight retained above 9 mm sieve, with at least one fractured face. 85/80 denotes 85 percent coarse aggregate has one fractured face and 80 percent has two or more fractured faces.<br>3. Wear of aggregate retained above 2.36 mm sieve unless specific aggregates have higher values are known to be satisfactory.<br>4. Flats or elongates retained above 4.75 mm sieve.<br>5. Friable particles passing No. 4.75 mm sieve.<br>6. Plasticity, passing No. 4.75 sieve. Aggregate is no-plastic even when filler material is added to aggregate. | | | | | |
| **Blended Physical Properties** | | | | | |
| Dry-rodded unit weight, lb/ft$^3$, minimum | | C29/C29M | - | 75 | -- |
| Weight loss (soundness), percent, maximum | | C88 | | -- | 16 |
| Clay content or cleanliness (sand equivalent), percent | | D2419 | less than 0.3 | 45 | -- |
| | | | more than 0.3 | 60 | -- |
| Notes:<br>1. Weight loss using sodium sulfate.<br>2. Sand equivalent value is after going through dryer or before drum mixer. The sand equivalent requirement is waived for RAP aggregate but applies to remainder of aggregate blend.<br>3. Friable particles of clay lumps, shale, wood, mica, and coal passing 4.75 sieve. | | | | | |

3. Admixture:
   a. Antistrip: Heat stable, cement slurry, lime slurry, dry lime, or liquid antistrip:
      1) Add if mix is moisture sensitive as determined by 'Moisture Susceptibility' paragraph below.
   b. Mineral Filler: Comply with requirements of ASTM D242/D242M.
   c. Recycle Agent: Comply with requirements of ASTM D4552/D4552M.

## 2.2 MATERIAL

A. Aggregate Base: Conform to applicable requirements as specified in Section 31 1123: 'Aggregate Base'.
B. Asphalt Paving Surface Treatment:
   1. Include mandatory Asphalt Paving Surface Treatment to be applied no sooner than thirty (30) days or no later than eighteen (18) months of placing Asphalt Paving to be included with this project:
      a. Asphalt Based Penetrating Seal as specified in Section 32 0113.01 'Asphalt Paving Surface Treatment: Asphalt Based Penetrating Seal'.

C. Pre-Emergent Herbicide:
   1. Design Criteria:
      a. Selective type pre-emergence control chemical containing forty (40) percent Trifluralin minimum for control of annual grasses and broadleaf weeds.
      b. Non-oil based sterilant.
      c. Labeled for under-pavement use.
   2. Type Two Acceptable Products:
      a. Treflan E.C. by Monterey AgResources, Fresno, CA www.montereyagresources.com (available in western United States).
      b. Trust 4EC by WinField Solutions LLC (Agrilsolutions), St Paul, MN www.agrisolutionsinfo.com (available in United States).
      c. Equal as approved by Architect before installation. See Section 01 6200.

D. Reclaimed Asphalt Pavement (RAP). Aggregate: Restrictions include:
   1. Allowed up to 25 percent. Asphalt binder shall be one grade softer when more than 15 percent RAP is used.

E. Tack Coat:
   1. Emulsified asphalt meeting requirements of ASTM D977, Grade SS-1H, CQS-1H, or ASTM D2397/D2397M, Grade CSS-1H.

# PART 3 - EXECUTION

## 3.1 INSTALLERS

A. Approved Applicators.

## 3.2 PREPARATION

A. General:
   1. Aggregate base and paving must be placed before any moisture or seasonal changes occur to subgrade that would cause compaction tests previously performed to be erroneous. Re-compact and retest subgrade soils that have been left exposed to weather.

B. Protection In-Place Conditions:
   1. Pre-emergent herbicide:
      a. Take necessary precautions to protect adjoining property and areas designated for planting on building site.
      b. Do not contaminate any body of water by direct application, cleaning of equipment or disposal of wastes.
   2. Asphalt Paving:
      a. Protect all structures, including curb, gutter, sidewalks, guard rails and guideposts.
      b. Protect neighborhood, storm drains and down-stream fish habitat.

C. Surface Preparation:
   1. Survey and stake parking surfaces to show grading required by Contract Documents.

2. Subgrade (soil below aggregate base):
    a. Prepare natural soil subgrade as specified in Section 31 2213 'Rough Grading' or prepare fill subgrade as described in Section 31 2216 'Fine Grading'.
3. Aggregate base:
    a. Finish grade parking surface area to grades required by Contract Documents.
    b. Compact aggregate base as specified in Geotechnical Report date May 30, 2018 by Patel and Associates, Inc..
    c. Tolerances:
        1) Elevation of aggregate base shall be 0.00 inches (0.00 mm) high and no more than 1/2 inch (12.7 mm) low.
        2) Measure using string line from curb to curb, gutter, flat drainage structure, or grade break.
4. Tack coat:
    a. Clean surface of all materials such as mud, dirt, leaves, etc. that prevent tack from bonding to existing surfaces.
        1) If flushed, allow surface to dry.
5. Asphalt paving:
    a. Area shall be clean and tack coat applied before placing of asphalt paving.
        1) Remove all moisture, dirt, sand, leaves, and other objectionable material from prepared surface before placing asphalt.
        2) Locate, reference, and protect all utility covers, monuments, curb, and gutter and other components affected by asphalt paving operations.
        3) Allow sufficient cure time for tack coat before placing asphalt.

## 3.3 APPLICATION

A. Interface with Other Work:
    1. Section 31 2213: 'Rough Grading' for rough grading and preparation of natural soil subgrades below fill and aggregate base materials.
    2. Section 31 2216: 'Fine Grading' for grading of subgrade below aggregate base and topsoil.
    3. Section 31 2323: 'Fill' for compaction procedures and tolerances.

B. Pre-Emergent Herbicide:
    1. Asphalt paving areas:
        a. Follow Manufacturer's printed application requirements:
        b. Apply to prepared subgrade dispersed in liquid. Concentrate shall be such that Manufacturer's full recommended amount of chemical will be applied to every 1000 sq ft (93 sq m) and liquid will penetrate minimum of 2 inches (50 mm).
        c. Application shall be no more than one (1) day before installation of aggregate base.

C. Tack Coat:
    1. General:
        a. Tack coat vertical surfaces or existing asphalt cement concrete or portland cement concrete that will be in contact with asphalt paving.
        b. Use tack coat diluted to a 2:1 (concentrate water) ratio.
        c. Use pressure distributor to apply in uniform, continuous spread.
        d. Cover all tacked surface areas with surfacing materials same day of application.
    2. Application rate. Typically, as follows:
        a. Emulsions, 0.08 to 0.15 gallons per sq yd (0.303 to 0.679 L per sq m) of diluted material:
            1) Apply sufficient to achieve ninety-five (95) percent or better coverage of existing surfaces.
            2) Above application rates may vary according to field conditions. Obtain approval from Civil Engineer for quantities, rate of application, temperatures, and areas to be treated before any application.

D. Asphalt Paving:
    1. General:
        a. Paving adjacent to cast-in-place concrete site elements shall be between 1/4 inch (6 mm) higher than concrete.

b. Surface texture of hand worked areas shall match texture of machine-laid areas.
c. Surface shall be uniform with no 'birdbaths'. Leave finished surfaces clean and smooth. Variations from specified grades shall not exceed 1/2 inch (12.7 mm).
d. Cross Slope: 1/4 inch (6 mm) in 10 feet (3.0 m) perpendicular to centerline except at cross section grade breaks.
e. Grade: 1/8 inch (3 mm) in 10 feet (3.0 m) parallel to centerline.
f. Do not place on frozen aggregate base or during adverse climatic conditions such as precipitation or when roadway surface is icy or wet.
g. Uniformly mix materials so aggregate is thoroughly coated with asphalt.
h. Place at temperatures established by the mix design with self-propelled laydown machine.
i. Use **Table 3 – MINIMUM TEMPERATURE, DEGREES** as guide:

**Table 3 – MINIMUM TEMPERATURE, DEGREES**

| Ambient Air Temperature Deg F. | Ambient Air Temperature Deg C. | Compacted Paving Mat Thickness | | | | | |
|---|---|---|---|---|---|---|---|
| | | 3/4" (19 mm) | 1" (25 mm) | 1 1/2" (38 mm) | 2" (50 mm) | 3" (75 mm) | 4" + (100 mm) + |
| 45 – 50 | 7 – 10 | --- | --- | --- | --- | 280 | 265 |
| 50 – 59 | 10 – 15 | --- | --- | --- | 280 | 270 | 255 |
| 60 – 69 | 16 – 20 | --- | --- | 285 | 275 | 265 | 250 |
| 70 – 79 | 21 – 79 | 285 | 285 | 280 | 270 | 265 | 250 |
| 80 - 89 | 27 - 31 | 280 | 275 | 270 | 265 | 260 | 250 |
| 90+ | 32+ | 275 | 270 | 265 | 260 | 250 | 250 |

j. Longitudinal bituminous joints shall be vertical and properly tack coated if cold. Transverse joints shall always be tack coated.

2. Compaction:
a. Compact asphalt paving to ninety-four (94) percent plus or minus two (2) percent of theoretical maximum specific gravity, ASTM D2041/D2041M (Rice Method - maximum theoretical density).
b. Roll with powered equipment capable of obtaining specified density while providing required smoothness.
c. Begin breakdown rolling immediately after asphalt is placed when asphalt temperature is at maximum.
d. Complete handwork compaction concurrently with breakdown rolling.
e. Execute compaction so visibility of joints is minimized:
f. Complete finish rolling to improve asphalt surface as soon as possible after intermediate rolling and while asphalt paving is still warm.
g. Do not use vibration for finish rolling.

3. Lift Thickness:
a. Preferred Method:
1) For pavements 3-1/2 inch (89 mm) or thinner apply asphalt paving in single lift.
2) For pavements greater than 3-1/2 inch (89 mm), use alternate method below.
b. Alternate Method:
1) Asphalt paving may be applied in two (2) lifts, first 2 inches (50 mm) thick minimum and second 1 1/2 inches (38 mm) thick minimum following temperature recommendations of following paragraph.
2) Surface of first lift shall be clean and provide tack coat between first and second lifts.
3) Provide not less than two (2) times maximum aggregate size in compacted asphalt concrete mixes.

E. Asphalt Paving Surface Treatments:
1. Apply mandatory Asphalt Paving Surface Treatment no sooner than thirty (30) days or no later than eighteen (60) days of placing Asphalt Paving to be included with this project. Do not apply prior to asphalt curing (refer to 'Asphalt, Concrete and Pervious Concrete Maintenance Guidelines'):

F. Paint Stripes:

1. Apply paint stripes per section after asphalt paving surface treatment has been applied to asphalt paving.

## 3.4 FIELD QUALITY CONTROL

A. Field Tests and Inspections:
   1. Civil and structural field tests, laboratory testing, and inspections are provided by Owner's independent Testing Agency:
      a. Quality Control is sole responsibility of Contractor:
         1) Owner's employment of an independent Testing Agency does not relieve Contractor of Contractor's obligation to perform testing and inspection as part of his Quality Control:
            a) Testing and inspections will be responsibility of Contractor to be performed by an independent entity.
         2) Contractor bears full responsible for compliance with all contract requirements and quality control on project and will be responsible for quality of asphalt mixture and asphalt installation.

B. Field Tests (Provided by Contractor):
   1. General:
      a. Contractor bears full responsibility for compliance with all contract requirements and quality control on project and will be responsible for quality of asphalt mixture and asphalt installation.
      b. Testing and Inspection Reports to be distributed as specified in Section 01 4523 'Testing And Inspection Services'.
   2. Compaction Tests:
      a. Contractor to provide compaction tests of asphalt being placed to establish rolling patterns and installation procedures.
      b. Compaction tests by Contractor are independent of compaction tests being provided by Owner.
      c. Asphalt paving shall be compacted to ninety-four (94) percent of Theoretical Maximum Specific Gravity (Rice) plus three (3) percent or minus two (2) percent. Determine percent compaction by ASTM D2041/D2041M.
   3. Thickness Tests:
      a. Determine thickness of paving being placed, no less than one (1) test per 10,000 sq. ft. (930 sq. m) of paving or portion thereof, three (3) tests minimum.

C. Field Tests and Inspections (Provided by Owner):
   1. General:
      a. Compaction tests provided by Owner will be used to validate or determine discrepancies with testing by Contractor.
      b. Civil engineer applies pay factor for Gradation/Asphalt Content, In-Place Density. Civil engineer computes pay factor for each lot.
      c. Opening paved surface to traffic does not constitute acceptance.
      d. Unless required by the Owner's Representative, Testing Agency is to base compaction testing on Contractor's submitted mix design for theoretical maximum specific gravity (Rice) or Marshall specific gravity (Bulk) values.
      e. Asphalt-aggregate mix sampling as per ASTM D979/D979M.
         1) Test for:
            a) Air voids as per ASTM D3203/D3203M.
            b) Asphalt binder content as per ASTM D6307.
            c) Aggregate gradation as per ASTM D5444.
      f. Lot size: 10,000 sq. ft. (930 sq. m) or part thereof.
      g. Sub lot size: 5,000 sq. ft. (465 sq. m) or part thereof.
   2. At Site Testing and Inspection:
      a. Asphalt Paving:
         1) Testing Agency shall provide full time nuclear density testing and inspection for asphalt paving during asphalt paving operations (nuclear density testing is informational testing only and does not constitute acceptance by Owner).
         2) Inspection to include:

a) Aggregate coating.
b) Compaction control and effort required.
c) Suitability of spreading and asphalt paving equipment.
d) Temperature of mix as delivered and placed.
(1) Reject mixes exceeding 325 deg F (163 deg C) in transport vehicle as required in Non-Conforming Work below.
(2) Dispose of cold mix in paver hopper as thin spread underlay.

3) Field Tests:
a) When tested with 10 foot (3 meter) straight edge, surface of completed work shall not contain irregularities in excess of 1/4 inch (6 mm).
b) Determine percent compaction per ASTM D2950/D2950M unless other nondestructive nonnuclear methods such as sonar are used.
c) Provide written nuclear density testing, or other nondestructive nonnuclear methods such as sonar, of asphalt paving at minimum rate of one (1) per 2,500 sq. ft. (232 sq. m). Select test locations by ASTM D3665 and sample per ASTM D979/D979M before compaction. Minimum of three (3) tests required.
d) Compact asphalt paving to ninety-four (94) percent of Theoretical Maximum Specific Gravity (Rice) plus three (3) percent or minus two (2) percent.
e) Maximum average total air voids in completed hot mix asphalt shall be eight (8) percent but more than three (3) percent as determined by ASTM D2041/D2041M.
f) Determine thickness of paving being placed, no less than one (1) test per 10,000 sq. ft. (930 sq. m) of paving or portion thereof, three (3) tests minimum.

3. At Laboratory Testing:
a. General:
1) Provide at least one (1) laboratory test series for every 10,000 sq. ft. (930 sq. m) or part thereof (minimum of one (1) test):
a) Test reports will show compliance with Contract Documents regarding type and depth of aggregate base, depth and density of asphalt paving, asphalt content, aggregate gradation, flow and stability, bulk specific gravity and maximum specific gravity.
b) Reports will also give test procedures used by testing laboratory.

b. Compaction and Final Density:
1) Pavement thickness and final density to be determined by results of coring. Provide one (1) core per 10,000 sq. ft. (930 sq. m) or part thereof. Minimum of three (3) tests required if under 30,000 sq. ft. (2 787 sq. m).
a) Based upon core samples, compaction is acceptable if test deviations are within pay factor 1.00 limits.
b) At Project Manager's discretion, after consulting with Design Team, a Lot with a sub-lot test deviation greater than Reject may stay in place at fifty (50) percent cost.
c) Select test locations by ASTM D3665 and sample per ASTM D979/D979M after compaction.

c. Compaction Pay Factor:
1) Based upon core samples, compaction is acceptable if test deviations are within pay factor 1.00 limits.
2) At Project Manager's discretion, after consulting with design team, a Lot with a sub-lot test deviation greater than Reject may stay in place at fifty (50) percent cost.
3) Average Density, in percent as shown in **Table 4 – COMPACTION PAY FACTORS**:

| Table 4 – COMPACTION PAY FACTORS<br>(94 percent of theoretical maximum specific gravity – Superpave (Rice)<br>(ASTM D2041/D2041M plus three (3) or minus two (2) percent) | | |
|---|---|---|
| Pay Factor | Density, in Percent | |
| | Average | Lowest Test |
| 0.70 | More than 96 | --- |
| 1.00 | 92 to 96 | 89 or Greater |
| 0.90 | 92 to 96 | Less than 89 |
| Reject | Less than 92 | --- |

Notes:
1. At Contractor's discretion and expense, do Hamburg wheel track test (AASHTO T 304) on 3 additional random core samples from non-complying sub-lot of 5,000 sq. ft. (465 sq. m). Sub-lot will be accepted if average rut depth is less than 10 mm at 20,000 passes.

d. Pavement Thickness:
   1) Pavement thickness and final density to be determined by results of coring. Provide one (1) core per 10,000 sq. ft. (930 sq. m) or part thereof. Minimum of three (3) tests required if under 30,000 sq. ft. (2 787 sq. m).
      a) Acceptance will be based on the average of all thickness tests.
      b) At Project Manager's discretion, after consulting with design team, payment may be made for areas deficient in thickness by more than 0.75 inches (19.05 mm) at fifty (50) percent. If not, remove and replace at no additional cost to the Owner as shown in **Table 5 – THICKNESS PAY FACTORS**:

| Table 5 – THICKNESS PAY FACTORS | |
|---|---|
| Pay Factors | Thickness Deficiency, in Inches<br>(ASTM D3549/D3549M) |
| 1.00 | 0.00 to 0.25 |
| 0.90 | 0.26 to 0.50 |
| 0.70 | 0.51 to 0.75 |
| Reject | 0.76 to 1.00 |

e. Air Voids:
   1) Basis of evaluation is laboratory compacted samples (not field compacted samples).
   2) Air voids will be mix design target plus or minus one (1) percent.
   3) If test results are not within this Section's limits, options include correction of production procedures or alternate mix design acceptable to Civil Engineer.

D. Non-Conforming Work: Non-conforming work as covered in the General Conditions applies, but is not limited to the following:
   1. Asphalt Paving:
      a. Deficient asphalt paving thickness:
         1) Place additional material over deficient areas. Do not skin patch. Mill for inlay if necessary. Correct deficient asphalt paving thickness at no additional cost to the Owner.
      b. Rejection and Removal of Asphalt Paving:
         1) Remove asphalt paving found defective after installation and install acceptable product at no additional cost to the Owner.
      c. Removal of Asphalt Paving:
         1) Remove spatter, over-coat, or mar at no additional cost to the Owner.
         2) Remove asphalt from borrow pits or gutters at no additional cost to the Owner.
      d. Repair of Asphalt Paving:

1) Repair or replace defective joints, seams, edges at no additional cost to the Owner.

## 3.5 PROTECTION

A. Tack Coat:
   1. Protect all surfaces exposed to public view from being spattered or marred. Remove any spattering, over-coating, or marring at no additional cost to Owner.
   2. Traffic:
      a. Do not permit traffic to travel over tacked surface until tack coat has cured and dried.

B. Asphalt Paving:
   1. Protect hot mixed asphalt (HMA) pavement from traffic until mixture has cooled enough not to become marked.

## 3.6 CLEANING

A. Waste Management:
   1. Pre-emergent herbicide:
      a. Follow Manufacturer's recommendations for disposal of product at approved waste disposal facility.
         1) Do not reuse empty containers.

**END OF SECTION**

**SECTION 32 1313**

**CONCRETE PAVING**

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Includes but Not Limited To:
   1. Prepare pavement subgrade and aggregate base as described in Contract Documents to receive concrete paving.
   2. Furnish and install pavement aggregate base as described in Contract Documents.
   3. Furnish and install Portland cement concrete paving, control joints and expansion joints as described in Contract Documents.

B. Related Requirements:
   1. Section 03 2116: 'Epoxy-Coated Reinforcement Steel Bars.
   2. Section 03 3111: 'Cast-In-Place Structural Concrete' for:
      a. Mix Type concrete mixes and admixtures.
      b. Field Quality Control Testing and Inspection requirements for concrete.
      c. Membrane Concrete Curing application.
      d. Water Concrete Curing application.
      e. Pre-installation conference held jointly with other concrete specifications.
   3. Section 03 3517: 'Concrete Sealer Finishing' for application in areas exposed to freeze/thaw cycles and deicing salts.
   4. Section 03 3913: ''Water Concrete Curing' for quality of curing materials used.
   5. Section 03 3923: 'Membrane Concrete Curing' for quality of curing materials used.
   6. Section 07 9213: 'Elastomeric Joint Sealants' for quality of joint sealants including other contractual and installation requirements.
   7. Section 31 0501: 'Common Earthwork Requirements' for:
      a. General procedures and requirements for earthwork.
      b. Pre-installation conference held jointly with other common earthwork related sections.
   8. Section 31 1123: 'Aggregate Base' for compaction of aggregate base.
   9. Section 31 2213: 'Rough Grading' for grading requirements and preparation of natural soil subgrades below fill and aggregate base materials.
   10. Section 31 2216: 'Fine Grading' for grading of subgrade below aggregate base and topsoil.
   11. Section 31 2323: 'Fill' for compaction procedures and tolerances.

### 1.2 REFERENCES

A. Association Publications:
   1. American Concrete Institute, Farmington Hills, MI www.concrete.org. Abstracts of ACI Periodicals and Publications.
      a. ACI 330R-13, '*Guide for the Design and Construction of Concrete Parking Lots'.*
      b. Certifications:
         1) ACI CP-1(13), *'Technical Workbook for ACI Certification of Concrete Field Testing Technician-Grade 1*'.
         2) ACI CP-10(10), *'Craftsman Workbook for ACI Certification of Concrete Flatwork Technician/Finisher'*.
         3) ACI CP-19(13), *'Technical Workbook for ACI Certification of Concrete Strength Testing Technician'*.
         4) ACI CP-43(11), *'Technical Workbook for ACI Certification of Aggregate Base Testing Technician'*.

B. Definitions:

1. Cold Weather, as referred to in this Section, is four (4) hours with ambient temperature below 40 deg F (4.4 deg C) in twenty-four (24) hour period.
2. Hot Weather, as referred to in this Section, is ambient air temperature above 100 deg F (38 deg C) or ambient air temperature above 90 deg F (32 deg C) with wind velocity 8 mph (12.9 kph) or greater.

C. Reference Standards:
1. American Concrete Institute:
   a. ACI 301-10, 'Specification for Structural Concrete'.
   b. ACI 305.1-14, 'Specification for Hot Weather Concreting'.
   c. ACI 306.1-90 (R2002), 'Standard Specification for Cold Weather Concreting'.
2. American Association of State and Highway Transportation Officials:
   a. AASHTO M 153-06 (2011), 'Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction'.
3. ASTM International:
   a. ASTM C39/C39M-17a, 'Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens'.
   b. ASTM C78/C78M-16, 'Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)'.
   c. ASTM C94/C94M-17, 'Standard Specification for Ready-Mixed Concrete'.
   d. ASTM D1752-04a(2013), 'Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction'.
   e. ASTM D3549/D3549-11, 'Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens'.
4. California Building Code (CBC):
   a. Chapter 17, 'Structural Tests and Special Inspections' (2016 or latest approved edition).

## 1.3 ADMINISTRATIVE REQUIREMENTS

A. Pre-Installation Conferences:
1. Participate in MANDATORY pre-installation conference:
   a. In addition to agenda items review following:
      1) Review placement, finishing, and curing of concrete including cold and hot weather requirements.
      2) Review approved mix design and use of admixtures requirements.
      3) Review concrete joint layout and joint sealant requirements.
      4) Review Section 01 4523 for Testing and Inspection administrative requirements and responsibilities and Field Quality Control tests and inspections required of this section.
         a) Review frequency of testing and inspections.
2. Participate in pre-installation conference:
   a. In addition to agenda items specified review following:
      1) Review surveying and staking of parking areas and installation of sleeves.
      2) Review fill and compaction requirements.
      3) Review proposed aggregate base schedule.
      4) Review rough grading elevations before placing paving fill.
      5) Review fine grading elevations of subgrade before placing aggregate base and paving.
      6) Review Section 01 4523 for Testing and Inspection administrative requirements and responsibilities and Field Quality Control tests and inspections required of this section.
         a) Review frequency of testing and inspections.

B. Scheduling:
1. Notify Testing Agency, Geotechnical Engineer and Architect twenty-four (24) hours minimum before aggregate base.
2. Notify Testing Agency Geotechnical Engineer and Architect twenty-four (24) hours minimum before placing concrete paving.

## 1.4 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings:
      a. Joint layout plan for written approval before starting work on this Section.

B. Informational Submittals:
   1. Certificates:
      a. Installers:
         1) Certification for National Ready Mixed Concrete Association (NRMCA).
         2) Certification for ACI-certified Flatwork Finishers and Technicians.
   2. Design Data:
      a. Mix Design:
         1) Furnish proposed mix design to Architect for review prior to commencement of Work.
            a) Mix design shall show proposed admixtures, amount, usage instructions, and justification for proposed use.
      b. Ready-Mix Supplier:
         1) Require mix plant to furnish delivery ticket for each batch of concrete. Keep delivery tickets at job-site for use of Owner or his representatives. Tickets shall show following:
            a) Name of ready-mix batch plant.
            b) Serial number of ticket.
            c) Date and truck number.
            d) Name of Contractor.
            e) Name and location of Project.
            f) Specific class or designation of concrete conforming to that used in Contract Documents.
            g) Amount of concrete.
            h) Amount and type of cement.
            i) Total water content allowed by mix design.
            j) Amount of water added at plant.
            k) Sizes and weights of sand and aggregate.
            l) Time loaded.
            m) Type, name, manufacturer, and amount of admixtures used.
            n) Design Data.
         2) Provide certificates with supporting testing reports verifying compliance with Contract Document requirements and that materials provided are from single source for following:
            a) Cement.
            b) Aggregate.
            c) Fly Ash.
   3. Source Quality Control Submittals:
      a. Concrete mix design. See Section 03 3111 ‘Normal Weight Structural Concrete’ for mix type submittal.
   4. Special Procedure Submittals:
      a. Curing plan.

C. Closeout Submittals:
   1. Include following in Operations and Maintenance Manual specified in Section 01 7800:
      a. Record Documentation:
         1) Testing and Inspection Reports:
            a) Testing Agency Testing and Inspecting Reports of concrete paving.

## 1.5 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Concrete paving to be installed in strict accordance with original design in accordance with all pertinent codes and regulations and all pertinent portions of Reference Standards.
   2. Obtain all necessary permits and permission to work in public right-of-ways.
   3. All equipment shall conform to all local and state regulations.

B. Qualifications: Requirements of Section 01 4301 applies, but is not limited to following:
   1. Installers and Installation Supervisor:
      a. ACI-certified Flatwork Finishers and Technicians.
   2. Ready-Mix Supplier:
      a. Comply with ASTM C94/C94M requirements and be certified according to NRMCA's 'Certification of Ready Mixed Concrete Production Facilities.'
   3. Testing Agencies:
      a. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technicians, Grade I.
      b. Personnel performing laboratory tests shall be ACI-certified Laboratory Testing Technicians, Grade I, and laboratory supervisor shall be ACI-certified Laboratory Testing Technician, Grade II.

C. Testing and Inspection:
   1. Owner will provide Testing and Inspection for concrete paving:
      a. Owner will employ testing agencies to perform testing and inspection for concrete paving as specified in Field Quality Control in Part 3 of this specification.
         1) Owner's employment of an independent Testing Agency does not relieve Contractor of Contractor's obligation to perform the Work in strict accordance with requirements of Contract Documents and perform contractor testing and inspection.
         2) See Section 01 1200: 'Multiple Contract Summary'.
      b. Owner's employment of an independent Testing Agency does not relieve Contractor of Contractor's obligation to perform testing and inspection as part of his Quality Control.
         1) Testing and inspections, if performed by Contractor, will be responsibility of Contractor to be performed by an independent entity.

## 1.6 FIELD CONDITIONS

A. Ambient Conditions:
   1. Cold Weather Limitations:
      a. Follow requirements of ACI 306 for cold weather concreting.
   2. Hot Weather Limitations:
      a. Follow requirements of ACI 305 for hot weather concreting.
   3. Do not perform work during unfavorable conditions as specified below:
      a. Presence of free surface water.
      b. Over-saturated aggregate base and subgrade materials.

# PART 2 - PRODUCTS

## 2.1 MATERIALS

A. Design Criteria:
   1. Design life of concrete paving system to be forty (40) years minimum.
   2. Aggregate: Conform to applicable requirements as specified in Section 03 3111 for concrete aggregate.
   3. Concrete: Conform to applicable requirements as specified in Section 03 3111 for mix type concrete mix and admixtures.
   4. Concrete curb and gutter shall be of type and size as shown on Contract Drawings.
   5. Provide wet cut control joints at spaces indicated on Contract Drawings.

B. Aggregate Base per Geotechnical Report dated May 30 2019 by Patel & Associates, Inc.

C. Control Joint Filler Material:
   1. As specified in Section 07 9213 'Elastomeric Joint Sealants'.

D. Expansion Filler Material:

1. Recycled PVC Joint Filler:
    a. Design Criteria:
        1) Expansion joint filler manufactured from 100 percent recycled vinyl material meeting requirements of ASTM D1752 and AASHTO M 153.
        2) 1/2 inch (12.7 mm) thick.
        3) Compressive/Recovery:
            a) Meet requirements for ASTM D1752 recover minimum of 90 percent of original thickness.
        4) Light gray color.
    b. Type One Approved Products:
        1) Proflex by Oscoda Plastics Inc, Oscoda, MI www.oscodaplastics.com.
        2) Equal as approved by Architect before bidding. See Section 01 6200.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions:
1. Inspect installed work of all other trades and verify that work is complete where installation of concrete paving may properly commence.
2. Verify elevations of rough grading are correct before paving aggregate base and paving are placed.
3. Verify grades of existing pavements at connection locations.
4. Notify Architect of unsuitable conditions or discrepancies in writing.
5. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.
6. Subgrade preparation may not begin until all utilities have been installed, including underground lighting and sprinkler systems.

### 3.2 PREPARATION

A. Barricades:
1. Provide all necessary barricading.

B. Surface Preparation:
1. Survey and stake parking surfaces to show grading required by Contract Documents.
2. Subgrade (soil below aggregate base):
    a. Prepare natural soil subgrade as specified in Section 31 2213 'Rough Grading' or prepare fill subgrade as described in Section 31 2216 'Fine Grading'.
3. Aggregate base:
    a. Finish grade parking surface area to grades required by Contract Documents.
    b. Compact aggregate base as specified in Section 31 1123.
    c. Tolerance:
        1) Aggregate base:
            a) Elevation of aggregate base shall be no more than 1/4 inch (6.4 mm) above or 1/2 inch (12.7 mm) below the design grade.
            b) Measure using string line from curb to curb, gutter, flat drainage structure, or grade break.

### 3.3 INSTALLATION

A. Interface with Other Work:
1. Section 31 2213: 'Rough Grading' for rough grading and preparation of natural soil subgrades below fill and aggregate base materials.
2. Section 31 2216: 'Fine Grading' for grading of subgrade below aggregate base and topsoil.

3. Section 31 2323: 'Fill' for compaction procedures and tolerances.

B. Paving Forming:
   1. Forms shall be cleaned and oiled each time they are used.
   2. Sufficient forms shall be provided so that they may remain in place twelve (12) hours or longer after concrete has been placed.
   3. Forms shall be secured to resist pressure of concrete and any finishing equipment riding on them without springing or settlement.
   4. Joint forms neatly and tightly and securely pinned and staked to line and elevation shown.
   5. Staked form lines shall be inspected and approved in advance of placing concrete.

C. Manholes And Valves:
   1. Adjust manholes and valves in areas of concrete paving after forms have been set.

D. Paving Placement:
   1. Place, strike off, and consolidate concrete with mechanical finishing machine or vibrating screed.
      a. Hand finishing methods may be used if approved by Architect.
      b. If screed is used, carry 2 inches (50 mm) of concrete minimum in front of screed for full width of pavement.
      c. Concrete may also be placed with slipform paver designed to spread, consolidate, screed, and float-finish concrete in one pass.
      d. When paving is being laid contiguous to previously finished concrete of the same finish grade elevation or contiguous to previously finished curb, such concrete or curb may be made to serve as side forms and as guide for implements for striking, tamping, and finishing.
   2. Bull float surface with magnesium float immediately after screeding:
      a. Steel tools are not allowed.
      b. Surface of concrete must remain open to allow bleed water to pass.
   3. Finish float surface with magnesium or wood float after bleed water has evaporated:
      a. Steel tools are not allowed.
   4. Finish: Skid-resistant finish made with burlap drag or broom:
      a. Do not finish water into top surface trapping bleed water prior to bleed water evaporating.
   5. Curing:
      a. Apply product as specified in Section 03 3923' Membrane Concrete Curing' to concrete paving:
      b. Apply Concrete Sealer Finishing to exterior concrete placed after about September 1st and located in areas exposed to freeze/thaw cycles and deicing salts.
         1) See Section 03 3517 'Concrete Sealer Finishing' for options available.
   6. Joints:
      a. Control:
         1) Depth shall be 1/4 slab thickness except 1 inch (25 mm) is acceptable when using early entry saws (soft cut):
            a) Use 1/10 inch (2.54 mm) to 3/16 inch (4.76 mm) for unsealed joints.
            b) Use 1/8 inch (3 mm) to 1/4 inch (6.4 mm) for sealed joints.
         2) Complete before shrinkage cracking occurs.
         3) Make continuous across slab unless interrupted by expansion joint. Extend through adjoining curbs, gutters, and sidewalks.
         4) Space not more than 30 times thickness of slab up to maximum of 12-1/2 feet (3.8 meters) apart in any direction.
         5) Control Jointing Methods:
            a) Sawing: Begin sawing joints as soon as concrete has hardened enough to permit sawing without raveling.
            b) Hand-Formed: Maximum edge radius shall be 1/4 inch (6 mm).
            c) Pre-molded joint former.
         6) Seal control joints.
         7) Use to isolate fixed objects abutting or within paved area. Joints shall contain pre-molded joint filler for full depth of slab.
         8) Do not use expansion joints along face of curb and gutter.
         9) Clean and seal before opening parking area to traffic.

E. Tolerances:

1. Paving thickness is shown on Contract Drawings.

## 3.4 FIELD QUALITY CONTROL

A. Field Tests and Inspections:
   1. General:
      a. Owner is responsible for Quality Assurance. Quality assurance performed by Owner will be used to validate Quality Control performed by Contractor.
      b. Quality Control is sole responsibility of Contractor as specified in Section 01 4523 'Testing And Inspection Services'.
   2. Concrete Paving:
      a. Testing Agency shall provide testing and inspection for 'Concrete Paving' as specified in Section 03 3111 'Normal Weight Structural Concrete' in Part 3 Field Quality Control for concrete paving.

B. Non-Conforming Work: Non-conforming work as covered in the General Conditions applies, but is not limited to the following:
   1. Rejection and Removal of Concrete Paving:
      a. Reject concrete paving that does not meet requirements of Section 03 3111.
      b. Remove concrete paving found defective after installation and install acceptable product at no additional cost to the Owner.
   2. Acceptance:
      a. General:
         1) Opening paved surface to traffic does not constitute acceptance.
      b. Strength:
         1) General:
            a) Lot is acceptable if strength test deviations are within Pay Factor 1.00 limits.
            b) At Project Manager's discretion, after consulting with design team, a Lot with test deviation greater than Reject may stay in place at 50% cost.
         2) Compression: ASTM C39/C39M. Lot size - 5,000 sq. ft. (465 sq. m):
            a) Pay Factor:
               (1) 1.00 for 0 psi (0 kPA) below 28 day compressive strength required.
               (2) 0.90 for 1 psi (6.895 kPA) to 100 psi (690 kPA) below 28 day compressive strength required.
               (3) 0.80 for 101 psi (0.96 MPa) to 200 psi (1.38 MPa) below 28 day compressive strength required.
               (4) 0.70 for 201 psi (1.39 MPa) to 300 psi (2.07 MPa) below 28 day compressive strength required.
               (5) 0.60 for 301 psi (2.08 MPa) to 400 psi (2.75 MPa) below 28 day compressive strength required.
               (6) Reject for 401 psi (2.76 MPa) or more below 28 day compressive strength required.
         3) Flexural: ASTM C78/C78M. Lot size - 5,000 sq. ft. (465 sq. m):
            a) Pay Factor:
               (1) 1.00 for 0 psi (0 kPA) less than 28 day flexural strength required.
               (2) 0.95 for 1 psi (6.895 kPA) to 29 psi (200 kPA) below 28 day flexural strength required.
               (3) 0.85 for 30 psi (207 kPA) to 60 psi (415 kPA) below 28 day flexural strength required.
               (4) Reject for 61 psi (420 kPA) or more below 28 day flexural strength required.
      c. Thickness:
         1) General:
            a) At Project Manager's discretion, after consulting with design team, payment may be made for areas deficient in thickness by more than 1 inch (25.4 mm) at 50 percent. If not, remove and replace at no additional cost to the Owner.
         2) Paving thickness shall be as indicated in Tolerances above.
         3) Grade: 1/8 inch (3.175 mm) in 10 foot (3 meter) parallel to centerline.
         4) Cross Slope: 1/4 inch (6.35 mm) in 10 foot (3 meter) perpendicular to centerline except at cross section grade breaks.

5) Thickness will be determined on ASTM D3549/D3549 cored or sawed specimens. Acceptance will be based on the average of all Lot thickness tests:
   a) Pay Factor:
      (1) 1.00 for 0.00 inches (0.00 mm) to 0.25 inches (6.35 mm) less than specified thickness.
      (2) 0.90 for 0.26 inch (6.60 mm) to 0.50 inches (12.70 mm) less than specified thickness.
      (3) 0.70 for 0.51 inches (12.95 mm) to 0.75 inches (19.05 mm) less than specified thickness.
      (4) 0.50 for 0.76 inches (19.30 mm) to 1.00 inches (25.4 mm) less than specified thickness.
6) When thickness measurement is less than specified by more than 1 inch (25.4 mm), actual thickness of pavement will be determined by taking additional cores at intervals less than 10 foot (3 meter) parallel to centerline in each direction from affected location, until in each direction core is found which is not deficient by more than 1 inch (25.4 mm). Exploratory cores for deficient thickness will not be used in averages for price adjustments.

## 3.5 PROTECTION

A. Traffic:
   1. Do not open pavement to traffic for three (3) days or until concrete reaches compressive strength of 1800 psi (12.4 MPa) minimum, whichever is longer.
   2. Restrict traffic to passenger cars and light trucks for seven (7) days.
   3. In all cases, obtain approval from Architect before allowing access to parking area by traffic.

**END OF SECTION**

**SECTION 32 1723**

**PAVEMENT MARKINGS**

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Includes But Not Limited To:
   1. Furnish acrylic paint and apply pavement and curb markings as described in Contract Documents including:

### 1.2 REFERENCES

A. Reference Standards:
   1. Federal Specifications and Standards:
      a. FED-STD-595C, 'Federal Standard: Colors Used in Government Procurement' (16 Jan 2008).
      b. FED TT-P-1952F, 'Paint, Traffic and Airfield Marking, Waterborne' (17 Feb 2015).
   2. U.S. Department of Transportation Federal Highway Administration:
      a. FHWA MUTCD-10, 'Manual on Uniform Traffic Control Devices'.

### 1.3 SUBMITTALLS

A. Action Submittal:
   1. Product Data:
      1) Manufacturer's published product data and certification that product supplied meets requirements of this specification.

B. Informational Submittal:
   1. Test And Evaluation Reports:
      a. Acrylic Paint:
         1) Provide reports showing compliance to FED TT-P-1952F.

C. Closeout Submittals:
   1. Include following in Operations And Maintenance Manual specified in Section 01 7800:
      a. Record Documentation:
         1) Manufacturer's Documentation:
            a) Product data.
            b) Specification compliance documentation.
         2) Testing and Inspection Reports:
            a) Reports showing compliance.

### 1.4 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Paint must meet requirements of FED TT-P-1952-F and local regulations for VOC.
   2. Paint handicap spaces to conform to ADA Standards and local code requirements.

### 1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:
   1. Materials shall be delivered in original, unopened containers with labels intact.

a. Labels to include:
    1) Manufacturer's name and address.
    2) TT-P-1952F reference.
    3) Classification Type.
    4) Color.

B. Storage and Handling Requirements:
    1. Follow Manufacturer's storage and handling requirements.
    2. Protect stored material from freezing at temperatures above 35 deg F (2 deg C) or above 115 deg F (46.1 deg C).
    3. Do not invert or roll containers.

## 1.6 FIELD CONDITIONS

A. Ambient Conditions:
    1. Acrylic Paint:
        a. Apply only on dry clean surfaces, during favorable weather (not excessively windy, dusty, or foggy), and when damage by rain, fog, or condensation not anticipated.
        b. Paving surface and Ambient temperature shall be minimum 50 deg F (10 deg C) and rising.
        c. Temperature shall not drop below 50 deg F (10 deg C) within twenty four (24) hour period following application.
        d. Acetone based paints that are one hundred (100) percent acrylic shall not drop below 32 deg F (0 deg C) within twenty four (24) hour period following application.

# PART 2 - PRODUCTS

## 2.1 MATERIAL

A. Acrylic Paint:
    1. Description:
        a. Low VOC, ready-mixed, one- component, acrylic waterborne traffic marking paint suitable for application on concrete, asphalt, sealers, and previously painted areas of these surfaces.
    2. Design Criteria:
        a. General:
            1) Traffic Paint.
            2) Non-volatile portion of vehicle for all classification types shall be composed of one hundred (100) percent acrylic.
            3) Meet FED TT-P-1952F specification requirements.
            4) Fast drying when applied at ambient conditions requirement.
            5) Low VOC.
            6) Non-Reflectorized.
            7) Traffic paints not intended for use as floor paints. Do not use on pedestrian walkways or large surfaces such as ramps, floors and stairs which may become slippery when wet.
        b. Classification:
            1) Type I for use under normal conditions.
            2) Type II for use under adverse conditions.
            3) Type III for increased durability.
        c. Composition:
            1) Non-volatile portion for all types shall be composed of one hundred (100) percent acrylic polymer as determined by infrared spectral analysis.
            2) Prohibited material:
                a) Product does not contain mercury, lead, hexavalent chromium, toluene, chlorinated solvents, hydrolysable chlorine derivatives, ethylene-based glycol ethers and their acetates, nor any carcinogen.
        d. Qualitative Requirements:

1) Meet FED TT-P-1952F requirements for:
   a) Abrasion resistance.
   b) Accelerated package stability.
   c) Accelerated weathering.
   d) Appearance.
   e) Color requirements:
      (1) Color Match (all colors except white and yellow).
      (2) Daylight directional reflectance.
      (3) Yellow color match.
   f) Condition in container.
   g) Dry-through (early washout) for Type II only.
   h) Flexibility.
   i) Freeze/thaw stability.
   j) Heat-shear stability.
   k) Scrub resistance.
   l) Skinning.
   m) Titanium dioxide content.
   n) Water resistance.

e. Quantitative requirements:
   1) Meet FED TT-P-1952F requirements (Table 1).
   2) Acetone based paints that are one hundred (100) percent acrylic and have exempt status under Federal law are exempt from meeting FED TT-P-1925F requirements.

3. Colors:
   a. General:
      1) Traffic Paint will be furnished in white and any Federal Standard 595 color in accordance to FED-STD-595C:
         a) Yellow: 33538.
         b) Blue: 35180.
         c) Red: 31136.
         d) White: 37925
   b. White:
      1) Lane lines, edge lines, transverse lines, arrows, words, symbol markings, parking space markings.
   c. Yellow:
      1) Cross-hatching in medians, cross hatching in safety zones separating opposing traffic flows, crosswalk stripes, safety markings, centerlines.
   d. Blue and White:
      1) In parking spaces specifically designated as reserved for disabled.
   e. Red:
      1) Fire lanes, no parking zones, special raised pavement markers that are placed to be visible to “wrong-way” drivers.
4. Type Two Acceptable Products:
   a. Any product meeting design criteria of this specification as approved by Architect/Owner’s Representative before application.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Acrylic Paint:
   1. Asphalt Surfaces:
      a. Do not apply paint until asphalt has cooled.
      b. Allow new seal coated surfaces to cure for at least twenty four (24) hours before applying paint.
   2. Concrete Surfaces:
      a. Do not apply paint to new concrete surfaces until concrete has cured seven (7) days minimum.

B. Surfaces shall be dry and free of grease and loose dirt particles.

C. Perform layout with chalk or lumber crayon only.

## 3.2 APPLICATION

A. General:
   1. Mix in accordance and apply as per Manufacturer's instructions.
   2. Apply at locations and to dimensions and spacing as shown on Contract Drawings.

B. Tolerances:
   1. General: Make lines parallel, evenly spaced, and with sharply defined edges.
      a. Plus or minus 1/4 inch (6 mm) variance on straight segments.
      b. Plus or minus 1/2 inch (13 mm) variance on curved alignments.

C. Coverage:
   1. Paint stripes added to new asphalt and concrete surfaces:
      a. Apply single coat.
   2. Apply traffic paint at rate of 13 to 15 mils minimum wet thickness, 8 to 9 mils dry thickness. Application at more than 15 mils may result in extended dry times and may cause lifting or cracking on some asphalt surfaces.

## 3.3 FIELD QUALITY CONTROL

A. Non-Conforming Work:
   1. Replace or correct defective material not conforming to requirements of this specification or any work performed that is of inferior quality at no cost to Owner.

## 3.4 CLEANING

A. General:
   1. Remove drips, overspray, improper markings, and paint material tracked by traffic by sand blasting, wire brushing, or other method approved by Architect/Owner’s Representative before performance.

B. Waste Management:
   1. Remove debris resulting from work of this Section. Dispose of or recycle all trash and excess material in manner conforming to current EPA regulations and local laws.

**END OF SECTION**

# SECTION 32 3111
# GATE OPERATORS

## PART 1 - GENERAL

### 1.1 SECTION INCLUDES

A. Electric Gate Operators
with detection loops B.
C. Monitored Retro-Reflective Photo Eye

### 1.2 RELATED SECTIONS

A. Section 32 3119 – Decorative Metal Fence And Gates
B. Division 26 - Requirements for electrical connections.

### 1.3 REFERENCES

A. National Electrical Manufacturers Association (NEMA): NEMA ICS 6 - Industrial Control and Systems: Enclosures.

B. Underwriters Laboratories (UL): UL 325 - Standard for Safety for Door, Drapery, Gate, Louver, and Window Operators and Systems.

C. Underwriters Laboratories (UL): UL 991 - Standard for Tests for Safety- Related Controls Employing Solid-State Devices.

D. International Organization for Standardization: ISO 9001 - Quality Management Systems.

### 1.4 SUBMITTALS

A. Submit under provisions of Section 01 3300.

B. Product Data: Equipment list, system description, electrical wiring diagrams for installation, and manufacturer's data sheets on each product to be used, including:

1. Preparation instructions and recommendations.
2. Storage and handling requirements and recommendations.
3. Installation methods.

C. Shop Drawings: Submit shop drawings showing layout, profiles, and product components, including anchorage, edge conditions, and accessories.

1. Operation, installation, and maintenance manuals including wiring diagrams.
2. Risers, layouts, and special wiring diagrams showing any changes to standard drawings.

### 1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials and products in strict compliance with manufacturer's instructions and industry standards.

B. Store products indoors in manufacturer's original containers and packaging, with labels clearly identifying product name and manufacturer. Protect from damage.

### 1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 Certified Manufacturer.

B. Installer Qualifications: Installation performed by factory authorized contractor specifically trained in gate operation systems of the type found within this section.
1. Provide documentation of maintenance and repair service availability for emergency conditions.
2. Provide quarterly maintenance for one year following Substantial Completion of the Project.

### 1.7 WARRANTY

A. Manufacturer's Standard Limited Warranty:
1. Warranty Period: 5 years for commercial applications, 7 years for single home applications.

## PART 2 PRODUCTS

### 2.1 MANUFACTURERS

A. BASIS OF DESIGN:

Maximum Controls LLC - Max 2200 DC
27211 Burbank ; Foothills Ranch, CA. 92610
Tel: 949-669-0220.

B. Requests for substitutions will be considered in accordance with provisions of Division 1.

C. All operator units shall be able to integrate with ONGUARD access control system.

### 2.2 GATE OPERATORS

A. Gate Operators: MAX 2200 SERIES Commercial High Traffic DC Slide Gate Operator.
1. LiftMaster MAX 2200 Slide Gate Operator. Compliance: UL listed; compliant with UL 325 and CSA C22.2 No. 247 standards.

a. Ratings: Class I.
b. Ratings: Class II.
c. Ratings: Class III.

d. Ratings: Class IV.

2. Electrical Power Requirements: 120V AC, single phase
3. Motor: 24V DC, Brushless with soft start/stop operation.
   a. Duty cycle: Continuous.
4. Capacity: 50-foot gate at 1,500 pounds.
5. Recommended Cycles per Day: Continuous duty.
6. Gate Travel Speed: 12 inches per second.
7. Warranty: 8 years for motor and cover , 5 years for everything else on commercial applications. 1 year only on battery.
8. Wormgear Reduction: Commercial oil bath gearbox with 30:1 wormgear reduction running in synthetic oil bath.
9. Battery Backup: Power Management system draws 14.8 mA when gate is idle with remote controls programmed. Provides 208 cycles on Battery Backup with two 7 Ah batteries or 1179 cycles with two 33 Ah batteries.
10. Standby Time: Provides up to 24 days of standby power in the event of a power loss with two 7 Ah batteries or 105 days with two 33 Ah batteries (excluding accessories).
11. Accessory Electrical Power Requirements: 24V DC 500 mA output, switched and unswitched power.
12. Receiver: Security+ 2.0, holds 50 remote controls, HomeLink compatible
    a. Transmits 310 MHz, 315 MHz, 390 MHz.
13. Electronic Limits: Maintains accurate limit position throughout travel, even after using the manual disconnect.
14. Programmable Auxiliary Relays: 2 programmable relays with 6 settings each.
    a. Pre-warning or gate-in-motion sounder.
    b. Switch on/off devices at open or close limits or while gate is in motion.
    c. Quick-close, anti-tailgate.
    d. Tamper detection if gate is pushed off Close limit.
    e. Cycle quantity feedback.
15. Plug-in loop detector inputs with 8 settings.
16. Alarm Reset Button: Instantly resets the built-in safety alarm siren.
17. Fire Department Compliant: Selectable settings allow gate to auto open on power failure or battery depletion. Shall be included.
18. Surge Suppression: Industrial strength on high and low voltage outputs.
19. Keyed Manual Disconnect: Simple-to-use disconnect allows gate to be operated manually and maintain limit position once re-engaged.
20. Chassis: Constructed with 1/4-inch (6 mm) gold zinc-plated steel for rust prevention.
21. Cover: High-density, UV-resistant polycarbonate two-piece cover.
22. Operating Temperature Range: -40 degrees F (-40 degrees C) to 140 degrees F (60 degrees C)
23. MyQ Enabled Accessories:

a. LiftMaster 829LM Garage and Gate Monitor: Allows remote monitoring and operation.

24. Accessories: Provide the optional accessories listed below.
    a. Single Entry Access Control Keypad and Proximity Reader.
    b. Plug-in Loop Detector.
    c. Thru-Beam Photo Eyes.
    d. Reflective Photo Eye.
    e. Commercial Access Control Receiver.
    f. LiftMaster PPWR Passport Receiver with Security+ 2.0

B. LiftMaster CPS-RPEN4GM Monitored Retro-Reflective Photo Eye.

1. LiftMaster CPS-RPEN4GM Monitored Retro-Reflective Photo Eye: Photo eye assembly, bracket, 3-inch (76 mm) reflector, 6-1/2 foot (1981 mm) cable.
2. Compliance:
    a. Meets UL 325 requirements for gates for secondary entrapment protection.
    b. Enclosure: IP65, NEMA 4X waterproof enclosure.
3. Installation Design:
    a. Single-sided, does not require trenching.
    b. Alignment: LED indicator with visible feedback and adjustable photo eye assembly.
4. Photo Eye Beam: Polarized beam technology sends and receives beam through 2 polarized filters to avoid interference from shiny objects.
5. Sensing Distance: 50 feet.
6. Operating Temperature Range: -22 degrees F (-30 degrees C) to 140 degrees F.
7. Power: LiftMaster 2-wire photo eye interface.
8. Operating Current: Greater than or equal to 40 mA.
9. Output Versions: Monitored 2-wire.
10. Response time: 30 milliseconds.
11. Wake-up Delay: 500 milliseconds.
12. Connection: 6-1/2 foot cable, fine stranded with crimp terminals wire size 1 sq. inch.

## PART 3 EXECUTION

### 3.1 EXAMINATION AND PREPARATION

A. Inspect and prepare substrates using the methods recommended by the manufacturer for achieving best result for the substrates under project conditions.

B. Do not proceed with installation until substrates have been prepared using the methods recommended by the manufacturer and deviations from manufacturer's recommended tolerances are corrected. Commencement of installation constitutes acceptance of conditions.

C. If preparation is the responsibility of another installer, notify Architect in writing of deviations from manufacturer's recommended installation tolerances and conditions.

## 3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions. Test for proper operation and adjust until satisfactory results are obtained.

## 3.3 PROTECTION

A. Protect installed products until completion of project.

B. Touch up, repair or replace damaged products before Substantial Completion.

**END OF SECTION**

**SECTION 32 3114**
**ORNAMENTAL STEEL GATES**

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Rolling steel gates ("wrought iron").

B. Related Sections:

1. Section 03 3000 - Cast-in-Place Concrete for cast-in-place concrete post footings.

2. Section 32 3119 – Electric Gate Operators and accessories.

### 1.3 REFERENCES

ASTM A 653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

ASTM A 787 - Standard Specification for Electric-Resistance-Welded Metallic- Coated Carbon Steel Mechanical Tubing.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include plan layout, construction details, material descriptions, dimensions of individual components and profiles, and finishes for gates.

1. Gates and hardware.
2. Fence components and fasteners.
3.

### 1.5 PROJECT CONDITIONS

A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

## PART 2 - PRODUCTS

### 2.1 FENCE FRAMING

A. Pickets: 1” X 1” x 16 GA 5” on center

B. Perimeter Grate Frame: 3” x 3” x 11 GA

C. Gate Post: 4” X 4” 11 GA

D. Gate Post Footing: 12” X 30”

E. Gate Guide: Continuous 4” w X 1/4" steel plate w/ in 12” deep #4 hooks 12” o.c. alternating sides set in continuous concrete base.

F. Cantilever Pinch Rollers 2 ea. top and bottom: UHMW plastic with sealed roller bearings. Provide inverted channel track full length of gate run and overrun. Continuous 4” w X 1/4" steel plate w/ in 12” deep #4 hooks 12” o.c. alternating sides set in continuous concrete base.

G. Paint: Color as selected, shop primer & field applied alkyd-based electrostatic paint system.

H. Manufacture: Hoover Fence Company, Newton Falls, OH: (330) 358-2335 or equal by Local Fabricator.

### 2.2 GROUT AND ANCHORING CEMENT

A. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water

exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer, for exterior applications.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

### 3.2 INSTALLATION, GENERAL

A. Install fencing to comply with ASTM F 567 and more stringent requirements indicated.

### 3.3 POST INSTALLATION

A. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

B. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

a. Exposed Concrete: Extend 2 inches above grade; shape and smooth to shed water.
b. Posts Set into Concrete in Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
c. Posts Set into Voids in Concrete: Form or core drill holes not less than 5 inches deep and 3/4 inch larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped

to drain water away from post.

## 3.4 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper- resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

## 3.5 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

**END OF SECTION**