

13-01R



	BROOKSIDE ELEMENTARY SCHOOL																		
	MODERNIZATION																		
	BUILDING B/200 (BID AND CA)																		

PART 2

PART 2.

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes the following:

- 1.2.1.1.** Piping materials and installation instructions common to most piping systems.
- 1.2.1.2.** Transition fittings.
- 1.2.1.3.** Dielectric fittings.
- 1.2.1.4.** Mechanical sleeve seals.
- 1.2.1.5.** Sleeves.
- 1.2.1.6.** Escutcheons.
- 1.2.1.7.** Grout.
- 1.2.1.8.** HVAC demolition.
- 1.2.1.9.** Equipment installation requirements common to equipment sections.
- 1.2.1.10.** Painting and finishing.
- 1.2.1.11.** Concrete bases.
- 1.2.1.12.** Supports and anchorages.

1.3. DEFINITIONS

- 1.3.1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- 1.3.2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- 1.3.3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- 1.3.4. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- 1.3.5. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- 1.3.6. The following are industry abbreviations for plastic materials:
 - 1.3.6.1. CPVC: Chlorinated polyvinyl chloride plastic.
 - 1.3.6.2. PE: Polyethylene plastic.
 - 1.3.6.3. PVC: Polyvinyl chloride plastic.
- 1.3.7. The following are industry abbreviations for rubber materials:
 - 1.3.7.1. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 1.3.7.2. NBR: Acrylonitrile-butadiene rubber.

1.4. SUBMITTALS

- 1.4.1. Product Data: For the following:

- 1.4.1.1. Transition fittings.
- 1.4.1.2. Dielectric fittings.
- 1.4.1.3. Mechanical sleeve seals.
- 1.4.1.4. Escutcheons.

1.4.2. Welding certificates.

1.5. QUALITY ASSURANCE

- 1.5.1. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- 1.5.2. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1.5.2.1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 1.5.2.2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- 1.5.3. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6. DELIVERY, STORAGE, AND HANDLING

- 1.6.1. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- 1.6.2. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7. COORDINATION

- 1.7.1. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- 1.7.2. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- 1.7.3. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

- 2.1.1. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 - 2.1.1.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
 - 2.1.1.2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2. PIPE, TUBE, AND FITTINGS

- 2.2.1. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.
- 2.2.2. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3. JOINING MATERIALS

- 2.3.1. Refer to individual Division 23 piping Sections for special joining materials not listed below.

2.3.2. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

2.3.2.1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

2.3.2.1.1. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

2.3.2.1.2. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2.3.2.2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

2.3.3. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

2.3.4. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

2.3.5. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

2.3.6. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

2.3.7. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.3.8. Solvent Cements for Joining Plastic Piping:

2.3.8.1. CPVC Piping: ASTM F 493.

2.3.8.2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

- 2.3.9.** Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.4. TRANSITION FITTINGS

- 2.4.1.** Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

2.4.1.1. Manufacturers:

2.4.1.1.1. Eslon Thermoplastics.

2.4.1.1.2. Or approved equal.

- 2.4.2.** Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

2.4.2.1. Manufacturers:

2.4.2.1.1. Thompson Plastics, Inc.

2.4.2.1.2. Or approved equal.

- 2.4.3.** Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

2.4.3.1. Manufacturers:

2.4.3.1.1. NIBCO, Inc.; Chemtrol Div.

2.4.3.1.2. Or approved equal.

2.5. DIELECTRIC FITTINGS

- 2.5.1.** Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

- 2.5.2.** Insulating Material: Suitable for system fluid, pressure, and temperature.

- 2.5.3.** Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

2.5.3.1. Manufacturers:

- 2.5.3.1.1.** Capitol Manufacturing Co.
- 2.5.3.1.2.** Central Plastics Company.
- 2.5.3.1.3.** Eclipse, Inc.
- 2.5.3.1.4.** Epco Sales, Inc.
- 2.5.3.1.5.** Hart Industries, International, Inc.
- 2.5.3.1.6.** Watts Industries, Inc.; Water Products Div.
- 2.5.3.1.7.** Zurn Industries, Inc.; Wilkins Div.
- 2.5.3.1.8.** Or approved equal.

- 2.5.4.** Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

2.5.4.1. Manufacturers:

- 2.5.4.1.1.** Capitol Manufacturing Co.
- 2.5.4.1.2.** Central Plastics Company.
- 2.5.4.1.3.** Epco Sales, Inc.
- 2.5.4.1.4.** Watts Industries, Inc.; Water Products Div.
- 2.5.4.1.5.** Or approved equal.

- 2.5.5.** Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

2.5.5.1. Manufacturers:

2.5.5.1.1. Advance Products & Systems, Inc.

2.5.5.1.2. Calpico, Inc.

2.5.5.1.3. Central Plastics Company.

2.5.5.1.4. Pipeline Seal and Insulator, Inc.

2.5.5.1.5. Or approved equal.

2.5.5.2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.

2.5.6. Dielectric Couplings: Galvanized-steel coupling with inert and non-corrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

2.5.6.1. Manufacturers:

2.5.6.1.1. Calpico, Inc.

2.5.6.1.2. Lochinvar Corp.

2.5.6.1.3. Or approved equal.

2.5.7. Dielectric Nipples: Electroplated steel nipple with inert and non-corrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

2.5.7.1. Manufacturers:

2.5.7.1.1. Perfection Corp.

2.5.7.1.2. Precision Plumbing Products, Inc.

2.5.7.1.3. Sioux Chief Manufacturing Co., Inc.

2.5.7.1.4. Victaulic Co. of America.

2.5.7.1.5. Or approved equal.

2.6. MECHANICAL SLEEVE SEALS

2.6.1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

2.6.1.1. Manufacturers:

2.6.1.1.1. Advance Products & Systems, Inc.

2.6.1.1.2. Calpico, Inc.

2.6.1.1.3. Metraflex Co.

2.6.1.1.4. Pipeline Seal and Insulator, Inc.

2.6.1.1.5. Or approved equal.

2.6.1.2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

2.6.1.3. Pressure Plates: Carbon steel and Stainless steel. Include two for each sealing element.

2.6.1.4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7. SLEEVES

2.7.1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.7.2. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

2.7.3. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.7.4. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

2.7.4.1. Underdeck Clamp: Clamping ring with set screws.

2.7.5. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

2.7.6. PVC Pipe: ASTM D 1785, Schedule 40.

2.7.7. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.8. ESCUTCHEONS

2.8.1. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

2.8.2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

2.8.3. One-Piece, Cast-Brass Type: With set screw.

2.8.3.1. Finish: Polished chrome-plated and rough brass.

2.8.4. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

2.8.4.1. Finish: Polished chrome-plated and rough brass.

2.8.5. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

2.8.6. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips and chrome-plated finish.

2.8.7. One-Piece, Floor-Plate Type: Cast-iron floor plate.

2.8.8. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9. GROUT

2.9.1. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

2.9.1.1. Characteristics: Post-hardening, volume-adjusting, non-staining, non-corrosive, nongaseous, and recommended for interior and exterior applications.

2.9.1.2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

2.9.1.3. Packaging: Premixed and factory packaged.

3. PART 3 - EXECUTION

3.1. PIPING SYSTEMS - COMMON REQUIREMENTS

3.1.1. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

3.1.2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

3.1.3. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

3.1.4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

3.1.5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

3.1.6. Install piping to permit valve servicing.

3.1.7. Install piping at indicated slopes.

- 3.1.8.** Install piping free of sags and bends.
- 3.1.9.** Install fittings for changes in direction and branch connections.
- 3.1.10.** Install piping to allow application of insulation.
- 3.1.11.** Select system components with pressure rating equal to or greater than system operating pressure.
- 3.1.12.** Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 3.1.12.1.** New Piping:
 - 3.1.12.1.1.** Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - 3.1.12.1.2.** Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - 3.1.12.1.3.** Insulated Piping: One-piece, stamped-steel type with spring clips.
 - 3.1.12.1.4.** Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - 3.1.12.1.5.** Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - 3.1.12.1.6.** Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
 - 3.1.12.1.7.** Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
 - 3.1.12.1.8.** Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.

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- 3.1.15.3.2.** Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
- 3.1.15.3.3.** Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
 - 3.1.15.3.3.1.** Seal space outside of sleeve fittings with grout.
- 3.1.15.4.** Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- 3.1.16.** Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 3.1.16.1.** Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
 - 3.1.16.2.** Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
 - 3.1.16.3.** Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.1.17. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

3.1.17.1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.1.18. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

3.1.19. Verify final equipment locations for roughing-in.

3.1.20. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2. PIPING JOINT CONSTRUCTION

3.2.1. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

3.2.2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

3.2.3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

3.2.4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

3.2.5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

- 3.2.6.** Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
- 3.2.6.1.** Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 3.2.6.2.** Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- 3.2.7.** Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- 3.2.8.** Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- 3.2.9.** Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
- 3.2.9.1.** Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 3.2.9.2.** CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3.2.9.3.** PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 3.2.9.4.** PVC Non-pressure Piping: Join according to ASTM D 2855.
- 3.2.10.** Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- 3.2.11.** Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.2.12. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

3.2.12.1. Plain-End Pipe and Fittings: Use butt fusion.

3.2.12.2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.2.13. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.3. PIPING CONNECTIONS

3.3.1. Make connections according to the following, unless otherwise indicated:

3.3.1.1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.

3.3.1.2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.3.1.3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

3.3.1.4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

3.4.1. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

3.4.2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

- 3.4.3.** Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- 3.4.4.** Install equipment to allow right of way for piping installed at required slope.

3.5. PAINTING

- 3.5.1.** Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."
- 3.5.2.** Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6. CONCRETE BASES

- 3.6.1.** Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 3.6.1.1.** Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
 - 3.6.1.2.** Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 - 3.6.1.3.** Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 3.6.1.4.** Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 3.6.1.5.** Install anchor bolts to elevations required for proper attachment to supported equipment.

3.6.1.6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.6.1.7. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.7. ERECTION OF METAL SUPPORTS AND ANCHORAGES

3.7.1. Refer to Division 05 Section "Metal Fabrications" for structural steel.

3.7.2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

3.7.3. Field Welding: Comply with AWS D1.1.

3.8. ERECTION OF WOOD SUPPORTS AND ANCHORAGES

3.8.1. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

3.8.2. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

3.8.3. Attach to substrates as required to support applied loads.

3.9. GROUTING

3.9.1. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

3.9.2. Clean surfaces that will come into contact with grout.

3.9.3. Provide forms as required for placement of grout.

3.9.4. Avoid air entrapment during placement of grout.

3.9.5. Place grout, completely filling equipment bases.

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- 3.9.6. Place grout on concrete bases and provide smooth bearing surface for equipment.
- 3.9.7. Place grout around anchors.
- 3.9.8. Cure placed grout.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3. COORDINATION

- 1.3.1.** Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1.3.1.1.** Motor controllers.
 - 1.3.1.2.** Torque, speed, and horsepower requirements of the load.
 - 1.3.1.3.** Ratings and characteristics of supply circuit and required control sequence.
 - 1.3.1.4.** Ambient and environmental conditions of installation location.

2. PART 2 - PRODUCTS

2.1. GENERAL MOTOR REQUIREMENTS

- 2.1.1.** Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- 2.1.2.** Comply with NEMA MG 1 unless otherwise indicated.

- 2.1.3.** Comply with IEEE 841 for severe-duty motors.

2.2. MOTOR CHARACTERISTICS

- 2.2.1.** Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- 2.2.2.** Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3. POLYPHASE MOTORS

- 2.3.1.** Description: NEMA MG 1, Design B, medium induction motor.
- 2.3.2.** Efficiency: Energy efficient, as defined in NEMA MG 1.
- 2.3.3.** Service Factor: 1.15.
- 2.3.4.** Multispeed Motors: Variable torque.
 - 2.3.4.1.** For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2.3.4.2.** For motors with other than 2:1 speed ratio, separate winding for each speed.
- 2.3.5.** Multispeed Motors: Separate winding for each speed.
- 2.3.6.** Rotor: Random-wound, squirrel cage.
- 2.3.7.** Bearings: Re-greasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- 2.3.8.** Temperature Rise: Match insulation rating.
- 2.3.9.** Insulation: Class F.
- 2.3.10.** Code Letter Designation:

- 2.3.11.** Motors 15 HP and Larger: NEMA starting Code F or Code G.
- 2.3.12.** Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- 2.3.13.** Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4. POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- 2.4.1.** Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- 2.4.2.** Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 2.4.2.1.** Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2.4.2.2.** Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 2.4.2.3.** Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 2.4.2.4.** Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- 2.4.3.** Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5. SINGLE-PHASE MOTORS

- 2.5.1.** Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

- 2.5.1.1. Permanent-split capacitor.
- 2.5.1.2. Split phase.
- 2.5.1.3. Capacitor start, inductor run.
- 2.5.1.4. Capacitor start, capacitor run.
- 2.5.2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- 2.5.3. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- 2.5.4. Motors 1/20 HP and Smaller: Shaded-pole type.
- 2.5.5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

3. PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes the following:
 - 1.2.1.1.** Isolation pads.
 - 1.2.1.2.** Isolation mounts.
 - 1.2.1.3.** Restrained elastomeric isolation mounts.
 - 1.2.1.4.** Housed spring mounts.
 - 1.2.1.5.** Elastomeric hangers.
 - 1.2.1.6.** Spring hangers.
 - 1.2.1.7.** Spring hangers with vertical-limit stops.
 - 1.2.1.8.** Restrained vibration isolation roof-curb rails.
 - 1.2.1.9.** Seismic snubbers.
 - 1.2.1.10.** Restraining braces and cables.

1.3. DEFINITIONS

- 1.3.1.** IBC: International Building Code.
- 1.3.2.** ICC-ES: ICC-Evaluation Service.
- 1.3.3.** Office of Statewide Health Planning and Development for the State of California.

1.4. PERFORMANCE REQUIREMENTS

1.4.1.1. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

1.4.1.2. Seismic-Restraint Details:

1.4.1.2.1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.

1.4.1.2.2. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

1.4.1.2.3. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.

1.4.1.2.4. Pre-approval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4.2. Coordination Drawings: Show coordination of seismic bracing for HVAC equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

- 1.4.3. Welding certificates.
- 1.4.4. Qualification Data: For professional engineer and testing agency.
- 1.4.5. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.
- 1.4.6. Field quality-control test reports.
- 1.4.7. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.5. QUALITY ASSURANCE

- 1.5.1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- 1.5.2. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- 1.5.3. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- 1.5.4. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage pre-approval OPA number from pre-approval by ICC-ES, or pre-approval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If pre-approved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

2. PART 2 - PRODUCTS

2.1. VIBRATION ISOLATORS

2.1.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.1.2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.1.3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

2.1.3.1. Ace Mountings Co., Inc.

2.1.3.2. Amber/Booth Company, Inc.

2.1.3.3. California Dynamics Corporation.

2.1.3.4. Isolation Technology, Inc.

2.1.3.5. Kinetics Noise Control.

2.1.3.6. Mason Industries.

2.1.3.7. Vibration Eliminator Co., Inc.

2.1.3.8. Vibration Isolation.

2.1.3.9. Vibration Mountings & Controls, Inc.

2.1.3.10. M. W. Sausse.

2.1.4. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a non-slip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

2.1.4.1. Resilient Material: Oil- and water-resistant neoprene and rubber hermetically sealed compressed fiberglass.

2.1.5. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

2.1.5.1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

2.1.5.2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

2.1.6. Restrained Mounts: All-directional mountings with seismic restraint.

2.1.6.1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

2.1.6.2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

2.1.7. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

2.1.7.1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2.1.7.2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

2.1.7.3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

2.1.7.4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

- 2.1.7.5.** Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
- 2.1.7.6.** Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- 2.1.8.** Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

 - 2.1.8.1.** Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - 2.1.8.2.** Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
 - 2.1.8.3.** Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 2.1.8.4.** Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 2.1.8.5.** Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 2.1.8.6.** Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- 2.1.9.** Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

 - 2.1.9.1.** Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

- 2.1.9.2.** Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
- 2.1.9.3.** Minimum Additional Travel: 50 percent of the required deflection at rated load.
- 2.1.9.4.** Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 2.1.9.5.** Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- 2.1.9.6.** Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
- 2.1.9.7.** Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.2. AIR-MOUNTING SYSTEMS

- 2.2.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.2.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.2.3.** Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
 - 2.2.3.1.** M.W. Sausse.
 - 2.2.3.2.** California Dynamics Corporation.
 - 2.2.3.3.** Firestone Industrial Products Company.
 - 2.2.3.4.** Kinetics Noise Control.
 - 2.2.3.5.** Mason Industries.

2.2.3.6. Vibration Eliminator Co., Inc.

2.2.4. Air Mounts: Freestanding, single or multiple, compressed-air bellows.

2.2.4.1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows.

2.2.4.2. Maximum Natural Frequency: 3 Hz.

2.2.4.3. Operating Pressure Range: 25 to 100 psig (172 to 690 kPa).

2.2.4.4. Burst Pressure: At least three times manufacturer's published maximum operating pressure.

2.2.4.5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch (3 mm).

2.3. SEISMIC-RESTRAINT DEVICES

2.3.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.3.2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.3.3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

2.3.3.1. Amber/Booth Company, Inc.

2.3.3.2. California Dynamics Corporation.

2.3.3.3. Cooper B-Line, Inc.; a division of Cooper Industries.

2.3.3.4. Hilti, Inc.

2.3.3.5. Kinetics Noise Control.

2.3.3.6. Loos & Co.; Cableware Division.

- 2.3.3.7.** Mason Industries.
- 2.3.3.8.** TOLCO Incorporated; a brand of NIBCO INC.
- 2.3.3.9.** Unistrut; Tyco International, Ltd.
- 2.3.4.** General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
 - 2.3.4.1.** Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- 2.3.5.** Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - 2.3.5.1.** Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 - 2.3.5.2.** Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 - 2.3.5.3.** Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch (6-mm-) thick resilient cushion.
- 2.3.6.** Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
- 2.3.7.** Restraint Cables: ASTM A 603 galvanized cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

- 2.3.8.** Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- 2.3.9.** Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- 2.3.10.** Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- 2.3.11.** Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- 2.3.12.** Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
- 2.3.13.** Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.4. FACTORY FINISHES

- 2.4.1.** Finish: Manufacturer's standard prime-coat finish ready for field painting.
- 2.4.2.** Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 2.4.2.1.** All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.

- 2.4.2.2.** Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

3. PART 4 - EXECUTION

3.1. EXAMINATION

- 3.1.1.** Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- 3.1.2.** Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- 3.1.3.** Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. APPLICATIONS

- 3.2.1.** Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- 3.2.2.** Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- 3.2.3.** Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3. VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

- 3.3.1.** Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- 3.3.2.** Equipment Restraints:

- 3.3.2.1.** Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
- 3.3.2.2.** Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
- 3.3.2.3.** Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- 3.3.3.** Piping Restraints:
 - 3.3.3.1.** Comply with requirements in MSS SP-127.
 - 3.3.3.2.** Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - 3.3.3.3.** Brace a change of direction longer than 12 feet (3.7 m).
- 3.3.4.** Install cables so they do not bend across edges of adjacent equipment or building structure.
- 3.3.5.** Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- 3.3.6.** Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- 3.3.7.** Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- 3.3.8.** Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

3.3.9. Drilled-in Anchors:

- 3.3.9.1.** Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
- 3.3.9.2.** Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
- 3.3.9.3.** Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
- 3.3.9.4.** Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
- 3.3.9.5.** Set anchors to manufacturer's recommended torque, using a torque wrench.
- 3.3.9.6.** Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

1.2.1. Section Includes:

- 1.2.1.1.** Equipment labels.
- 1.2.1.2.** Warning signs and labels.
- 1.2.1.3.** Duct labels.
- 1.2.1.4.** Stencils.
- 1.2.1.5.** Valve tags.
- 1.2.1.6.** Warning tags.

1.3. SUBMITTALS

- 1.3.1.** Product Data: For each type of product indicated.
- 1.3.2.** Samples: For color, letter style, and graphic representation required for each identification material and device.
- 1.3.3.** Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

1.4. COORDINATION

- 1.4.1.** Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- 1.4.2.** Coordinate installation of identifying devices with locations of access panels and doors.

- 1.4.3.** Install identifying devices before installing acoustical ceilings and similar concealment.

2. PART 2 - PRODUCTS

2.1. EQUIPMENT LABELS

2.1.1. Metal Labels for Equipment:

- 2.1.1.1.** Material and Thickness: Brass, 0.032-inch (0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
- 2.1.1.2.** Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- 2.1.1.3.** Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- 2.1.1.4.** Fasteners: Stainless-steel self-tapping screws.
- 2.1.1.5.** Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.1.2. Plastic Labels for Equipment:

- 2.1.2.1.** Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
- 2.1.2.2.** Letter Color: Blue.
- 2.1.2.3.** Background Color: Black.
- 2.1.2.4.** Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

- 2.1.2.5.** Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- 2.1.2.6.** Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- 2.1.2.7.** Fasteners: Stainless-steel self-tapping screws.
- 2.1.2.8.** Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- 2.1.3.** Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
- 2.1.4.** Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2. WARNING SIGNS AND LABELS

- 2.2.1.** Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm)] thick, and having predrilled holes for attachment hardware.
- 2.2.2.** Letter Color: Blue.
- 2.2.3.** Background Color: Black.
- 2.2.4.** Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

- 2.2.5.** Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- 2.2.6.** Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- 2.2.7.** Fasteners: Stainless-steel self-tapping screws.
- 2.2.8.** Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- 2.2.9.** Label Content: Include caution and warning information, plus emergency notification instructions.

2.3. DUCT LABELS

- 2.3.1.** Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
- 2.3.2.** Letter Color: Blue.
- 2.3.3.** Background Color: Black.
- 2.3.4.** Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
- 2.3.5.** Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- 2.3.6.** Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- 2.3.7.** Fasteners: Stainless-steel self-tapping screws.

2.3.8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.3.9. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

2.3.9.1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2.3.9.2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.4. STENCILS

2.4.1. Stencils: Prepared with minimum letter height of 1-1/4 inches (32 mm) for ducts; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.

2.4.1.1. Stencil Material: Brass.

2.4.1.2. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.

2.4.1.3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.

2.5. WARNING TAGS

2.5.1. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

2.5.1.1. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum.

2.5.1.2. Fasteners: Reinforced grommet and wire or string.

2.5.1.3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE", "HAZARDOUS MATERIAL."

2.5.1.4. Color: Yellow background with black lettering.

3. PART 3 - EXECUTION

3.1. PREPARATION

3.1.1. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2. EQUIPMENT LABEL INSTALLATION

3.2.1. Install or permanently fasten labels on each major item of mechanical equipment.

3.2.2. Locate equipment labels where accessible and visible.

3.2.3. Pipe Label Color Schedule:

3.2.3.1. Refrigerant Piping:

3.2.3.1.1. Background Color: Black.

3.2.4. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

3.2.4.1. Black: For cold-air supply ducts.

3.2.4.2. Black: For hot-air supply ducts.

3.2.4.3. Black: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

3.2.4.4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

3.2.5. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.

- 3.2.6.** Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

3.3. WARNING-TAG INSTALLATION

- 3.3.1.** Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the contract, including general and supplementary conditions, Divisions 01 and all other Division 23 specification sections, apply to this section.
- 1.1.2.** Where contradictions occur between this Section and Division 01, and between contract specifications and drawings, the more stringent of the two shall apply. The Owner's Representative shall decide which is most stringent.

1.2. SUMMARY

- 1.2.1.** Furnish the services and coordination required for a completely balanced, tested and certified air and water systems including testing and pre-certification of "operating/clean" rooms at as-built condition.
- 1.2.2.** The work shall be accomplished by the services of a Contractor-furnished air-balance and testing (TAB) agency that specializes in the balancing and testing of heating, ventilating, and air conditioning systems, to balance, adjust and test air moving equipment, duct mounted smoke detectors, air distribution systems, and water systems as specified.
- 1.2.3.** Coordinate with HVAC and control contractors for additional testing required for city acceptance of smoke control system. See Section 230913, BUILDING CONTROL SYSTEM (DDC).
- 1.2.4.** Coordinate all activities with the designated Commissioning agent and Owner's third party test/balance inspector.

1.3. TOTAL SYSTEM BALANCE

- 1.3.1.** Performance Testing and/or Balancing of the Air Conditioning Include:
 - 1.3.1.1.** Fan systems.

- 1.3.1.2. Single duct systems using air valves.
- 1.3.1.3. Kitchen systems.
- 1.3.1.4. Duct leakage testing.
- 1.3.1.5. Temperature control systems.
- 1.3.1.6. Report analysis and verification.
- 1.3.1.7. NOTE: Sections referred to herein are detailed in the current edition of The National Standards Manual of the Associated Air Balance Council.

1.4. SUBMITTALS

1.4.1. First Submittal:

- 1.4.1.1. Submit three (3) copies of documentation to confirm compliance with quality assurance provisions:
 - 1.4.1.1.1. Organization, supervisor and personnel training, and qualifications.
 - 1.4.1.1.2. Specimen copy of each of the report forms proposed for use. Forms shall be equivalent to those shown in the latest "National Standards for the Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" of the AABC.
 - 1.4.1.1.3. General plan of testing procedures and sequences.

1.4.2. Second Submittal: With the initial HVAC shop drawing and at least sixty (60) days prior to starting field work, submit three (3) copies of:

- 1.4.2.1. A set of report forms filled out as to the design flow values and the installed equipment pressure drops, and the required CFM for air terminals.

1.4.2.2. A complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each. Show:

1.4.2.2.1. Manufacturer and model number.

1.4.2.2.2. Description and use when needed to further identify the instrument.

1.4.2.2.3. Size or capacity range.

1.4.2.2.4. Latest calibration date.

1.4.2.2.4.1. A detailed description of the balancing and testing procedures. These procedures shall conform to AABC requirements and recommendations.

1.4.2.2.4.2. Owner's Representative will review submittals for compliance with Contract Documents, and will return one set marked to indicate:

1.4.2.2.4.2.1. Discrepancies noted between data shown and Contract Documents.

1.4.2.2.4.2.2. Additional or more accurate instruments required.

1.4.2.2.4.2.3. Requests for re-calibration of specific instruments.

1.4.2.2.4.2.4. Expansion or abbreviation of the test procedures and sequences.

1.4.3. Third Submittal: The testing agency shall perform the tests described, compile the test data, and submit seven (7) copies of the complete test data to Contractor for forwarding to Owner's Representative for approval within (10) working days of completion.

1.4.3.1. Report shall contain, at minimum, the following:

1.4.3.1.1. Project cover sheet.

1.4.3.1.2. Project summary/general comments.

1.4.3.1.3. Log data and reference records.

1.4.3.1.4. Calibration certificates for all test equipment used on project including model and serial number.

1.4.3.1.5. Drawings: The Air Balance Agency shall prepare a complete set of full scale drawings showing actual duct runs and outlet/inlet locations. Drawings shall be keyed to and furnished with the Air Balance Report. The HVAC design drawings are not acceptable for this purpose. Drawings shall be in AutoCAD latest version.

1.4.3.1.6. AABC National Performance Guaranty.

1.4.3.2. Submit Test and Balance Agency qualifications per Paragraph 1.03A herein, within 30 days after notice to proceed.

1.5. QUALITY ASSURANCE

1.5.1. Testing Agency (General and HVAC Systems):

- 1.5.1.1. All Work by this agency shall be done under direct supervision of a qualified balancing and testing professional certified by AABC. All instruments used by this agency shall be accurately calibrated and maintained in good working order. Testing procedure shall be as specified in PART 3 – EXECUTION, herein. The tests shall be conducted in the presence of Owner's Representative and Owner's HVAC Inspector.
- 1.5.1.2. Total System Balance shall be performed by an independent, non-affiliated agency certified by the Associated Air Balance Council (AABC) which specializes in and whose business is dedicated to testing, adjusting and verification of the HVAC system performance.
- 1.5.1.3. The submittal of reports shall be timely upon completion of work. This work shall conform to AABC specifications referred to in the AABC National Standard and other criteria as set forth in this specification.
- 1.5.1.4. The Contractor shall procure the services of an independent testing and balancing agency, with previous consent of the District Representative. The Testing and Balancing Agency shall specialize in testing and balancing of heating, ventilating, air-moving equipment, air-conditioning system and Hydronic systems. The testing agency shall provide proof of having successfully completed at least five projects of similar size and scope, and shall be a certified member of the Associated Air Balance Council and/or National Environmental Balancing Bureau, unless otherwise approved. The Mechanical Contractor shall award the test and balance contract to the selected agency as soon as possible after approval of the agency by the District Representative.
- 1.5.1.5. Furnish written proof that testing agency has not been called before the AABC Board or placed on probation at any time during the past five (5) years.

- 1.5.2.** In addition to testing requirements set forth herein, the Owner's Representative will randomly select and direct the Contractor to test 10% of the diffusers, grilles, air handling equipment or devices to confirm the system has been properly balanced in accordance with the contract documents. It is the Owner Representative's discretion that the system(s) and/or devices shall be rebalanced at no additional cost if the random testing indicates that the selected air devices or equipment does not meet the design airflows.

1.6. PRODUCT CONDITIONS

1.6.1. General:

- 1.6.1.1.** Notify Owner's Representative when any test is ready to be performed. Owner's Representative is to be present for all tests including air balance.
- 1.6.1.2.** Furnish all equipment required for testing including fittings for additional openings and all openings required inside and outside the building.
- 1.6.1.3.** After the inspection has been approved, or portions thereof, certify in writing the time, date, name and title of the person approving the test. This shall also include the description and what portion of the system has been approved. The person making the inspection shall sign the certification.
- 1.6.1.4.** A complete record shall be maintained of all testing that has been approved, and shall be made available at the Project site to all authorities concerned.
- 1.6.1.5.** Upon completion of the work, all records and certifications approving testing requirements shall be submitted to Owner's Representative.
- 1.6.1.6.** Defective work or material shall be replaced or repaired as necessary at no additional cost to Owner and the inspection and test repeated at Contractor's expenses. Repairs shall be made with new materials. No caulking of screwed joints or holes will be acceptable.

- 1.6.1.7.** Isolate all equipment subject to damage from test pressure. Make no test against a service valve or meter.
- 1.6.2.** Timing of Tests: Two weeks before expected completion date, put all systems and equipment into operation and continue operation of same during each working day, but not less than five 8-hour periods, until demonstration of all adjusting, balancing and testing has been approved.
- 1.6.3.** Functional Tests: Any installed item not meeting the schedule or specified performance shall be removed and replaced with items whose performance is in accordance with the Drawings and Specifications at no additional cost to Owner.
- 1.6.4.** After all systems have been completely installed, connections made and tests completed, make arrangements with Owner's Representative to operate the systems for a period of ten (10) working days during the hours of a normal working day.
- 1.6.5.** Notify Owner's Representative in writing when the operational period may start and the time for this period shall be scheduled by mutual agreement.
- 1.6.6.** During this operation period, instruct Owner's operating personnel in accordance with written instructions of the Service Manual specified.
- 1.6.7.** Perform tests as specified and as requested by Owner's Representative to prove installation is in accordance with Contract requirements. Perform tests in presence of Owner's Representative, and furnish test equipment, facilities, and technical personnel required to perform tests.
- 1.6.8.** Coordination: Promptly report to Owner's Representative any deficiencies noted during performance of services. Contractor shall rectify these deficiencies, and any tests interrupted shall be re-done at no additional cost to Owner.
- 1.6.9.** Test Failures: Notify General Contractor to repair duct system if test pressure and leakage is not attained. Repairs and sealing to be done with sheet metal and sealant by HVAC Contractor Division 23.

1.7. WORK BY HVAC SUBCONTRACTOR

- 1.7.1.** Preparation: Before any testing or balancing operations are started, the HVAC Subcontractor shall adjust belts and sheaves, align parts, oil and grease bearings in accordance with manufacturer's instructions, clean exterior surfaces of coil tubes and fins, flush interior of coil tubes until clean and check mixing damper operation to insure free operation and activation by correct thermostat. Install filters and startup equipment.
- 1.7.2.** Certification: HVAC Subcontractor shall certify in writing that the system, as scheduled for balancing, is operational and complete. Completeness shall include not only the physical installation, but HVAC Subcontractor's certification that prime movers, fans, pumps, refrigeration machines, boilers, etc., are installed in good working order, and full load performance has been preliminarily tested under certification of HVAC Subcontractors. Before any testing and balancing is started, a complete report shall be sent to the Agency. Refer to Part 4 of this Section for Checklist forms to be completed by the HVAC Subcontractor.

1.8. WARRANTY

- 1.8.1.** National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
 - 1.8.1.1.** The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 1.8.1.2.** Systems are balanced to optimum performance capabilities within design and installation limits.

2. PART 2 - PRODUCTS (NOT USED)

3. PART 3 - EXECUTION

3.1. GENERAL

3.1.1. The Test and Balance Agency (TAB) shall be provided with:

3.1.1.1. Within thirty (30) days after agency selection:

3.1.1.1.1. Construction drawings

3.1.1.1.2. Equipment Specification

3.1.1.1.3. Written contract

3.1.1.1.3.1. As Issued or Received:

3.1.1.1.3.1.1. Change orders.

3.1.1.1.3.1.2. Equipment
manufacturer's
submittal data.

3.1.1.1.3.1.3. HVAC shop drawings.

3.1.1.1.3.1.4. Temperature control
drawings.

3.1.1.1.3.1.5. Project Schedule.

3.1.1.1.3.1.6. Completely operable
system.

3.1.1.2. Before testing and balancing is started, the HVAC installer shall, adjust belts and sheaves, align all parts, oil and grease bearings in accordance with manufacturer's instructions, clean exterior surfaces of coil tubes and fins, flush interior of coil tubes until clean and check damper operation to ensure free operation and activation by the correct thermostat.

- 3.1.1.3.** Submit written certification by the HVAC Installer that the system, as scheduled for balancing, is operational and complete. Completeness shall include not only the physical installation, but the HVAC Installer's certification that the prime movers, fans, pumps, refrigeration machines, boilers, etc. are installed in good working order, and the full load performance has been preliminarily tested under the certification of the HVAC Installer. Before any testing and balancing is started, a complete report shall be sent to the Test and Balance Agency. Refer to Part 4 herein for Hydronic and Air Handling System Checklists.
- 3.1.1.4.** Make all modifications to rectify discrepancies reported by the Balancing Contractor as indicating non-compliance with the Contract Documents.
- 3.1.1.5.** The air system shall be adjusted to obtain the air volumes specified, but readjusted if required to obtain design temperature in each room. Make drive changes, install additional dampers, vanes, grille baffles, etc., as may be required on the job to achieve correct operation and design conditions.

3.2. BALANCING

3.2.1. Air Systems:

3.2.1.1. Preparation of Duct System:

- 3.2.1.1.1.** All supply and return air duct dampers are set at full open position.
- 3.2.1.1.2.** All diffuser and sidewall registers are set at full open position.
- 3.2.1.1.3.** Outside air damper is set at minimum position.
- 3.2.1.1.4.** All controls checked and set for full cooling cycle.

- 3.2.1.1.5.** Branch line splitter dampers to open position.
- 3.2.1.1.6.** Set all extractors and distribution grids to wide-open position.
- 3.2.1.2.** Preparation of Air Handler:
 - 3.2.1.2.1.** Drill all probe holes for static pressure readings, pitot tube traverse readings and temperature readings.
 - 3.2.1.2.2.** Check motor electrical current supply and rated-running amperage of fan motors.
 - 3.2.1.2.3.** Check available adjustment tolerance.
- 3.2.1.3.** Main Duct Proportioning:
 - 3.2.1.3.1.** Make first complete air distribution run throughout entire system, recording first run statistics.
 - 3.2.1.3.2.** Using pitot tube traverse in all main duct and branch duct supply and return, proportion all air in required amounts to the various main duct runs and branch runs.
 - 3.2.1.3.3.** All fan systems with filters shall be balanced to the air flows as shown on the drawings based on the filter final pressure drop as shown on the equipment schedule. Apply an artificial pressure to match the filter final pressure drop. Balance the airflows to the quantities as shown on the drawings. Make readings and record on report. Remove the artificial pressure drop.
 - 3.2.1.3.4.** Make second complete air distribution run throughout entire system for check on proper proportion of air.

3.2.1.4. Inlet and Outlet Proportioning:

- 3.2.1.4.1.** Using pitot tube traverse, set all main line dampers to deliver proper amount of CFM to all areas.
- 3.2.1.4.2.** Using pitot tube traverse, set all branch line dampers to deliver proper amount of CFM to diffusers and sidewall supply grilles in each zone.
- 3.2.1.4.3.** Read CFM at each outlet and adjust to meet requirements.
- 3.2.1.4.4.** Test and record all items as listed (Testing Procedure).

3.2.1.5. Testing Procedure for Air Systems:

- 3.2.1.5.1.** Test and adjust blower RPM to design requirements.
- 3.2.1.5.2.** Test and record motor full load amperes.
- 3.2.1.5.3.** Make pitot tube traverse of main supply ducts and obtain design CFM at fans where applicable.
- 3.2.1.5.4.** Test and record system static pressures, suction and discharge.
- 3.2.1.5.5.** Test and adjust system for design recirculated air CFM.
- 3.2.1.5.6.** Test and adjust system for design CFM outside air.
- 3.2.1.5.7.** Test and record entering air temperatures. (D.B. heating and cooling.)

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- 3.2.1.5.8.** Test and record entering air temperatures. (W.B. cooling.)
- 3.2.1.5.9.** Test and record leaving air temperatures. (D.B. heating and cooling.)
- 3.2.1.5.10.** Test and record leaving air temperatures. (W.B. cooling.)
- 3.2.1.5.11.** Adjust all main supply and return air ducts to proper design CFM.
- 3.2.1.5.12.** Adjust all zones to proper design CFM supply and return.
- 3.2.1.5.13.** Test and adjust each diffuser, grille and register to within 10% of design requirements. Supply, return, and/or exhaust air quantity relationship shall be maintained as shown on drawings so that the room will maintain the proper air pressurization (positive, negative or equal).
- 3.2.1.5.14.** Each grille, diffuser and register shall be identified as to location and area.
- 3.2.1.5.15.** Size, type, and manufacturer of diffusers, grilles, registers, and all tested equipment shall be identified and listed. Manufacturer's ratings on all equipment shall be used to make required calculations.
- 3.2.1.5.16.** Readings and tests of diffusers, grilles and registers shall include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustments.
- 3.2.1.5.17.** In cooperation with control manufacturer's representative, setting adjustments of automatically operated dampers to operate as specified, indicated or noted.

3.2.1.5.18. All diffusers and registers shall be adjusted to minimize drafts in all areas.

3.2.1.5.19. As a part of the Work, the HVAC installer shall make all changes in the pulleys, belts, and dampers or the addition of dampers required for correct balance, as recommended by the Air Balance Agency, at no additional cost to Owner.

3.2.1.5.20. Provide static pressure profile for air handling units showing pressure drop of individual internal component sections (e.g., coil, filter, sound traps, inlet and discharge sections, etc.)

3.3. VENTED CHEMICAL STORAGE CABINETS

3.3.1. Confirm all cabinets maintained under negative pressure.

3.3.2. Adjust individual exhaust connections as needed for negative pressure condition.

3.4. SPACE DIFFERENTIAL PRESSURE MEASUREMENTS

3.4.1. Measure space pressures and make necessary adjustments to achieve differential pressure relationships shown on the drawings.

3.4.2. HVAC Installer is responsible for providing all sheet metal blank off plates or other devices as directed by TAB Agency to achieve necessary pressure differentials between clean room and service chase openings. Appearance of all Architectural devices are to be approved by the Architect and Owner Representative whenever visible from occupied lab spaces.

3.4.3. Pressure measurements are recorded in inches water gauge.

3.5. TESTING PROCEDURE FOR DUCT MOUNTED SMOKE DETECTORS

- 3.5.1.** When air system testing and balancing is completed, the balance agency shall verify proper location and operation of duct mounted smoke detector. Smoke detectors shall be installed per NFPA 72 and the manufacturer's recommendations.

3.6. DUCT PRESSURE/LEAK TESTING

- 3.6.1.** Test shall be in accordance with of the National Standards Manual of the Associated Air Balance Council.
- 3.6.2.** HVAC Contractor to close off and seal all openings in the duct section to be tested as specified by the Air Balance Contractor.
- 3.6.3.** Test duct in sections, not exceeding 150 feet for horizontal ducts and 100 feet for vertical risers.
- 3.6.4.** Each section shall be tested at the duct pressure classification. Total allowable leakage should not exceed 2% of the total CFM design for that section being tested.
- 3.6.5.** Contractor shall conduct leakage test on ductwork and the Test and Balance Agency shall witness and certify all tests. Tests shall be performed prior to installing ductwork insulation.
- 3.6.6.** Pressure test all medium pressure ductwork (pressure class of 3" and higher) prior to installation of insulation.
- 3.6.7.** Pressure test all ductwork starting at fan discharge, to inlet of air terminal units.
- 3.6.8.** Pressure test all ductwork concealed in shafts or rated enclosures regardless of pressure class.
- 3.6.9.** Pressure test all ductwork, supply, return, exhaust, and outside air, regardless of pressure class, that are associated with the smoke control system.

3.6.10. Systems shall be inspected and tested to positive pressures, in accordance with the following:

3.6.10.1. There are no visible HVAC defects.

3.6.10.2. There is no audible leakage at any point when area ambient noise is at normal-occupancy level.

3.6.11. Leak Tests: Test apparatus and procedures shall be similar in all respects to those defined in AABC standards. Filtered blower inlet and automatic safety relief device shall be provided to protect system.

3.6.12. Complete testing after the installation of all tapoffs, fire dampers, motorized dampers, access doors, etc., but before installation of terminal air devices. Provide temporary blankoffs at all takeoffs. Complete the testing before shaft is closed up.

3.6.13. If leakage exceeds allowable limits correct the deficiency in ductwork and retest the system until leakage is within acceptable limits.

3.7. DETAILED REQUIREMENTS

3.7.1. Furnish Typewritten Data for all Fans Tabulating:

3.7.1.1. Quantity of air in CFM at each air outlet or inlet.

3.7.1.2. Dry and wet bulb temperatures at each thermostat to the nearest 1/10 of 1 degree.

3.7.1.3. Outdoor dry and wet bulb temperatures, wind direction and velocity, and barometric pressure at the time tests are conducted.

3.7.1.4. RPM of fan or blower.

3.7.1.5. RPM of motor.

3.7.1.6. Ampere input of each motor (one reading on each leg if three (3) phase).

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- 3.7.1.7. No load Amperage and brake horsepower calculations on all motors 1/2 horsepower or larger.
- 3.7.1.8. Static pressure in inches water gauge at inlet of fan or blower.
- 3.7.1.9. Duct traverse data.

3.8. REPORT

- 3.8.1. Provide a General Information Sheet Listing:
 - 3.8.1.1. Instruments used and most recent calibration date.
 - 3.8.1.2. Method of balancing.
 - 3.8.1.3. Altitude correction.
 - 3.8.1.4. Manufacturer's performance data for all air devices used.
- 3.8.2. The Test and Balance Agency shall prepare and submit six (6) copies of the Test and Balance Analysis Report within ten (10) working days of completion.
- 3.8.3. Report to Contain , at Minimum, the Following:
 - 3.8.3.1. Project cover sheet.
 - 3.8.3.2. Project summary/general comments.
 - 3.8.3.3. Log, data and reference records.
 - 3.8.3.4. Calibration certificates for all test equipment used on project including model and serial number.

3.8.3.5. Drawings. The Air Balance Agency shall prepare a complete set of full scale drawings showing actual duct runs and outlet/inlet locations. Drawings shall be keyed to and furnished with the Air Balance Report. The HVAC plans are not acceptable for this purpose. Drawings shall be in Auto Cad Latest Version or as approved by the Owner's Representative.

3.8.3.6. AABC National performance guaranty.

3.9. ACCEPTANCE TEST OF HVAC SYSTEMS

3.9.1. Perform at least two (2) operational tests of the entire HVAC system.

3.9.2. Give each element of the system an operating test of not less than 48 hours' duration to demonstrate to the satisfaction of the Owner that the control system is functioning properly and that the system is capable of producing the required environmental conditions. During this test, operate the system entirely on automatic control and take periodic readings of the inside and outside wet and dry bulb temperatures. Obtain wet and dry bulb temperatures with a recording thermometer-hygrometer. Conduct tests with outside temperature and humidity conditions as near design conditions as practical.

3.9.3. Notify Owner seven (7) days in advance of proposed tests.

3.9.4. Record temperature and humidity at an exterior and interior location for each system as designated by the Engineer at least once every hour, for 48 hours during tests.

3.9.5. Submit a Report Detailing the Following:

3.9.5.1. Instrument used:

3.9.5.1.1. Most recent calibration date

3.9.5.2. Date of tests.

3.9.5.3. Description of test apparatus locations and methods.

3.9.5.4. Results of tests.

3.9.5.5. Any abnormal usage of the building or abnormal system characteristics observed during the course of the test.

3.9.6. Duct Leakage Tests:

3.9.6.1. Seal all openings in duct section to be tested.

3.9.6.2. Connect test apparatus to test section of duct using a flexible duct connection or hose.

3.9.6.3. Close damper or blower suction side to prevent excessive build up of pressure.

3.9.6.4. Start blower and gradually open damper on suction side of blower.

3.9.6.5. Build up pressure in duct test section between air handling unit and air terminal units to the level of the duct pressure classification.

3.9.6.6. Read the flow meter and compare the leakage in cfm per square foot with the allowable rate. If it meets the allowable rate, proceed to step (11). If it does not meet the allowable rate, follow steps (8), (9), (10) and (11).

3.9.6.7. Inspect the pressurized duct for all sensible leaks. Mark location of each leak.

3.9.6.8. Depressurize and repair all visual and audible leaks.

3.9.6.9. Upon completion of repairs, retest until leakage rate is acceptable.

3.9.6.10. Complete test report on air leakage test summary form. Remove temporary blankouts and seals.

- 3.9.6.11.** Each tested duct section shall be certified by the field test inspector. Provide a certified report at the end of the project. At a minimum, the report shall include a certification letter certifying that all the tested sections have met the requirement, test data, results, and tested dated, technician name(s) that performed the tests, and drawings indicating the test sections.

3.10.ADDITIONAL TESTS

- 3.10.1.** Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- 3.10.2.** Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

1.2.1. Section Includes:

1.2.1.1. Insulation Materials:

- 1.2.1.1.1.** Calcium silicate.
- 1.2.1.1.2.** Cellular glass.
- 1.2.1.1.3.** Flexible elastomeric.
- 1.2.1.1.4.** Mineral fiber.
- 1.2.1.1.5.** Phenolic.
- 1.2.1.1.6.** Polyisocyanurate.
- 1.2.1.1.7.** Polyolefin.
- 1.2.1.1.8.** Polystyrene.

1.2.1.2. Fire-rated insulation systems.

1.2.1.3. Insulating cements.

1.2.1.4. Adhesives.

1.2.1.5. Mastics.

1.2.1.6. Lagging adhesives.

1.2.1.7. Sealants.

- 1.2.1.8. Factory-applied jackets.
- 1.2.1.9. Field-applied fabric-reinforcing mesh.
- 1.2.1.10. Field-applied cloths.
- 1.2.1.11. Field-applied jackets.
- 1.2.1.12. Tapes.
- 1.2.1.13. Securements.
- 1.2.1.14. Corner angles.

1.2.2. Related Sections:

- 1.2.2.1. Division 21 Section "Fire-Suppression Systems Insulation."
- 1.2.2.2. Division 22 Section "Plumbing Insulation."
- 1.2.2.3. Division 23 Section "Metal Ducts" for duct liners.
- 1.2.2.4. Division 33 Section "Underground Hydronic Energy Distribution" for loose-fill pipe insulation in underground piping outside the building.
- 1.2.2.5. Division 33 Section "Underground Steam and Condensate Distribution Piping" for loose-fill pipe insulation in underground piping outside the building.

1.3. SUBMITTALS

- 1.3.1. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).
- 1.3.2. Shop Drawings:
 - 1.3.2.1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

- 1.3.2.2. Detail attachment and covering of heat tracing inside insulation.
- 1.3.2.3. Detail insulation application at pipe expansion joints for each type of insulation.
- 1.3.2.4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
- 1.3.2.5. Detail removable insulation at piping specialties, equipment connections, and access panels.
- 1.3.2.6. Detail application of field-applied jackets.
- 1.3.2.7. Detail application at linkages of control devices.
- 1.3.2.8. Detail field application for each equipment type.
- 1.3.3. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.
 - 1.3.3.1. Sample Sizes:
 - 1.3.3.1.1. Sheet Form Insulation Materials: 12 inches (300 mm) square.
 - 1.3.3.1.2. Sheet Jacket Materials: 12 inches (300 mm) square.
 - 1.3.3.1.3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.
- 1.3.4. Qualification Data: For qualified Installer.
- 1.3.5. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

1.3.6. Field quality-control reports.

1.4. QUALITY ASSURANCE

1.4.1. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.4.2. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1.4.2.1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.4.2.2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.4.3. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1.4.3.1. Piping Mockups:

1.4.3.1.1. One 10-foot (3-m) section of NPS 2 (DN 50) straight pipe.

1.4.3.1.2. One each of a 90-degree threaded, welded, and flanged elbow.

1.4.3.1.3. One each of a threaded, welded, and flanged tee fitting.

- 1.4.3.1.4.** One NPS 2 (DN 50) or smaller valve, and one NPS 2-1/2 (DN 65) or larger valve.
- 1.4.3.1.5.** Four support hangers including hanger shield and insert.
- 1.4.3.1.6.** One threaded strainer and one flanged strainer with removable portion of insulation.
- 1.4.3.1.7.** One threaded reducer and one welded reducer.
- 1.4.3.1.8.** One pressure temperature tap.
- 1.4.3.1.9.** One mechanical coupling.
- 1.4.3.2.** Ductwork Mockups:
 - 1.4.3.2.1.** One 10-foot (3-m) section each of rectangular and round straight duct.
 - 1.4.3.2.2.** One each of a 90-degree mitered round and rectangular elbow, and one each of a 90-degree radius round and rectangular elbow.
 - 1.4.3.2.3.** One rectangular branch takeoff and one round branch takeoff from a rectangular duct. One round tee fitting.
 - 1.4.3.2.4.** One rectangular and round transition fitting.
 - 1.4.3.2.5.** Four support hangers for round and rectangular ductwork.
- 1.4.3.3.** For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
- 1.4.3.4.** Notify Architect seven days in advance of dates and times when mockups will be constructed.

- 1.4.3.5. Obtain Architect's approval of mockups before starting insulation application.
- 1.4.3.6. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
- 1.4.3.7. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
- 1.4.3.8. Demolish and remove mockups when directed.

1.5. DELIVERY, STORAGE, AND HANDLING

- 1.5.1. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6. COORDINATION

- 1.6.1. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- 1.6.2. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- 1.6.3. Coordinate installation and testing of heat tracing.

1.7. SCHEDULING

- 1.7.1. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

- 1.7.2. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

2. PART 2 - PRODUCTS

2.1. INSULATION MATERIALS

- 2.1.1. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- 2.1.2. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- 2.1.3. 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.
- 2.1.4. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- 2.1.5. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- 2.1.6. Calcium Silicate:
 - 2.1.6.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.1.6.1.1. Industrial Insulation Group (The); Thermo-12 Gold.
 - 2.1.6.1.2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

- 2.1.6.1.3.** Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

- 2.1.6.1.4. Prefabricated Fitting Covers:** Comply with ASTM C 450 and ASTM C 585 for dimensions used in pre-forming insulation to cover valves, elbows, tees, and flanges.

- 2.1.7.** Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

- 2.1.7.1. Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- #### 2.1.7.1.1. Cell-U-Foam Corporation; Ultra-CUF.

- 2.1.7.1.2.** Pittsburgh Corning Corporation; Foamglas Super K.

- 2.1.7.2. Block Insulation:** ASTM C 552, Type I.

- 2.1.7.3. Board Insulation:** ASTM C 552, Type IV.

- 2.1.7.4. Preformed Pipe Insulation without Jacket:** Comply with ASTM C 552, Type II, Class 1.

- 2.1.7.5.** Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

- 2.1.8. Flexible Elastomeric:** Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

2.1.8.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.1.8.1.1. Aeroflex USA Inc.; Aerocel.

2.1.8.1.2. Armacell LLC; AP Armaflex.

2.1.8.1.3. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2.1.9. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

2.1.9.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.1.9.1.1. Fibrex Insulations Inc.; FBX.

2.1.9.1.2. Johns Manville; 1000 Series Spin-Glas.

2.1.9.1.3. Owens Corning; High Temperature Industrial Board Insulations.

2.1.9.1.4. Rock Wool Manufacturing Company; Delta Board.

2.1.9.1.5. Roxul Inc.; Roxul RW.

2.1.9.1.6. Thermafiber; Thermafiber Industrial Felt.

2.2. ADHESIVES

2.2.1. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

2.2.2. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).

2.2.2.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.2.2.1.1. Childers Products, Division of ITW; CP-97.

2.2.2.1.2. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.

2.2.2.1.3. Marathon Industries, Inc.; 290.

2.2.2.1.4. Mon-Eco Industries, Inc.; 22-30.

2.2.2.1.5. Vimasco Corporation; 760.

2.2.3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).

2.2.3.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.2.3.1.1. Childers Products, Division of ITW; CP-96.

2.2.3.1.2. Foster Products Corporation, H. B. Fuller Company; 81-33.

2.2.4. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

2.2.4.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.2.4.1.1. Aeroflex USA Inc.; Aero Seal.

- 2.2.4.1.2.** Armacell LCC; 520 Adhesive.
- 2.2.4.1.3.** Foster Products Corporation, H. B. Fuller Company; 85-75.
- 2.2.4.1.4.** RBX Corporation; Rubatex Contact Adhesive.
- esive, and FSK and PVDC Jacket Adhesive: Comply with 16C, Class 2, Grade A for bonding insulation jacket lap and joints.
- Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
- 2.2.5.1.1.** Childers Products, Division of ITW; CP-82.
- 2.2.5.1.2.** Foster Products Corporation, H. B. Fuller Company; 85-20.
- 2.2.5.1.3.** ITW TACC, Division of Illinois Tool Works; S-90/80.
- 2.2.5.1.4.** Marathon Industries, Inc.; 225.
- 2.2.5.1.5.** Mon-Eco Industries, Inc.; 22-25.
- ket Adhesive: Compatible with PVC jacket.
- Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
- 2.2.6.1.1.** Dow Chemical Company [The]; 739, Dow Silicone.
- 2.2.6.1.2.** Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
- 2.2.6.1.3.** P.I.C. Plastics, Inc.; Welding Adhesive.
- 2.2.6.1.4.** Red Devil, Inc.; Celulon Ultra Clear.

2.2.6.1.5. Speedline Corporation; Speedline Vinyl Adhesive.

2.3. MASTICS

2.3.1. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

2.3.2. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

2.3.2.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.3.2.1.1. Childers Products, Division of ITW; CP-35.

2.3.2.1.2. Foster Products Corporation, H. B. Fuller Company; 30-90.

2.3.2.1.3. ITW TACC, Division of Illinois Tool Works; CB-50.

2.3.2.1.4. Marathon Industries, Inc.; 590.

2.3.2.1.5. Mon-Eco Industries, Inc.; 55-40.

2.3.2.1.6. Vimasco Corporation; 749.

2.3.2.2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.

2.3.2.3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).

2.3.2.4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.

2.3.2.5. Color: White.

2.3.3. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

2.3.3.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.3.3.1.1. Childers Products, Division of ITW; CP-30.

2.3.3.1.2. Foster Products Corporation, H. B. Fuller Company; 30-35.

2.3.3.1.3. ITW TACC, Division of Illinois Tool Works; CB-25.

2.3.3.1.4. Marathon Industries, Inc.; 501.

2.3.3.1.5. Mon-Eco Industries, Inc.; 55-10.

2.3.3.2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.

2.3.3.3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).

2.3.3.4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.

2.3.3.5. Color: White.

2.3.4. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

2.3.4.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.3.4.1.1. Childers Products, Division of ITW; Encacel.

2.3.4.1.2. Foster Products Corporation, H. B. Fuller Company; 60-95/60-96.

2.3.4.1.3. Marathon Industries, Inc.; 570.

2.3.4.1.4. Mon-Eco Industries, Inc.; 55-70.

2.3.4.2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.

2.3.4.3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).

2.3.4.4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.

2.3.4.5. Color: White.

2.4. LAGGING ADHESIVES

2.4.1. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

2.4.1.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.4.1.1.1. Childers Products, Division of ITW; CP-52.

2.4.1.1.2. Foster Products Corporation, H. B. Fuller Company; 81-42.

2.4.1.1.3. Marathon Industries, Inc.; 130.

2.4.1.1.4. Mon-Eco Industries, Inc.; 11-30.

2.4.1.1.5. Vimasco Corporation; 136.

2.4.1.2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.

2.4.1.3. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).

2.4.1.4. Color: White.

2.5. SEALANTS

2.5.1. Joint Sealants:

2.5.2. FSK and Metal Jacket Flashing Sealants:

2.5.2.1. Products: Subject to compliance with requirements, provide one, but are not limited to, the following:

2.5.2.1.1. Childers Products, Division of ITW; CP-76-8.

2.5.2.1.2. Foster Products Corporation, H. B. Fuller Company; 95-44.

2.5.2.1.3. Marathon Industries, Inc.; 405.

2.5.2.1.4. Mon-Eco Industries, Inc.; 44-05.

2.5.2.1.5. Vimasco Corporation; 750.

2.5.2.2. Materials shall be compatible with insulation materials, jackets, and substrates.

2.5.2.3. Fire- and water-resistant, flexible, elastomeric sealant.

2.5.2.4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

2.5.2.5. Color: Aluminum.

2.5.3. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

2.5.3.1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:

2.5.3.1.1. Childers Products, Division of ITW; CP-76.

- 2.5.3.2.** Materials shall be compatible with insulation materials, jackets, and substrates.
- 2.5.3.3.** Fire- and water-resistant, flexible, elastomeric sealant.
- 2.5.3.4.** Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
- 2.5.3.5.** Color: White.

2.6. FACTORY-APPLIED JACKETS

- 2.6.1.** Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 2.6.1.1.** ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 - 2.6.1.2.** ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 - 2.6.1.3.** FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
 - 2.6.1.4.** FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
 - 2.6.1.5.** PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

2.6.1.5.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.6.1.5.1.1. Dow Chemical Company (The);
Saran 540 Vapor Retarder Film and
Saran 560 Vapor Retarder Film.

2.6.1.6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perms) when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7. FIELD-APPLIED JACKETS

2.7.1. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

2.7.2. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

2.7.3. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

2.7.3.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.7.3.1.1. Johns Manville; Zeston.

2.7.3.1.2. P.I.C. Plastics, Inc.; FG Series.

2.7.3.1.3. Proto PVC Corporation; LoSmoke.

2.7.3.1.4. Speedline Corporation; SmokeSafe.

2.7.3.2. Adhesive: As recommended by jacket material manufacturer.

2.7.3.3. Color: Color-code jackets based on system. Color as selected by Architect.

2.7.3.4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

2.7.3.4.1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.7.3.5. Factory-fabricated tank heads and tank side panels.

2.7.4. Metal Jacket:

2.7.4.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.7.4.1.1. Childers Products, Division of ITW; Metal Jacketing Systems.

2.7.4.1.2. PABCO Metals Corporation; Surefit.

2.7.4.1.3. RPR Products, Inc.; Insul-Mate.

2.7.4.2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.

2.7.4.2.1. Sheet and roll stock ready for shop or field sizing.

2.7.4.2.2. Finish and thickness are indicated in field-applied jacket schedules.

2.7.4.2.3. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.

2.7.4.2.4. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

2.7.4.2.5. Factory-Fabricated Fitting Covers:

2.7.4.2.5.1. Same material, finish, and thickness as jacket.

2.7.4.2.5.2. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.

2.7.4.2.5.3. Tee covers.

2.7.4.2.5.4. Flange and union covers.

2.7.4.2.5.5. End caps.

2.7.4.2.5.6. Beveled collars.

2.7.4.2.5.7. Valve covers.

2.7.4.2.5.8. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.7.4.3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

2.7.4.3.1. Sheet and roll stock ready for shop or field sizing.

2.7.4.3.2. Material, finish, and thickness are indicated in field-applied jacket schedules.

2.7.4.3.3. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.

2.7.4.3.4. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

2.7.4.3.5. Factory-Fabricated Fitting Covers:

2.7.4.3.5.1. Same material, finish, and thickness as jacket.

2.7.4.3.5.2. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.

2.7.4.3.5.3. Tee covers.

2.7.4.3.5.4. Flange and union covers.

2.7.4.3.5.5. End caps.

2.7.4.3.5.6. Beveled collars.

2.7.4.3.5.7. Valve covers.

2.7.4.3.5.8. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.7.5. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

2.7.5.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.7.5.1.1. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.

2.8. TAPES

2.8.1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

2.8.1.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.8.1.1.1. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.

2.8.1.1.2. Compac Corp.; 104 and 105.

2.8.1.1.3. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.

2.8.1.1.4. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2.8.1.2. Width: 3 inches (75 mm).

2.8.1.3. Thickness: 11.5 mils (0.29 mm).

2.8.1.4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.

2.8.1.5. Elongation: 2 percent.

2.8.1.6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.

2.8.1.7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.8.2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

2.8.2.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- 2.8.2.1.1. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - 2.8.2.1.2. Compac Corp.; 110 and 111.
 - 2.8.2.1.3. Ideal Tape Co., Inc., an American Bilrite Company; 491 AWF FSK.
 - 2.8.2.1.4. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
 - 2.8.2.2. Width: 3 inches (75 mm).
 - 2.8.2.3. Thickness: 6.5 mils (0.16 mm).
 - 2.8.2.4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 2.8.2.5. Elongation: 2 percent.
 - 2.8.2.6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 2.8.2.7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
 - 2.8.3. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 - 2.8.3.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.8.3.1.1. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
 - 2.8.3.1.2. Compac Corp.; 130.
 - 2.8.3.1.3. Ideal Tape Co., Inc., an American Bilrite Company; 370 White PVC tape.
 - 2.8.3.1.4. Venture Tape; 1506 CW NS.

- 2.8.3.2.** Width: 2 inches (50 mm).
- 2.8.3.3.** Thickness: 6 mils (0.15 mm).
- 2.8.3.4.** Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
- 2.8.3.5.** Elongation: 500 percent.
- 2.8.3.6.** Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

2.8.4. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

- 2.8.4.1.** Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- 2.8.4.1.1.** Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.

- 2.8.4.1.2.** Compac Corp.; 120.

- 2.8.4.1.3.** Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.

- 2.8.4.1.4.** Venture Tape; 3520 CW.

- 2.8.4.2.** Width: 2 inches (50 mm).
- 2.8.4.3.** Thickness: 3.7 mils (0.093 mm).
- 2.8.4.4.** Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
- 2.8.4.5.** Elongation: 5 percent.
- 2.8.4.6.** Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.9. SECUREMENTS

- 2.9.1.** Bands:

2.9.1.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.9.1.1.1. Childers Products; Bands.

2.9.1.1.2. PABCO Metals Corporation; Bands.

2.9.1.1.3. RPR Products, Inc.; Bands.

2.9.1.2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

2.9.2. Insulation Pins and Hangers:

2.9.2.1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated.

2.9.2.1.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.9.2.2. AGM Industries, Inc.; CWP-1.

2.9.2.3. GEMCO; CD.

2.9.2.4. Midwest Fasteners, Inc.; CD.

2.9.2.5. Nelson Stud Welding; TPA, TPC, and TPS.

2.9.2.6. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

2.9.2.6.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.9.2.6.1.1. AGM Industries, Inc.; CWP-1.

2.9.2.6.1.2. GEMCO; Cupped Head Weld Pin.

2.9.2.6.1.3. Midwest Fasteners, Inc.; Cupped Head.

2.9.2.6.1.4. Nelson Stud Welding; CHP.

2.9.2.7. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

2.9.2.7.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.9.2.7.1.1. AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.

2.9.2.7.1.2. GEMCO; Perforated Base.

2.9.2.7.1.3. Midwest Fasteners, Inc.; Spindle.

2.9.2.7.2. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

2.9.2.7.3. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

2.9.2.7.4. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2.9.2.8. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

2.9.2.8.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.9.2.8.1.1. GEMCO; Nylon Hangers.

2.9.2.8.1.2. Midwest Fasteners, Inc.; Nylon Insulation Hangers.

2.9.2.8.2. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.

2.9.2.8.3. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).

2.9.2.8.4. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2.9.2.9. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

2.9.2.9.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.9.2.9.1.1. AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.

2.9.2.9.1.2. GEMCO; Press and Peel.

2.9.2.9.1.3. Midwest Fasteners, Inc.; Self Stick.

2.9.2.9.2. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

2.9.2.9.3. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

2.9.2.9.4. Adhesive-backed base with a peel-off protective cover.

2.9.2.10. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

2.9.2.10.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.9.2.10.1.1. AGM Industries, Inc.; RC-150.

2.9.2.10.1.2. GEMCO; R-150.

2.9.2.10.1.3. Midwest Fasteners, Inc.; WA-150.

2.9.2.10.1.4. Nelson Stud Welding; Speed Clips.

2.9.2.10.2. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

2.9.2.11. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

2.9.2.11.1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.9.2.11.1.1. GEMCO.

2.9.2.11.1.2. Midwest Fasteners, Inc.

2.9.3. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

2.9.4. Wire: 0.062-inch (1.6-mm) soft-annealed, galvanized steel.

2.9.4.1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.9.4.1.1. C & F Wire.

2.9.4.1.2. Childers Products.

2.9.4.1.3. PABCO Metals Corporation.

2.9.4.1.4. RPR Products, Inc.

3. PART 3 - EXECUTION

3.1. EXAMINATION

3.1.1. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

3.1.1.1. Verify that systems and equipment to be insulated have been tested and are free of defects.

3.1.1.2. Verify that surfaces to be insulated are clean and dry.

3.1.1.3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. PREPARATION

3.2.1. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2.2. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

3.2.2.1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

- 3.2.2.2.** Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- 3.2.3.** Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- 3.2.4.** Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3. GENERAL INSTALLATION REQUIREMENTS

- 3.3.1.** Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- 3.3.2.** Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- 3.3.3.** Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- 3.3.4.** Install insulation with longitudinal seams at top and bottom of horizontal runs.
- 3.3.5.** Install multiple layers of insulation with longitudinal and end seams staggered.
- 3.3.6.** Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- 3.3.7.** Keep insulation materials dry during application and finishing.

- 3.3.8.** Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- 3.3.9.** Install insulation with least number of joints practical.
- 3.3.10.** Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 3.3.10.1.** Install insulation continuously through hangers and around anchor attachments.
 - 3.3.10.2.** For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3.3.10.3.** Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 3.3.10.4.** Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- 3.3.11.** Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- 3.3.12.** Install insulation with factory-applied jackets as follows:
 - 3.3.12.1.** Draw jacket tight and smooth.
 - 3.3.12.2.** Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.

3.3.12.3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.

3.3.12.3.1. For below ambient services, apply vapor-barrier mastic over staples.

3.3.12.4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.

3.3.12.5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

3.3.13. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

3.3.14. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

3.3.15. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.3.16. For above ambient services, do not install insulation to the following:

3.3.16.1. Vibration-control devices.

3.3.16.2. Testing agency labels and stamps.

3.3.16.3. Nameplates and data plates.

3.3.16.4. Manholes.

3.3.16.5. Handholes.

3.3.16.6. Cleanouts.

3.4. PENETRATIONS

3.4.1. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

3.4.1.1. Seal penetrations with flashing sealant.

3.4.1.2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3.4.1.3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.

3.4.1.4. Seal jacket to roof flashing with flashing sealant.

3.4.2. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

3.4.3. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

3.4.3.1. Seal penetrations with flashing sealant.

3.4.3.2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3.4.3.3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).

3.4.3.4. Seal jacket to wall flashing with flashing sealant.

3.4.4. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

3.4.5. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).

3.4.5.1. Comply with requirements in Division 07 Section "Penetration Firestopping" and fire-resistive joint sealers.

3.4.6. Insulation Installation at Floor Penetrations:

3.4.6.1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).

3.4.6.2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5. EQUIPMENT INSULATION INSTALLATION

3.5.1. Secure insulation with adhesive and anchor pins and speed washers.

3.5.1.1. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.

3.5.1.2. Protect exposed corners with secured corner angles.

3.5.1.3. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

- 3.5.1.3.1.** Do not weld anchor pins to ASME-labeled pressure vessels.
 - 3.5.1.3.2.** Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - 3.5.1.3.3.** On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
 - 3.5.1.3.4.** Do not over compress insulation during installation.
 - 3.5.1.3.5.** Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - 3.5.1.3.6.** Impale insulation over anchor pins and attach speed washers.
 - 3.5.1.3.7.** Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
- 3.5.1.4.** Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

- 3.5.1.5.** Where insulation hangers on equipment are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch pre-stressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch pre-stressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
- 3.5.1.6.** Stagger joints between insulation layers at least 3 inches (75 mm).
- 3.5.1.7.** Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
- 3.5.1.8.** Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
- 3.5.1.9.** For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.6. MINERAL-FIBER INSULATION INSTALLATION

- 3.6.1.** Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

 - 3.6.1.1.** Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.

- 3.6.1.2.** Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
- 3.6.1.3.** Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - 3.6.1.3.1.** On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - 3.6.1.3.2.** On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - 3.6.1.3.3.** Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - 3.6.1.3.4.** Do not over compress insulation during installation.
 - 3.6.1.3.5.** Impale insulation over pins and attach speed washers.
 - 3.6.1.3.6.** Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

- 3.6.1.4.** For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

 - 3.6.1.4.1.** Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - 3.6.1.4.2.** Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).
- 3.6.1.5.** Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
- 3.6.1.6.** Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
- 3.6.1.7.** Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.
- 3.6.2.** Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

- 3.6.2.1.** Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
- 3.6.2.2.** Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
- 3.6.2.3.** Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - 3.6.2.3.1.** On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - 3.6.2.3.2.** On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - 3.6.2.3.3.** Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - 3.6.2.3.4.** Do not over compress insulation during installation.
 - 3.6.2.3.5.** Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

3.6.3. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

3.6.3.1.1. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

3.6.3.1.2. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).

3.6.3.2. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

3.6.3.3. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.7. FIRE-RATED INSULATION SYSTEM INSTALLATION

3.7.1. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

- 3.7.2.** Insulate duct access panels and doors to achieve same fire rating as duct.
- 3.7.3.** Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Penetration Firestopping."

3.8. FINISHES

- 3.8.1.** Duct and Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
 - 3.8.1.1.** Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - 3.8.1.1.1.** Finish Coat Material: Interior, flat, latex-emulsion size.
- 3.8.2.** Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- 3.8.3.** Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- 3.8.4.** Do not field paint aluminum or stainless-steel jackets.

3.9. FIELD QUALITY CONTROL

- 3.9.1.** Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- 3.9.2.** Perform tests and inspections.
- 3.9.3.** Tests and Inspections:

- 3.9.3.1.** Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each duct system defined in the "Duct Insulation Schedule, General" Article.
- 3.9.3.2.** Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
- 3.9.4.** All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10.DUCT INSULATION SCHEDULE, GENERAL

3.10.1. Plenums and Ducts Requiring Insulation:

- 3.10.1.1.** Indoor, concealed supply and outdoor air.
- 3.10.1.2.** Indoor, exposed supply and outdoor air.
- 3.10.1.3.** Indoor, concealed return located in non-conditioned space.
- 3.10.1.4.** Indoor, exposed return located in non-conditioned space.
- 3.10.1.5.** Indoor, concealed, Type I, commercial, kitchen hood exhaust.
- 3.10.1.6.** Indoor, exposed, Type I, commercial, kitchen hood exhaust.
- 3.10.1.7.** Indoor, concealed oven and warewash exhaust.
- 3.10.1.8.** Indoor, exposed oven and warewash exhaust.

3.10.1.9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.

3.10.1.10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

3.10.1.11. Outdoor, concealed supply and return.

3.10.1.12. Outdoor, exposed supply and return.

3.10.2. Items Not Insulated:

3.10.2.1. Fibrous-glass ducts.

3.10.2.2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.

3.10.2.3. Factory-insulated flexible ducts.

3.10.2.4. Factory-insulated plenums and casings.

3.10.2.5. Flexible connectors.

3.10.2.6. Vibration-control devices.

3.10.2.7. Factory-insulated access panels and doors.

3.11. INDOOR DUCT AND PLENUM INSULATION SCHEDULE

3.11.1. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:

3.11.1.1. Flexible Elastomeric: 1 inch (25 mm) thick.

3.11.1.2. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

3.11.1.3. Mineral-Fiber Board: 1-1/2 inches (38 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.

3.11.1.4. Phenolic: 1 inch (25 mm) thick.

- [illegible]

3.12.INDOOR PIPING INSULATION SCHEDULE

3.12.1. Refrigerant Suction and Hot-Gas Flexible Tubing:

3.12.1.1. All Pipe Sizes: Insulation shall be one of the following:

3.12.1.1.1. Flexible Elastomeric: 1 inch (25 mm) thick.

3.12.1.1.2. Polyolefin: 1 inch (25 mm) thick.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1. This Section includes refrigerant piping used for air-conditioning applications.

1.3. PERFORMANCE REQUIREMENTS

- 1.3.1. Line Test Pressure for Refrigerant R-410A:

- 1.3.1.1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
- 1.3.1.2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
- 1.3.1.3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

1.4. SUBMITTALS

- 1.4.1. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
 - 1.4.1.1. Thermostatic expansion valves.
 - 1.4.1.2. Solenoid valves.
 - 1.4.1.3. Hot-gas bypass valves.
 - 1.4.1.4. Filter dryers.
 - 1.4.1.5. Strainers.
- 1.4.2. Welding certificates.
- 1.4.3. Field quality-control test reports.
- 1.4.4. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5. QUALITY ASSURANCE

- 1.5.1.** Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- 1.5.2.** Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- 1.5.3.** Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6. PRODUCT STORAGE AND HANDLING

- 1.6.1.** Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.7. COORDINATION

- 1.7.1.** Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

2. PART 2 - PRODUCTS

2.1. COPPER TUBE AND FITTINGS

- 2.1.1.** Copper Tube: ASTM B 88M, Type A or B).
- 2.1.2.** Wrought-Copper Fittings: ASME B16.22.
- 2.1.3.** Wrought-Copper Unions: ASME B16.22.
- 2.1.4.** Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- 2.1.5.** Brazing Filler Metals: AWS A5.8.
- 2.1.6.** Flexible Connectors:
 - 2.1.6.1.** Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2.1.6.2.** End Connections: Socket ends.
 - 2.1.6.3.** Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
 - 2.1.6.4.** Pressure Rating: Factory test at minimum 500 psig (3450 kPa).

2.1.6.5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.1.7. Check Valves:

2.1.7.1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.

2.1.7.2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.

2.1.7.3. Piston: Removable polytetrafluoroethylene seat.

2.1.7.4. Closing Spring: Stainless steel.

2.1.7.5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.

2.1.7.6. End Connections: Socket, union, threaded, or flanged.

2.1.7.7. Maximum Opening Pressure: 0.50 psig (3.4 kPa).

2.1.7.8. Working Pressure Rating: 500 psig (3450 kPa).

2.1.7.9. Maximum Operating Temperature: 275 deg F (135 deg C).

2.1.8. Service Valves:

2.1.8.1. Body: Forged brass with brass cap including key end to remove core.

2.1.8.2. Core: Removable ball-type check valve with stainless-steel spring.

2.1.8.3. Seat: Polytetrafluoroethylene.

2.1.8.4. End Connections: Copper spring.

2.1.8.5. Working Pressure Rating: 500 psig (3450 kPa).

2.1.9. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

2.1.9.1. Body and Bonnet: Plated steel.

2.1.9.2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.

2.1.9.3. Seat: Polytetrafluoroethylene.

- 2.1.9.4. End Connections: Threaded.
- 2.1.9.5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 24 or 115-V ac coil.
- 2.1.9.6. Working Pressure Rating: 400 psig (2760 kPa).
- 2.1.9.7. Maximum Operating Temperature: 240 deg F (116 deg C).
- 2.1.9.8. Manual operator.
- 2.1.10. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
 - 2.1.10.1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 - 2.1.10.2. Piston, Closing Spring, and Seat Insert: Stainless steel.
 - 2.1.10.3. Seat Disc: Polytetrafluoroethylene.
 - 2.1.10.4. End Connections: Threaded.
 - 2.1.10.5. Working Pressure Rating: 400 psig (2760 kPa).
 - 2.1.10.6. Maximum Operating Temperature: 240 deg F (116 deg C).
- 2.1.11. Thermostatic Expansion Valves: Comply with ARI 750.
 - 2.1.11.1. Body, Bonnet, and Seal Cap: Forged brass or steel.
 - 2.1.11.2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 - 2.1.11.3. Packing and Gaskets: Non-asbestos.
 - 2.1.11.4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 - 2.1.11.5. Suction Temperature: 40 deg F (4.4 deg C)
 - 2.1.11.6. Superheat: Adjustable.
 - 2.1.11.7. Reverse-flow option (for heat-pump applications).
 - 2.1.11.8. End Connections: Socket, flare, or threaded union.
 - 2.1.11.9. Working Pressure Rating: 700 psig (4820 kPa).

2.1.12. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

- 2.1.12.1.** Body, Bonnet, and Seal Cap: Ductile iron or steel.
- 2.1.12.2.** Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
- 2.1.12.3.** Packing and Gaskets: Non-asbestos.
- 2.1.12.4.** Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
- 2.1.12.5.** Seat: Polytetrafluoroethylene.
- 2.1.12.6.** Equalizer: External.
- 2.1.12.7.** Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 24-V ac coil.
- 2.1.12.8.** End Connections: Socket.
- 2.1.12.9.** Set Pressure: Jamet.
- 2.1.12.10.** Throttling Range: Maximum 5 psig (34 kPa).
- 2.1.12.11.** Working Pressure Rating: 500 psig (3450 kPa).
- 2.1.12.12.** Maximum Operating Temperature: 240 deg F (116 deg C).

2.1.13. Straight-Type Strainers:

- 2.1.13.1.** Body: Welded steel with corrosion-resistant coating.
- 2.1.13.2.** Screen: 100-mesh stainless steel.
- 2.1.13.3.** End Connections: Socket or flare.
- 2.1.13.4.** Working Pressure Rating: 500 psig (3450 kPa).
- 2.1.13.5.** Maximum Operating Temperature: 275 deg F (135 deg C).

2.1.14. Angle-Type Strainers:

- 2.1.14.1.** Body: Forged brass or cast bronze.
- 2.1.14.2.** Drain Plug: Brass hex plug.

- 2.1.14.3.** Screen: 100-mesh monel.
- 2.1.14.4.** End Connections: Socket or flare.
- 2.1.14.5.** Working Pressure Rating: 500 psig (3450 kPa).
- 2.1.14.6.** Maximum Operating Temperature: 275 deg F (135 deg C).
- 2.1.15.** Moisture/Liquid Indicators:
 - 2.1.15.1.** Body: Forged brass.
 - 2.1.15.2.** Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 - 2.1.15.3.** Indicator: Color coded to show moisture content in ppm.
 - 2.1.15.4.** Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 - 2.1.15.5.** End Connections: Socket or flare.
 - 2.1.15.6.** Working Pressure Rating: 500 psig (3450 kPa).
 - 2.1.15.7.** Maximum Operating Temperature: 240 deg F (116 deg C).
- 2.1.16.** Replaceable-Core Filter Dryers: Comply with ARI 730.
 - 2.1.16.1.** Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 - 2.1.16.2.** Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 - 2.1.16.3.** Desiccant Media: Activated charcoal.
 - 2.1.16.4.** Designed for reverse flow (for heat-pump applications).
 - 2.1.16.5.** End Connections: Socket.
 - 2.1.16.6.** Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
 - 2.1.16.7.** Maximum Pressure Loss: 2 psig (14 kPa).
 - 2.1.16.8.** Working Pressure Rating: 500 psig (3450 kPa).

- 2.1.16.9.** Maximum Operating Temperature: 240 deg F (116 deg C).
- 2.1.17.** Permanent Filter Dryers: Comply with ARI 730.
 - 2.1.17.1.** Body and Cover: Painted-steel shell.
 - 2.1.17.2.** Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 - 2.1.17.3.** Desiccant Media: Activated charcoal
 - 2.1.17.4.** Designed for reverse flow (for heat-pump applications).
 - 2.1.17.5.** End Connections: Socket.
 - 2.1.17.6.** Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
 - 2.1.17.7.** Maximum Pressure Loss: 2 psig (14 kPa).
 - 2.1.17.8.** Working Pressure Rating: 500 psig (3450 kPa).
 - 2.1.17.9.** Maximum Operating Temperature: 240 deg F (116 deg C).
- 2.1.18.** Mufflers:
 - 2.1.18.1.** Body: Welded steel with corrosion-resistant coating.
 - 2.1.18.2.** End Connections: Socket or flare.
 - 2.1.18.3.** Working Pressure Rating: 500 psig (3450 kPa).
 - 2.1.18.4.** Maximum Operating Temperature: 275 deg F (135 deg C).
- 2.1.19.** Receivers: Comply with ARI 495.
 - 2.1.19.1.** Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
 - 2.1.19.2.** Comply with UL 207; listed and labeled by an NRTL.
 - 2.1.19.3.** Body: Welded steel with corrosion-resistant coating.
 - 2.1.19.4.** Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
 - 2.1.19.5.** End Connections: Socket or threaded.

2.1.19.6. Working Pressure Rating: 500 psig (3450 kPa).

2.1.19.7. Maximum Operating Temperature: 275 deg F (135 deg C).

2.1.20. Liquid Accumulators: Comply with ARI 495.

2.1.20.1. Body: Welded steel with corrosion-resistant coating.

2.1.20.2. End Connections: Socket or threaded.

2.1.20.3. Working Pressure Rating: 500 psig (3450 kPa).

2.1.20.4. Maximum Operating Temperature: 275 deg F (135 deg C).

2.2. REFRIGERANTS

2.2.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.2.2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.2.2.1. Atofina Chemicals, Inc.

2.2.2.2. DuPont Company; Fluorochemicals Div.

2.2.2.3. Honeywell, Inc.; Genetron Refrigerants.

2.2.3. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

3. PART 3 - EXECUTION

3.1. PIPING INSTALLATION

3.1.1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

3.1.2. Install refrigerant piping according to ASHRAE 15.

3.1.3. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

- 3.1.4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- 3.1.5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- 3.1.6. Install piping adjacent to machines to allow service and maintenance.
- 3.1.7. Install piping free of sags and bends.
- 3.1.8. Install fittings for changes in direction and branch connections.
- 3.1.9. Select system components with pressure rating equal to or greater than system operating pressure.
- 3.1.10. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operation" for solenoid valve controllers, control wiring, and sequence of operation.
- 3.1.11. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- 3.1.12. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- 3.1.13. Install refrigerant piping in protective conduit where installed belowground.
- 3.1.14. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- 3.1.15. Slope refrigerant piping as follows:
 - 3.1.15.1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 3.1.15.2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3.1.15.3. Install traps and double risers to entrain oil in vertical runs.
 - 3.1.15.4. Liquid lines may be installed level.

- 3.1.16.** When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- 3.1.17.** Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
 - 3.1.17.1.** Shot blast the interior of piping.
 - 3.1.17.2.** Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
 - 3.1.17.3.** Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 - 3.1.17.4.** Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
 - 3.1.17.5.** Finally, draw a clean, dry, lintless cloth through the tube or pipe.
 - 3.1.17.6.** Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.
- 3.1.18.** Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- 3.1.19.** Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."
- 3.1.20.** Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- 3.1.21.** Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- 3.1.22.** Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.
- 3.1.23.** Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

3.2. PIPE JOINT CONSTRUCTION

- 3.2.1.** Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- 3.2.2.** Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- 3.2.3.** Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- 3.2.4.** Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- 3.2.5.** Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 3.2.5.1.** Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 - 3.2.5.2.** Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
- 3.2.6.** Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 3.2.6.1.** Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
 - 3.2.6.2.** Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- 3.2.7.** Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.
- 3.2.8.** Welded Joints: Construct joints according to AWS D10.12/D10.12M.
- 3.2.9.** Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3. HANGERS AND SUPPORTS

- 3.3.1.** Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- 3.3.2.** Install the following pipe attachments:

- 3.3.2.1.** Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
 - 3.3.3.** Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 3.3.3.1.** NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
 - 3.3.3.2.** NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).

3.4. FIELD QUALITY CONTROL

- 3.4.1.** Perform tests and inspections and prepare test reports.
- 3.4.2.** Tests and Inspections:
 - 3.4.2.1.** Comply with ASME B31.5, Chapter VI.
 - 3.4.2.2.** Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - 3.4.2.3.** Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - 3.4.2.3.1.** Fill system with nitrogen to the required test pressure.
 - 3.4.2.3.2.** System shall maintain test pressure at the manifold gage throughout duration of test.
 - 3.4.2.3.3.** Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - 3.4.2.3.4.** Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.5. SYSTEM CHARGING

- 3.5.1.1.** Install core in filter dryers after leak test but before evacuation.

- 3.5.1.2.** Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
- 3.5.1.3.** Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
- 3.5.1.4.** Charge system with a new filter-dryer core in charging line.

3.6. ADJUSTING

- 3.6.1.** Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- 3.6.2.** Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- 3.6.3.** Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- 3.6.4.** Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 3.6.4.1.** Open shutoff valves in condenser water circuit.
 - 3.6.4.2.** Verify that compressor oil level is correct.
 - 3.6.4.3.** Open compressor suction and discharge valves.
 - 3.6.4.4.** Open refrigerant valves except bypass valves that are used for other purposes.
 - 3.6.4.5.** Check open compressor-motor alignment and verify lubrication for motors and bearings.
- 3.6.5.** Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

1. PART 1 - GENERAL

1.1. SCOPE

- 1.1.1.** Provide and install ductwork and accessories complete for the air distribution system, as indicated on the drawings and as specified.

1.2. STANDARDS

- 1.2.1.** Comply with SMACNA (Sheet Metal and Air Conditioning Contractors National Association) recommendations for fabrication, construction and details, and installation procedures, except as otherwise indicated.
- 1.2.2.** Comply with American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), except as otherwise indicated.
- 1.2.3.** Comply with the National Standards Manual of the American Air Balance Council (AABC) for testing of duct systems.
- 1.2.4.** Use of proprietary manufacturers' tables for selection of duct gauges is not acceptable (e.g. "Ductmate", 'TDC').

1.3. SUBMITTALS

- 1.3.1.** Refer to Division 01 and Section 230500 BASIC HVAC REQUIREMENTS, MATERIALS AND METHODS.
- 1.3.2.** Submit manufacturer's product data and/or shop drawings for the following:
 - 1.3.2.1.** Transition elbows.
 - 1.3.2.2.** Seal and reinforcing schedule for all ductwork fabrication types.
 - 1.3.2.3.** Turning vane and turning vane installation.
 - 1.3.2.4.** Ductwork layouts and fabrication drawings.
 - 1.3.2.5.** Detailed drawings of fume hood exhaust plenums including fan connections, supports and bracings.

- 1.3.2.6. Standards.
- 1.3.2.7. Hangers and Supports.
- 1.3.2.8. Duct lining.
- 1.3.2.9. Duct lining adhesive.
- 1.3.2.10. Sealants.
- 1.3.2.11. Manual volume dampers.
- 1.3.2.12. Fire dampers.
- 1.3.2.13. Combination fire and smoke dampers.
- 1.3.2.14. Smoke dampers.
- 1.3.2.15. Automatic control dampers.
- 1.3.2.16. Sound attenuators.
- 1.3.2.17. Access doors.
- 1.3.2.18. Duct air monitoring stations.
- 1.3.3. Duct Pressure Leak Test:
 - 1.3.3.1. Procedures, including testing pressure.
 - 1.3.3.2. Certifications.

2. PART 2 - PRODUCTS

2.1. DUCTWORK MATERIALS

- 2.1.1. Ducts shall be constructed with G-90 or better galvanized steel (ASTM A 653) LFQ, chemical treat, unless otherwise noted.
- 2.1.2. Stainless steel duct shall be fabricated from lock form grade, Type 304, ASTM-A167, No. 4 general purpose finish. Protect finish with mill applied protective plastic/paper throughout construction.

- 2.1.3.** Aluminum exhaust air ducts for shower room: Gauge and construction per Table No. 6-A and 6-B for static pressure up to 2"w.g. to conform to California Mechanical Code (CMC).
- 2.1.4.** Grease exhaust ducts shall be welded and constructed of black steel with minimum thickness of 0.055" as stated in CMC.

2.2. RECTANGULAR DUCT

- 2.2.1.** Construct rectangular ductwork to meet criteria defined in the SMACNA "HVAC Duct Construction Standards Metal and Flexible" latest edition and latest CMC (where SMACNA and CMC requirements differ, SMACNA DCS requirements shall govern). All ductwork must comply with all local, state and federal code requirements.
- 2.2.2.** Where the standards allow the option of external reinforcing or internal tie rods, only the external reinforcing options shall be used.
- 2.2.3.** Pittsburgh lock shall be used on all longitudinal seams. All longitudinal seams will be sealed with mastic sealant. Snaplock is not acceptable.
- 2.2.4.** Ductmate, TDC or similar proprietary duct connection systems will not be accepted, except as a method of joinery.
- 2.2.5.** Fittings shall be constructed and reinforced as ductwork according to the longest span.

2.3. ROUND AND OVAL DUCT

- 2.3.1.** Round and oval duct shall be galvanized steel, constructed in accordance with SMACNA "Duct Construction Standards (DCS), Metal and Flexible" and the latest CMC (where SMACNA and CMC requirements differ, SMACNA DCS requirements shall govern), except as noted.
- 2.3.2.** Minimum duct gauge shall be 24 gauge.
- 2.3.3.** All round ducts shall be spiral lock seam. Longitudinal seam duct is not acceptable.

- 2.3.4.** Round ductwork shall be spiral seam construction only. Gauges and fittings shall be in accordance with SMACNA Duct Construction Standards and the latest CMC (where SMACNA and CMC requirements differ, SMACNA DCS requirements shall govern), except as noted.
- 2.3.4.1.** Joints 0"-20" diameter, interior slip coupling beaded at center, fastened to duct with screws and sealing compound applied continuously around joint before assembling and after fastening.
- 2.3.4.2.** Joints 21"-72" diameter, use 3 piece, gasketed, flanged joints consisting of 2 internal flanges (with integral mastic sealant) split to accommodate minor differences in duct diameter, and one external closure band designed to compress gasketing between internal flanges. Example: Ductmate Spiralmate or equal.
- 2.3.4.3.** Joints 73" diameter and up, use companion angle flanged joints only as defined in Fig. 3-2 of the SMACNA Manual. Refer to manual for proper sizing and construction details. Ductwall to be welded longitudinal seams.
- 2.3.5.** Fittings shall be continuously welded, standing seam, or spot welded and sealed. Metal thickness and reinforcing shall be equivalent to the requirements of largest span.
- 2.3.5.1.** All elbows greater than 45" shall be the radius type, $R=1.5$ times duct diameter.
- 2.3.5.2.** Elbows less than 12" shall be of die stamped construction. Elbows 12" or greater shall be 5-gore construction.

- 2.3.5.3.** Diverging and converging flow fittings shall be constructed with no excess material projecting from the body into the branch tap entrance. All such fittings shall be 45° "shoe" entrance, wye plus elbow, or 45° lateral branch. Special fittings such as heel tapped elbows and bullhead tees may be used only where shown on drawings. Straight saddle taps shall not be used.

2.4. LOW PRESSURE DUCTWORK

- 2.4.1.** Applicable to supply ductwork downstream of air terminal units, general and toilet exhaust systems, return air ductwork, outside air intake ductwork, and ductwork for fan-coil systems (except fan-coil unit system containing HEPA filters located in duct distribution system).
- 2.4.2.** Gauges, Reinforcement, Joints, Seams, Sealing, Fitting, Support and Other Details: Construct ducts per SMACNA DCS based on the total static pressure plus 1" of the corresponding fan (except supply air fan in air handling unit with system having air terminal units), as scheduled on the drawing.
- 2.4.3.** Sealing: In accordance with SMACNA DCS, Table 1.2.
- 2.4.4.** Ductwork used for transfer air purposes only can be constructed at 1" pressure class.

2.5. MEDIUM PRESSURE DUCTWORK

- 2.5.1.** Applicable to supply ductwork discharge of air handling unit to inlet of air terminal units and to HEPA filter connection and fan pressure above 3" external static pressure.
- 2.5.2.** Gauges, Reinforcement, Joints, Seams, Fitting, Support and Other Details: Construct ducts per SMACNA DCS based on the total static pressure of the corresponding supply fan as scheduled on the drawing. Round ducts, gauge according to SMACNA DCS Table 3-2, with the size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular ducts shown on the drawings.

- 2.5.3.** Sealing: Class A in accordance with SMACNA DCS, Table 1-2. Refer to Part 3 – EXECUTION for required pressure tests for installed duct systems.
- 2.5.4.** Rectangular Ducts and Casings: In accordance with SMACNA DCS. Submit details of proposed joints/sealing system. Provide bolted construction and tie-rod reinforcement where required.
- 2.5.5.** Round Ducts: Furnish duct and fittings made by the same manufacturer to ensure good fit of slip joints.
 - 2.5.5.1.** Elbows: Factory fabricated elbows, stamped or segmented standing seam per SMACNA DCS Figure 3-3. Coat galvanized areas of fittings, damaged by welding with a corrosion-resistant aluminum paint or galvanized repair compound.
 - 2.5.5.2.** Provide conical tees, laterals, reducers, and other low loss fittings as shown in SMACNA Standards.
 - 2.5.5.3.** Optional light gauge round/oval duct and fittings, such as United Sheet Metal "Uni-Light", United McGill or equal. Provide certified tests indicating that the rigidity and performance is equivalent to SMACNA standard gauge ducts.
 - 2.5.5.3.1.** Ducts: Manufacturer's published standard gauge, G60 coating, spiral lock seam construction with an intermediate standing rib.
 - 2.5.5.3.2.** Fittings: May be manufacturer's standard as shown in published catalogs, fabricated by spot welding and bonding with neoprene base cement or machine formed seam in lieu of continuous welded seams.
 - 2.5.5.4.** Double wall circular duct shall be Lindab "Spiro Sake Double Wall Duct System", United McGill or equal. Both the inner and outer shells shall be solid 18 gauge sheet metal, unless noted otherwise with perforated inner shell.

2.6. DOUBLE-WALL DUCT AND FITTINGS

2.6.1. Ducts: Fabricate double-wall (insulated) ducts with an outer shell and an inner duct. Dimensions indicated are for inner ducts.

2.6.1.1. Outer Shell: Base metal thickness on outer shell dimensions. Fabricate outer shell in metal, thickness specified for single wall duct.

2.6.1.2. Insulation: 1" thick fibrous glass, unless otherwise indicated. Terminate insulation where double wall duct connects to single wall duct or uninsulated components, and reduce outer shell dimensions to inner duct dimensions.

2.6.1.2.1. Thermal Conductivity (k-Value): 0.26 at 75°F mean temperature.

2.6.1.3. Solid Inner Ducts: Use the following sheet metal gauges:

2.6.1.3.1. 3" to 42" in dimensions: 26 gauge

2.6.1.3.2. 44" to 60" in dimensions 24 gauge

2.6.1.3.3. 62" to 88" in dimension 22 gauge

2.6.1.4. Perforated Inner Ducts: Fabricate with 22 gauge sheet metal having 3/32" diameter perforations, with overall open area of 23%.

2.6.1.5. Maintain concentricity of inner duct to outer shell by mechanical means. Prevent dislocation of insulation by mechanical means.

2.6.1.6. Joints Construction:

2.6.1.6.1. Rectangular: Factory formed transverse duct connector (TDC) and Pittsburgh locks longitudinal seams.

2.6.1.6.2. Round and Flat Oval: Spiral lockseam.

2.6.2. Fittings: Fabricate double wall (insulated) fittings with an outer shell and an inner duct.

2.6.2.1. Solid Inner Ducts: Use the following sheet metal gauges:

2.6.2.1.1. 3" to 34" in dimension: 24 gauge

2.6.2.1.2. 35" to 58" in dimension: 22 gauge

2.6.2.1.3. 60" to 88" in dimension 20 gauge

2.6.2.2. Perforated Inner Ducts: Fabricate with 22 gauge sheet metal having 3/32" diameter perforations, with overall open area of 23%.

2.6.2.3. Joints Construction:

2.6.2.3.1. Rectangular: Factory formed TDC flanged connection ends.

2.6.2.3.2. Round and Flat Oval: Joints construction shall be per specifications for single wall duct.

2.6.3. Manufacturers:

2.6.3.1. McGill AirFlow Corporation

2.6.3.2. Lindab Inc.

2.6.3.3. SEMCO Incorporated

2.7. CONTRACTOR FABRICATED CASINGS AND PLENUMS

2.7.1. Unless required otherwise by drawings, single wall casings and plenums may either be contractor or factory fabricated where shown on drawings. All double wall casings and plenums shall be factory fabricated.

2.7.2. Casings and plenums shall be constructed in accordance with SMACNA "HVAC Duct Construction Standards" and as specified below.

- 2.7.3.** All casings and plenums on the suction side of any fan, including return air, outside air, or mixing plenum shall be constructed to 2" negative pressure class.
- 2.7.4.** Louver blank-off panels shall be constructed to 2" negative pressure class.
- 2.7.5.** All casings and plenums for relief and exhaust air shall be 2" positive or negative pressure class.
- 2.7.6.** All casings and plenums on the discharge side of supply fans shall be 4" positive pressure class.
- 2.7.7.** Single wall plenums shall be of the standing seam type construction. Submit shop drawings indicating overall dimensions, support details, corner & edge details, penetration details, equipment installation details, and pressure class.
- 2.7.8.** Seal all seams, edges, and corners with approved duct sealant.
- 2.7.9.** Casing materials shall be the same as that for the connected duct systems.
- 2.7.10.** Where automatic dampers may completely shut off air flow and subject plenum or casing to fan close off pressure, install pressure relief panels, rated to open at 125% of system operating pressure.

2.8. MISCELLANEOUS DUCTWORK MATERIALS

- 2.8.1.** General: Provide miscellaneous materials and products of the types and sizes indicated, and where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.
- 2.8.2.** Turning vanes shall be Harper double wall turning vanes fabricated from the same material as the duct. Tab spacing shall be SMACNA standard. Rail systems with non-standard tab spacings shall not be accepted. All tabs shall be used, do not skip tabs. Mounting rails shall have friction insert tabs which align the vanes automatically. Vanes shall be subjected to tensile loading and be capable of supporting 250 lbs.

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- 2.8.3.** Ductwork support materials: Except as otherwise indicated, provide galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.
- 2.8.4.** Duct Liner: See Section 230702, HVAC SYSTEM ACOUSTICAL LINING.
- 2.8.5.** Duct liner adhesive:
 - 2.8.5.1.** Manufacturers:
 - 2.8.5.1.1.** Design basis: Design Polymerics Model DP 2501 and DP 2502.
 - 2.8.5.1.2.** Other acceptable manufacturers: Childers Model CP-127, King Co. Model II-410, or Hardcast Model Glasgrip 981
 - 2.8.5.2.** Description: Water based adhesive. Adhesive shall be used to encapsulate fiberglass duct liner that has been cut.
 - 2.8.5.3.** Fire Rating with Class 1 rating with flame spread/smoke development of less than 25/50 when tested in accordance with ASTM E-84 (UL723, NFPA 90A and B).
- 2.8.6.** Duct Sealant:
 - 2.8.6.1.** Manufacturers:
 - 2.8.6.1.1.** Design basis: Design Polymerics Model DP1010 and DP 1020.
 - 2.8.6.1.2.** Other acceptable manufacturers: United McGill (water based), Hardcast Model Irongrip 601, or Precision Model PA 3084.
 - 2.8.6.2.** Description: Non-hardening mastic elastic sealant. Sealant shall be UL 181 Listed.
 - 2.8.6.3.** Fire rating: Class I rating with flame spread/smoke development of less than 25/50 when tested in accordance with ASTM E-84 (UL 723, NFPA 90A and 90B).

2.8.7. Duct tape sealing system:

2.8.7.1. Duct tape shall be of fabric reinforced type. UL 181B-FX. Use of plastic duct tape is prohibited.

2.8.7.2. Manufacturers: NASHUA 558CA or equal.

2.8.7.3. California Energy Commission approved.

2.8.7.4. Use of plastic duct tape is prohibited.

2.8.8. Fiberglass ductboard is not accepted.

2.9. INSULATED FLEXIBLE DUCT (STANDARD DUTY)

2.9.1. Application: This product is to be used whenever making a flexible connection to supply air diffusers/registers and return air grilles, or as indicated on drawings.

2.9.2. Description: Factory preinsulated, encapsulated spring steel helix and impervious, smooth, non-perforated interior vinyl liner, and an exterior reinforced laminated vapor barrier. Air friction drop not greater than 0.15" water gauge per 100'.

2.9.3. Manufacturers: Casco CalFlex II, J.P. Lamborn (Genflex), or Thermaflex.

2.9.4. Fittings: Provide conical or tapered duct connection at all round duct takeoffs from rectangular sheet metal duct. Straight tap connections not acceptable. Flexible duct sections with integral manual damper not acceptable. Provide separate volume damper per Section 233300, AIR DUCT ACCESSORIES.

2.9.5. Duct: Operating pressure of 6" positive and 1" negative water gauge, temperature range shall be 0 to 200°F. Underwriters' Laboratories listed and meet the requirements of NFPA 90A with flame spread of 25 or less and a smoke developed rating of 50 or under.

2.9.6. Insulation: 1-1/2" thick fiberglass with density of 3/4 pound per cubic foot, R Value of 8.0..

2.9.7. Use of integral, factory volume damper accessory not acceptable.

2.10. INSULATED FLEXIBLE DUCT (SPECIAL DUTY)

- 2.10.1.** Application: This product is to be utilized whenever making a flexible connection to a HEPA filter, and at other inlet and outlet air devices serving clean rooms and operating rooms.
- 2.10.2.** Description: Factory preinsulated, fully encapsulated spring steel helix and impervious, smooth, non-perforated interior polymer inner liner, and an exterior reinforced polyethylene. Air friction drop not greater than 0.15" water gauge per 100'.
- 2.10.3.** Manufacturers: Casco L-181 or equal
- 2.10.4.** Fittings: Provide conical or tapered duct connection at all round duct takeoffs from rectangular sheet metal duct. Straight tap connections not acceptable. Flexible duct sections with integral manual damper not acceptable. Provide separate volume damper per Section 233300, AIR DUCT ACCESSORIES.
- 2.10.5.** Duct: Operating pressure of 6" positive water gauge, temperature range shall be 0 to 200°F. Underwriters' Laboratories listed and meet the requirements of NFPA 90A with flame spread of 25 or less and a smoke developed rating of 50 or under.
- 2.10.6.** Insulation: 1-1/2" thick fiberglass with density of 3/4 pound per cubic foot.
- 2.10.7.** Use of integral, factory volume damper accessory not acceptable.
- 2.10.8.** Use of nylon tie bands is prohibited.

2.11. EXHAUST DUCT FIRE WRAPPER

- 2.11.1.** Application: Grease exhaust ducts.

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- 2.11.2.** Description: Lightweight, non asbestos, high temperature inorganic foil encapsulated ceramic fiber blanket duct wrap. Duct wrap system allows a zero inch clearance to combustible construction and serves as fire resistive rated enclosure system, shaft enclosure, when used with a listed or approved through-penetration protection system. UL listed, California State Fire Marshall listing, and City of San Diego No. RR9425.
- 2.11.3.** Manufacturers: Thermal Ceramics "Firemaster" or equal.
- 2.11.4.** Performance Requirements:
 - 2.11.4.1.** Fire Resistive Enclosure Assembly ASTM E119: Large Scale Wall Test and Total Engulfment Test.
 - 2.11.4.2.** Non-combustibility, ASTM E136.
 - 2.11.4.3.** Class I interior finish materials, ASTM E84.
 - 2.11.4.4.** Zero inch clearance to combustibles, maximum allowable surface temperature on unexposed side, UL 1978.
- 2.11.5.** Materials:
 - 2.11.5.1.** Fire Resistive Duct Wrap: 1-1/2 inch thick.
 - 2.11.5.2.** Tapes:
 - 2.11.5.2.1.** High Performance Filament: One inch wide.
 - 2.11.5.2.2.** Aluminum foil Tape: To seal cut edges of blankets.
 - 2.11.5.3.** Banding Material: For Zero Clearance to Combustibles and One Hour Rating: 3/4 inch wide, no less than 0.015 inches thick, carbon steel.
 - 2.11.5.4.** Insulation Pins: 10 gauge, 4 inches to 5 inches long, copper coated steel, or no less than 1-1/2 inch by 1-1/2 inch or 1-1/2 inch diameter galvanized steel speed clip.
 - 2.11.5.5.** Fire Stopping Materials:

- 2.11.5.5.1.** Mesh: 304 stainless steel or 430 stainless steel, 0.005 inches thick.
- 2.11.5.5.2.** Bulk: UL No. R9464 classified, non-combustibles fiber with a Flame Spread of 0, Smoke Development of 0, and Fuel Contribution of 0.
- 2.11.5.5.3.** Putty: Water-based, mild chemical resistant, complying with ASTM E136-82.

2.12. AUXILIARY STEEL

- 2.12.1.** General: Provide auxiliary structural steel members for supports, seismic restraints and vibration isolators for ducts and equipment.
- 2.12.2.** All structural steel systems to be designed in accordance with AISC Steel Handbook.
- 2.12.3.** All systems to be secured to building structure or footings in a method acceptable to and approved by the Project Structural Engineer.
- 2.12.4.** Steel Work: Fabricate neatly. Grind off excess burrs and welding spatter. Paint with rust inhibitive primer. Apply finish topcoat where exposed to weather.
- 2.12.5.** Coordinate requirements for steel supports in shafts and elsewhere such that other trades may utilize the same support system.

2.13. MANUAL VOLUME DAMPERS

- 2.13.1.** Manual volume damper shall be provided at each branch duct for (1) supply air duct systems, (2) return air duct systems and (3) exhaust air duct systems, and where required for final air balance. At a minimum, provide damper at locations as shown in AABC "National Standards for Total System Balance", 2002 Edition Figure 6.1.
- 2.13.2.** Use 3/8" continuous square rod and 18 gauge galvanized stiffened blade for damper blade sizes (1) 18" wide by 18" high and smaller or (2) 12" diameter and smaller.

- 2.13.3.** Use 1/2" continuous square rod and 16 gauge galvanized stiffened blade for damper blade sizes 19" to 48" wide by 10" high. Maximum blade size shall be 48" by 10" high. Maximum diameter shall be 16".
- 2.13.4.** Maximum of Two Blades without a Frame: Over two blades, use a manufactured 16 gauge galvanized, stiffened, opposed blade damper in a 14 gauge galvanized steel frame. All hardware shall be galvanized except use brass unions and bronze oilite bearing; Pacific Air Products Series 200; Pottorff series 400, or equal.
- 2.13.5.** Quadrant shall be Durodyne Model 3/8" K-4/1/2" K-5 Quadline, Ventlock model 555 Ventline, or equal.
- 2.13.6.** Provide closed end bearing, Durodyne SB-338 (3/8")/SB-312 (1/2"), Ventlock Model 609, or equal.
- 2.13.7.** Cut slot in end of damper rod (Quadrant End) to indicate blade position.
- 2.13.8.** Provide galvanized sheet metal "hat section" on ducts with exterior insulation so that quadrant will be exposed.
- 2.13.9.** Each square rod shall be installed vertical or horizontal so that quadrant will be accessible for adjusting.
- 2.13.10.** Provide arm extension and remote damper controller where dampers are not readily accessible or located above in inaccessible ceilings.

2.14. DYNAMIC FIRE DAMPERS

- 2.14.1.** Fire Dampers: Design and construction in accordance with NFPA Pamphlet No. 90A and UL listed for use in dynamic systems. Installed in accordance with fire damper manufacturer's installation instructions. Shutter type, 100% free area.
 - 2.14.1.1.** Manufacturer: Ruskin D1BD2 Style C or equivalent by Air Balance, Pottorff or Airstream.

2.14.1.2. Frames: Galvanized steel with galvanized steel sleeve and provisions for attaching to ducts and securing to building structure.

2.14.1.3. Provide dampers label per UL Standard 555. Fire rating of 1-1/2 hour unless otherwise noted.

2.14.1.4. Fusible Link: 165°F.

2.15. COMBINATION FIRE AND SMOKE DAMPERS

2.15.1. Design and construction in accordance with NFPA 90A, UL 555 and UL 555S. Interlocking blade type. Installed in accordance with damper manufacturer's installation instructions. Furnished with microswitches and damper blade position indicator package.

2.15.2. Manufacturer: Ruskin FSD60, Greenheck, or equivalent by air Balance or Pottorff.

2.15.3. Frames: Galvanized steel with 16 gauge galvanized steel sleeve with provisions for attaching to duct and securing to building structure.

2.15.4. Blades: opposed blade, 14 gauge air foil and silicone rubber seals to withstand 450°F.

2.15.5. Provide damper label per UL 555. Fire rating of 1-1/2 hour. UL 555 classification and labeling as a leakage Class I, 350°F temperature.

2.15.6. Actuator: Electric damper and actuator shall meet applicable UL 555 and UL 555S qualifications. Manufacturer: Belimo or equal.

2.15.7. Resettable Reusable Link: Bi-Metallic Thermal Disc 165°F

2.15.8. Damper blade position indicator package: The package shall include two position indicator switches linked directly to the damper blade to provide the capability of remotely indicating damper blade position. Damper reset from fire alarm system. Fusible link trips and spring action close damper with fire mode. Ruskin Mode SP100.

- 2.15.9.** Control: Damper to close when smoke is detected by a smoke detector furnished and wired under Division 28. One microswitch shall close when the damper is fully closed, and the other switch shall close when the damper is fully open to indicate damper position. Damper reset from fire alarm system. Fusible link trips and spring action close damper with fire mode.
- 2.15.10.** Coordinate with Division 26 to provide local on/off switch at each individual damper where required by the local code authority.

2.16. SMOKE DAMPERS

- 2.16.1.** Smoke dampers shall utilize multi-blade construction and shall meet all requirements for smoke dampers in accordance with the latest edition of NFPA 90A and UL 555S and shall bear UL label for leakage resistance Class I. The leakage rating shall not exceed 4 CFM/square foot at 1" w.g. Provide damper blade position indicator.
- 2.16.2.** Manufacturer: Ruskin SD60 low leakage smoke damper.
- 2.16.3.** Blades: Blade edge shall be silicone rubber designed to withstand 450°F. Jamb seals shall be stainless steel.
- 2.16.4.** Actuator: Shall be electric and bear the UL label and shall be factory installed by the damper manufacturer to constitute a UL rated package. Linkage shall be arranged to permit emergency manual operation of damper.
- 2.16.5.** Damper Blade Position Indicator Package: The package shall include 2-position indicator switches linked directly to the damper blade to provide the capability of remotely indicating damper blade position. Damper reset from fire alarm system. Ruskin Model SP100.

2.17. AUTOMATIC CONTROL DAMPERS

- 2.17.1.** Refer to Section 230900 INSTRUMENTATION AND CONTROL FOR HVAC.

2.18. SOUND ATTENUATOR

- 2.18.1.** Description: Factory assembled unit, tested and certified by an independent acoustic testing laboratory, per ASTM E477. Provide test data taken within six months of submittal date.
- 2.18.2.** Manufacturer: IAC, Vibracoustics or equivalent.
- 2.18.3.** Construction:
 - 2.18.3.1.** Casings: 22 gauge minimum galvanized steel with minimum 26 gauge perforated galvanized steel baffle in accordance with ASHRAE Guide recommended construction for high pressure ductwork. Seams locked form and mastic filled. Acoustic baffles use smooth bellmouth at inlet and discharge, attached to casing using tongue and groove connection. Provide vertical supports where baffles are horizontal.
 - 2.18.3.2.** Acoustical Fill: Inorganic long fiberglass or mineral fiber packed under not less than 5% compression, and have a flame spread classification of 25, smoke development rating 15, and fuel contribution 20.
- 2.18.4.** Acoustical Performance: Sound trap tested by an independent testing laboratory and certified that units must meet the acoustic ratings. Meet local codes for fill erosion.

2.19. ACCESS DOOR

- 2.19.1.** Provide duct access doors with gaskets, hinged and with insulation where ductwork is indicated to be insulated. Access door with insulation shall have an internal sheet metal lining (sandwich type).
 - 2.19.1.1.** Manufacturer:
 - 2.19.1.1.1.** Design Basis: CESCO Model HAD hinged.
 - 2.19.1.2.** Other Acceptable Manufacturers: Ventfabrics.

2.20. DUCT AIR MONITORING STATIONS

- 2.20.1.** Description: Air monitoring stations shall be duct mounted, factory calibrated, and include manual volume control damper, airflow monitoring blades, and air straightening section. AMCA Standard 610-93 tested and bear the AMCA certified ratings seal.
- 2.20.2.** Manufacturer: Ruskin Model AMS 50 or equal.
- 2.20.3.** Application: Arena Bowl supply air duct.
- 2.20.4.** Control Damper: Heavy gauge extruded aluminum airfoil type with blade edge seal and flexible metal compression type jamb seals. Damper frame shall be 4" x 1", 0.081" thick with mounting flanges on both sides. Linkage shall be concealed out of the airstream and located within the damper frame to reduce pressure drop and noise, furnished with manual actuator.
- 2.20.5.** Airflow Monitoring Blades: Heavy gauge anodized extruded aluminum airfoil shaped fixed in 10" 16 gauge galvanized frame with measuring ports built into the monitoring blades.
- 2.20.6.** Air Straightening Section: 5" long 16 gauge galvanized sleeve attached to the monitoring blade frame.

3. PART 3 - EXECUTION

3.1. INSTALLATION OF DUCTWORK

3.1.1. General:

- 3.1.1.1.** Construct rectangular ductwork to meet all functional criteria defined in Section VII, of the SMACNA "HVAC Duct Construction Standards Metal and Flexible" latest edition. This shall be subsequently referred to as the SMACNA Manual. All ductwork must comply with all local, state and federal code requirements.
- 3.1.1.2.** See air handling unit and fan schedules for static pressure requirements. All fan pressures above 3" external static pressure shall be considered medium pressure.

- 3.1.1.3.** Use 1.5 radius elbows where possible. Use square elbows with turning vanes otherwise.
- 3.1.1.4.** Fabricate transition elbows turning vanes at correct angle so entering and leaving edges are parallel or tangent to air flow.
- 3.1.1.5.** All branch duct take-offs shall use 45° laterals or 45° "pants-leg" type fittings.
- 3.1.1.6.** Verify all dimensions at the site, making all field measurements and shop drawings necessary for fabrication and erection of sheet metal work. Dimensions of duct shown on design drawings are net free areas. Make allowances for beams. Pipes or other obstructions in building construction and for work of other contractors. Check plans showing work of other trades and consult with architect in the event of any interference.
- 3.1.1.7.** Fabricate ductwork in workmanlike manner with airtight joints, presenting smooth surfaces on inside, neatly finished on outside, construct with curves, bends, turning vanes to aid in easy flow of air.
- 3.1.1.8.** Construct, brace and support ducts and air plenum to prevent sagging and to minimize vibration when fans are operating.
- 3.1.1.9.** Maintain rectangular cross section of ductwork unless otherwise shown.
- 3.1.1.10.** Provide duct access doors for all fire dampers, control devices, smoke detectors and combination fire/smoke dampers.
- 3.1.1.11.** Use of "spin-ins" not permitted.
- 3.1.1.12.** Flexible duct not permitted in areas with exposed construction.
- 3.1.1.13.** Use of plastic duct tape is prohibited.

- 3.1.1.14.** All duct joints in designated exposed areas on the drawings to be clean and smooth and prepared for painting by others.
- 3.1.1.15.** Reapply protective coating to galvanized ductwork and accessories which have been welded. Use of product such as "Coldgalv" is acceptable.
- 3.1.1.16.** For ductwork serving areas of high humidity (showers, steam rooms, etc.) slope ductwork $\frac{1}{4}$ " per foot toward air inlet or outlet and install duct seam at top or side of the rectangular duct.
- 3.1.1.17.** Use of screws in ductwork serving laundry vents is prohibited.
- 3.1.1.18.** Cleanouts shall be provided in grease exhaust ducts at all low points, at each change of direction at 10' on centers in horizontal runs. Doors in ducts shall be hinged.
- 3.1.1.19.** Drains shall be provided at low point of dishwasher exhaust riser, piped to an approved receptor.
- 3.1.1.20.** The size of ductwork indicated on the drawings shall be net inside dimensions.
- 3.1.2.** Construction of rectangular galvanized steel ductwork:
 - 3.1.2.1.** Low pressure ductwork: Refer to the latest CMC and SMACNA "HVAC Duct Construction Standard", latest edition (DCS). Where CMC and SMACNA requirements differ, SMACNA DCS requirements shall govern.
 - 3.1.2.2.** Medium pressure ductwork: Refer to the latest CMC and latest SMACNA DCS. Where CMC and SMACNA requirements differ, the more stringent of the two shall govern. Seal all transverse joints, longitudinal seams and duct wall penetrations with approved sealant for Seal Class A per SMACNA DCS and Table 1-2. When duct reinforcement required on two sides, they shall be tied with rods at the ends.

3.1.2.3. Fittings and branch connections: Use 45° entry for rectangular and conical or bell mouth for round branch connections. Straight tap, flanged or spin-in fittings are not acceptable. Refer to SMACNA DCS, Figure 2-6. Transition fittings changing from rectangular to round made with transformation joint with minimum of 1 to 7 taper. Gauges to be 1 gauge heavier than connecting ductwork.

3.1.3. Construction of round ductwork:

3.1.3.1. Material: Spiral galvanized steel as manufactured by United Sheet Metal or equivalent by Omni Duct, Oreco, Clas Glas, Plenums Plus.

3.1.3.2. Construction: Refer to the latest CMC and SMACNA DCS. Where CMC and SMACNA requirements differ, SMACNA DCS requirements shall govern.

3.1.3.3. Fittings and connections for spiral ducts:

3.1.3.3.1. Use factory fabricated fittings as shown on drawings with radius of elbows and angle minimum of 1-1/2 times diameter of duct. Tee fittings of conical type or 45° lateral fitting. Refer to SMACNA DCS, Figures 3-4 and 3-5.

3.1.3.3.2. Joints between two ducts made with beaded sleeve joint with duct sealer applied to male end, mechanically fastened with sheet metal screws or pop rivets. Over joint and screw or rivet heads, apply coating of duct sealer.

3.1.3.3.3. Duct and fitting joined by slipping the projecting collar of the fittings into the pipe. Insertion length minimum of 2". Apply duct sealer and mechanically fasten per paragraph above.

- 3.1.3.3.4.** Adjustable elbows permitted only in pressure class of 2" w.g. and less. Elbows to be 4 gore type with continuous duct sealant at each gore joint. Short radius acceptable for low pressure system.

3.1.3.3.5. Fittings to be 1 gauge heavier than connecting ductwork.

3.1.3.3.6. Elbows in medium pressure systems shall be stamped or adjustable with each zone continuously included.

3.1.4. Bracing: Refer to 1995 SMACNA DCS, applicable tables and figures. Provide tie rod or angle at the ends where reinforcement requires on two sides for the medium pressure duct.

3.1.5. Duct Supports:

3.1.5.1. Support horizontal ducts with trapeze type hanger with all-thread rod for exposed areas; concealed areas can utilize strap type hangers of schedule size and spacing per SMACNA DCS, Tables 4-1 and 4-2 but not more than 10' apart. Install hangers at each change in direction of duct.

3.1.5.2. Extend strap hangers down both sides of ducts, turn under bottom 2" minimum. Metal screw hangers to bottom of duct and to upper and lower sides of ducts at not more than 12" on center.

3.1.5.3. Provide angle hangers formed by extending vertical bracing and angles or by rods connecting to bottom angles if size of bracing angles conforms to hanger schedule.

3.1.5.4. Support vertical ducts at every floor with angles or channels riveted to ducts. Rest angles or channels on floor slab or structural steel members placed in opening, otherwise noted.

3.1.5.5. Construct hangers of galvanized steel.

- 3.1.5.6.** Provide hangers for duct as recommended by SMACNA.
- 3.1.5.7.** Power driven anchor not permitted unless approved by Project Structural Engineer and Architect.
- 3.1.5.8.** Provide field applied primer finish to supports exposed to weather.
- 3.1.5.9.** Provide duct sealant at all duct wall penetrations using product appropriate to duct pressure class.
- 3.1.6.** Manual Balancing Dampers:
 - 3.1.6.1.** Provide manual balancing dampers (not all dampers are shown on drawings) where required to facilitate air distribution and balance. Reference AABC "National Standards for Total System Balance, 2002 Edition", Figure 6.1 as guideline.
 - 3.1.6.2.** After final adjustment of system, lock quadrants and mark clearly showing damper position.
 - 3.1.6.3.** Provide fluorescent colored plastic tape at dampers to facilitate identification by air balancer.
- 3.1.7.** Tapers:
 - 3.1.7.1.** Pitch sides of duct in a "diverging" airflow maximum of 20°.
 - 3.1.7.2.** Pitch sides of duct in a "converging" airflow maximum of 30°.
- 3.1.8.** Design elbows for minimum friction with inside radius not less than width of duct. Use square elbows with hollow double radius type duct turns where radius is less than duct width. For duct 18" and wider, use minimum 24 gauge vanes at 3-1/4" o.c. attach duct turns to duct securely with spot weld, screws, or rivets. Friction type attachment not acceptable. Tack welding of each turning vane to track required where elbows are within 20 feet of fan inlet or discharge.

- 3.1.9. Test holes: Drill instrument test holes into ductwork for Pitot tube tests. Install hole covers attached to ductwork by sheet metal screws. Locate test holes at intake, return and discharge from each air handling unit. Ventlok No. 699.
- 3.1.10. Flashing ducts through roof: Provide factory fabricated curb with rain collar soldered to duct for each duct penetrating through roof unless otherwise detailed on the drawings.

3.2. ALUMINUM DUCTS

- 3.2.1. Aluminum ducts shall be installed with the longitudinal seams located at the top side of the duct.

3.3. GREASE EXHAUST DUCTS

- 3.3.1. Construction per CCR, California Mechanical Code, Chapter 5, Type 1 hood.
- 3.3.2. Comply with applicable paragraphs above.
- 3.3.3. Joints and seams shall be made a continuous liquid-tight weld made on the external surface of the duct system.
- 3.3.4. Slope not less than $\frac{1}{4}$ " per linear foot toward hood to prevent grease accumulation.
- 3.3.5. Grease duct system shall not have opening therein other than those required for proper operation and maintenance of the system. Any portion of such system having sections inaccessible from the duct entry or discharge shall be provided with adequate cleanout openings with tight fitting doors.
- 3.3.6. Duct bracing and supports shall be of non-combustible material securely attached to the structure and designed to carry gravity and lateral loads within the stress limitations of the Building Code. Bolts, screws, rivets and other mechanical fasteners shall not penetrate duct walls.

3.4. EXHAUST DUCT FIRE WRAPPER

- 3.4.1.** Installation of exhaust duct fire wrapper shall be strictly in accordance with manufacturer's instruction and require approval from local code authority.
- 3.4.2.** Provide trapeze type hanger for all exhaust ducts with fire wrapper per fire wrapper manufacturer's requirement.

3.5. LINING

- 3.5.1.** Line ductwork as indicated on drawings:
 - 3.5.1.1.** Use one inch lining except where noted otherwise.
 - 3.5.1.2.** Dimensions indicate net free area.
- 3.5.2.** Ducts exposed to weather: Line all ducts exposed to weather with two inch thick lining, except ductwork serving cleanroom and/or supply air ducts for Patient areas.
 - 3.5.2.1.** Seal ducts to three inch static pressure standards.
 - 3.5.2.2.** Paint exposed surfaces with aluminum asphalt roof paint.
- 3.5.3.** Supply and return air ductwork which is not lined (as noted above) is to have exterior insulation. See Section 230700, HVAC INSULATION for insulation requirements on unlined work.
- 3.5.4.** Provide sheet metal nosing at exposed edges at access doors in ductwork and plenums.
- 3.5.5.** Seal all exposed ends of liner with duct liner adhesive back a minimum of 2" from ends. Seal all joints in liner a minimum of 1" overlap. Seal all fasteners.
- 3.5.6.** Completely remove any loose material from each section of lined ductwork as it is installed.

- 3.5.7.** Interrupt duct liner a minimum of 18" upstream and 30 inches downstream of all electric resistance heaters in duct system where applicable. If ductwork is used for cooling, wrap that portion of duct which is not lined and extend insulation a minimum of 12" beyond lining in each direction.

3.6. DUCT PRESSURE/LEAK TESTS

- 3.6.1.** Tests shall be performed by the Mechanical Contractor per the requirements and recommended procedures as outlined in Section 230593, TESTING, ADJUSTING AND BALANCING FOR HVAC, Paragraph "Medium Pressure Duct Leakage Test", and "Duct Pressure/Leak Testing, and "Acceptance Test of Mechanical Systems – Duct Leakage Tests."

- 3.6.2.** Provide certification at the end of the tests.

3.7. PROTECTION OF DUCTWORK

- 3.7.1.** Protection:

- 3.7.1.1.** Store duct a minimum of 4" above ground or floor to avoid damage from weather or spills.

- 3.7.1.2.** Cover all stored ducts to protect from moisture or debris.

- 3.7.1.3.** Cover all ends of installed ductwork at the end of each workday or when dust and debris producing construction (such as fire proofing, drywall, sanding, or core drilling) is occurring.

- 3.7.2.** Ductwork contaminated or damaged above "shop" or "mill" conditions shall be cleaned, repaired or replaced to the satisfaction of the Owner's Representative.

- 3.7.2.1.** Ductliner pre-installed in stored duct which has become wet may be installed if first allowed to completely dry out.

- 3.7.2.2.** Ductliner in installed ductwork which has become wet must be completely removed and replaced.

- 3.7.2.3.** Torn ductliner may be repaired by coating with adhesive if damage is minor and isolated. Extensively damaged liner shall be replaced back to a straight cut joint.

3.8. INSTALLATION OF ACCESSORIES

- 3.8.1.** Install fire and ceiling dampers in accordance with manufacturer's instructions and Fire, Smoke and Radiation Damper guide for HVAC Systems, published by SMACNA.
- 3.8.2.** Install access doors where necessary for inspection and maintenance.
 - 3.8.2.1.** Provide 12" x 12" access door at each low leakage damper, fire damper, combination fire/smoke damper and smoke damper.
 - 3.8.2.2.** Arrange access doors so that;
 - 3.8.2.2.1.** They open against the system air pressure, wherever feasible.
 - 3.8.2.2.2.** Their latches are operable from either side, except where the duct is too small to be entered.
 - 3.8.2.3.** Provide access door at side of duct. If side of duct is not feasible (e.g. height of duct is less than 14" or lack of clearance in front of access door), install access door at bottom of duct as an alternate location, providing the access door is readily accessible and has adequate clearance in front. Determine location at the field.
- 3.8.3.** Use of flexible duct upstream of air terminal units is not permitted.
- 3.8.4.** Notify fire alarm provider of smoke damper control requirements and fire alarm interlocks.
- 3.8.5.** Install flexible ductwork without tight bends and free of kinks.

- 3.8.5.1.** Insulated flexible ducts shall be continuous, maximum of 7' and minimum of 4' in length. Flexible ducts shall not penetrate any fire or smoke barrier.
 - 3.8.5.2.** Flexible ductwork shall be installed with a "minimum length of straight duct" upstream of the diffuser neck inlet. Unless defined differently on the drawings, "a minimum length" shall mean a length equal to three (3) duct diameters. Unless defined differently on the drawings, "straight duct" shall mean the centerline of the duct shall be aligned with a line perpendicular to the plane of the diffuser neck opening at the center point of the opening.
 - 3.8.6.** Install all dampers, including those furnished by Section 230913, BUILDING CONTROL SYSTEMS Contractor.
 - 3.8.6.1.** Caulk damper frames to ductwork.
 - 3.8.6.2.** Make sure dampers are free to operate properly.
 - 3.8.6.3.** Install parallel blade mixing dampers to two streams impinge on each other to facilitate mixing.
 - 3.8.7.** Provide protective sheet metal cover at top and 6" down each side of flexible duct connectors exposed to weather.
 - 3.8.8.** Provide seismic restraint for sound attenuators per Section 230550, SEISMIC RESTRAINTS.
 - 3.8.9.** Install duct air monitoring stations in accordance with manufacturer's instructions. Locate stations per contract drawings and directly above catwalks. Provide adequate straight duct upstream and downstream of station per manufacturer's recommendations.
- 3.9. CLEANING**
- 3.9.1.** Clean ductwork internally, of dust or debris, at the factory with all duct ends to be capped prior to shipping. The end caps shall stay intact until the section is ready for installation. Owner's Representative shall routinely inspect installed duct section for cleanliness and compliance of this section.

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- 3.9.2.** Clean external surfaces of foreign substances which might cause corrosion of metal, damage to insulation, or deterioration of paint.
- 3.9.3.** After duct systems have been installed, blow out all dirt, debris, and foreign matter from ductwork by using the system air handling unit or fan. During this blowout period, the air handling unit shall be placed under full economizer cycle with the return air exhausted 100%. Clean all diffusers, register, and grilles after the blowout period.
- 3.9.4.** Provide letter to state that all duct systems (interior and exterior) have been cleaned.
- 3.9.5.** The Owner's Representative shall inspect the cleanliness of all diffusers, register, and grilles, and interior and exterior (select several locations at each floor) of ductwork. For any devices and/or locations found unacceptable, the contractor shall provide additional cleaning at the failed devices and/or locations at no extra cost to the Owner.
- 3.9.6.** Refer to Section 230500 BASIC HVAC REQUIREMENTS, MATERIALS AND METHODS, for additional cleaning requirements for existing ductwork.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

1.2.1. Section Includes:

- 1.2.1.1. Manual volume dampers.
- 1.2.1.2. Fire dampers.
- 1.2.1.3. Combination fire and smoke dampers.
- 1.2.1.4. Flange connectors.
- 1.2.1.5. Duct silencers.
- 1.2.1.6. Turning vanes.
- 1.2.1.7. Duct-mounted access doors.
- 1.2.1.8. Flexible connectors.
- 1.2.1.9. Flexible ducts.
- 1.2.1.10. Duct accessory hardware.

1.2.2. Related Sections:

- 1.2.2.1. Division 28 Section "Fire Detection and Alarm" for duct-mounted fire and smoke detectors.

1.3. SUBMITTALS

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

- 1.3.1.1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

1.3.2. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1.3.2.1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

1.3.2.1.1. Special fittings.

1.3.2.1.2. Manual volume damper installations.

1.3.2.1.3. Fire-damper, combination fire and smoke-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.

1.3.2.1.4. Wiring Diagrams: For power, signal, and control wiring.

1.3.3. Source quality-control reports.

1.3.4. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4. QUALITY ASSURANCE

1.4.1. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.4.2. Comply with AMCA 500-D testing for damper rating.

1.5. EXTRA MATERIALS

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

2. PART 2 - PRODUCTS

2.1. MATERIALS

2.1.1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.1.2. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

2.1.2.1. Galvanized Coating Designation: G60 (Z180).

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- 2.2.2.4.** Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
- 2.2.2.5.** Blades:
 - 2.2.2.5.1.** Multiple or single blade.
 - 2.2.2.5.2.** Parallel- or opposed-blade design.
 - 2.2.2.5.3.** Stiffen damper blades for stability.
 - 2.2.2.5.4.** Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
 - 2.2.2.5.5.** Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
- 2.2.2.6.** Blade Axles: Nonferrous metal.
- 2.2.2.7.** Bearings:
 - 2.2.2.7.1.** Stainless-steel sleeve.
 - 2.2.2.7.2.** Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 2.2.2.8.** Tie Bars and Brackets: Aluminum.
- 2.2.3.** Low-Leakage, Steel, Manual Volume Dampers:
 - 2.2.3.1.** Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.2.3.1.1.** Air Balance Inc.; a division of Mestek, Inc.
 - 2.2.3.1.2.** McGill AirFlow LLC.
 - 2.2.3.1.3.** METALAIRE, Inc.
 - 2.2.3.1.4.** Nailor Industries Inc.
 - 2.2.3.1.5.** Pottorff; a division of PCI Industries, Inc.
 - 2.2.3.1.6.** Ruskin Company.

- 2.2.3.2.** Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- 2.2.3.3.** Suitable for horizontal or vertical applications.
- 2.2.3.4.** Frames:
 - 2.2.3.4.1.** Angle shaped.
 - 2.2.3.4.2.** Stainless-steel channels, 0.064 inch (1.62 mm) thick.
 - 2.2.3.4.3.** Mitered and welded corners.
 - 2.2.3.4.4.** Flanges for attaching to walls and flangeless frames for installing in ducts.
- 2.2.3.5.** Blades:
 - 2.2.3.5.1.** Multiple or single blade.
 - 2.2.3.5.2.** Parallel- or opposed-blade design.
 - 2.2.3.5.3.** Stiffen damper blades for stability.
 - 2.2.3.5.4.** Stainless roll-formed steel, 0.064 inch (1.62 mm) thick.
- 2.2.3.6.** Blade Axles: Nonferrous metal.
- 2.2.3.7.** Bearings:
 - 2.2.3.7.1.** Stainless-steel sleeve.
 - 2.2.3.7.2.** Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 2.2.3.8.** Blade Seals: Neoprene.
- 2.2.3.9.** Jamb Seals: Cambered stainless steel.
- 2.2.3.10.** Tie Bars and Brackets: Aluminum.
- 2.2.3.11.** Accessories:
 - 2.2.3.11.1.** Include locking device to hold single-blade dampers in a fixed position without vibration.

2.2.4. Low-Leakage, Aluminum, Manual Volume Dampers:

2.2.4.1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.2.4.1.1. Air Balance Inc.; a division of Mestek, Inc.

2.2.4.1.2. McGill AirFlow LLC.

2.2.4.1.3. METALAIRE, Inc.

2.2.4.1.4. Nailor Industries Inc.

2.2.4.1.5. Pottorff; a division of PCI Industries, Inc.

2.2.4.1.6. Ruskin Company.

2.2.4.2. Low-leakage rating, with linkage outside airstream and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

2.2.4.3. Suitable for horizontal or vertical applications.

2.2.4.4. Frames: Angle-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.

2.2.4.5. Blades:

2.2.4.5.1. Multiple or single blade.

2.2.4.5.2. Parallel- or opposed-blade design.

2.2.4.5.3. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.

2.2.4.5.4. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.

2.2.4.6. Blade Axles: Nonferrous metal.

2.2.4.7. Bearings:

2.2.4.7.1. Stainless-steel sleeve.

2.2.4.7.2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

2.2.4.8. Blade Seals: Neoprene.

2.2.4.9. Jamb Seals: Cambered aluminum.

2.2.4.10. Tie Bars and Brackets: Aluminum.

2.2.4.11. Accessories:

2.2.4.11.1. Include locking device to hold single-blade dampers in a fixed position without vibration.

2.2.5. Jackshaft:

2.2.5.1. Size: 1-inch (25-mm) diameter.

2.2.5.2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

2.2.5.3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

2.2.6. Damper Hardware:

2.2.6.1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.

2.2.6.2. Include center hole to suit damper operating-rod size.

2.2.6.3. Include elevated platform for insulated duct mounting.

2.3. FIRE DAMPERS

2.3.1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.3.1.1. Air Balance Inc.; a division of Mestek, Inc.

2.3.1.2. Arrow United Industries; a division of Mestek, Inc.

2.3.1.3. Greenheck Fan Corporation.

2.3.1.4. McGill AirFlow LLC.

2.3.1.5. METALAIR, Inc.

- ## 2.4. COMBINATION FIRE AND SMOKE DAMPERS

- 2.4.1.1.** Air Balance Inc.; a division of Mestek, Inc.
- 2.4.1.2.** Greenheck Fan Corporation.
- 2.4.1.3.** Nailor Industries Inc.
- 2.4.1.4.** Ruskin Company.
- 2.4.2.** Type: Static and dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
- 2.4.3.** Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 4000-fpm (20-m/s) velocity.
- 2.4.4.** Fire Rating: 1-1/2 and 3 hours.
- 2.4.5.** Frame: Curtain type with blades inside airstream and Curtain type with blades outside airstream grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- 2.4.6.** Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.
- 2.4.7.** Heat-Responsive Device: Pneumatic resettable link and switch package, factory installed, rated.
- 2.4.8.** Smoke Detector: Integral, factory wired for single-point connection.
- 2.4.9.** Frame: Curtain type with blades inside airstream and Curtain type with blades outside airstream fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- 2.4.10.** Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
- 2.4.11.** Leakage: Class I.
- 2.4.12.** Rated pressure and velocity to exceed design airflow conditions.
- 2.4.13.** Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.
- 2.4.14.** Master control panel for use in dynamic smoke-management systems.

- 2.4.15.** Damper Motors: Modulating or two-position action.
- 2.4.16.** Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 2.4.16.1.** Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2.4.16.2.** Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section "Instrumentation and Control for HVAC" and Division 26 Sections.
 - 2.4.16.3.** Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 2.4.16.4.** Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
 - 2.4.16.5.** Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
 - 2.4.16.6.** Non-spring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
 - 2.4.16.7.** Electrical Connection: 115 V, single phase, 60 Hz.
- 2.4.17.** Accessories:
 - 2.4.17.1.** Auxiliary switches for signaling fan control or position indication.
 - 2.4.17.2.** Momentary test switch mounted.

2.5. TURNING VANES

- 2.5.1.** Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- 2.5.1.1. Ductmate Industries, Inc.
 - 2.5.1.2. METALAIRE, Inc.
 - 2.5.1.3. SEMCO Incorporated.
 - 2.5.2. Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 2.5.2.1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
 - 2.5.3. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 2.5.4. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
 - 2.5.5. Vane Construction: Single wall.
 - 2.5.6. Vane Construction: Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.
- 2.6. DUCT-MOUNTED ACCESS DOORS
 - 2.6.1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.6.1.1. American Warming and Ventilating; a division of Mestek, Inc.
 - 2.6.1.2. Ductmate Industries, Inc.
 - 2.6.1.3. Flexmaster U.S.A., Inc.
 - 2.6.1.4. Greenheck Fan Corporation.
 - 2.6.1.5. McGill AirFlow LLC.
 - 2.6.1.6. Nailor Industries Inc.
 - 2.6.1.7. Pottorff; a division of PCI Industries, Inc.

- 2.6.2.** Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."

2.6.2.1. Door:

- 2.6.2.1.1.** Double wall, rectangular.
- 2.6.2.1.2.** Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
- 2.6.2.1.3.** Vision panel.
- 2.6.2.1.4.** Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
- 2.6.2.1.5.** Fabricate doors airtight and suitable for duct pressure class.

2.6.2.2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

2.6.2.3. Number of Hinges and Locks:

- 2.6.2.3.1.** Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
- 2.6.2.3.2.** Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
- 2.6.2.3.3.** Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
- 2.6.2.3.4.** Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.

2.7. DUCT ACCESS PANEL ASSEMBLIES

- 2.7.1.** Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- 2.7.1.1.** Ductmate Industries, Inc.
- 2.7.1.2.** Flame Gard, Inc.

- 2.7.2.** Labeled according to UL 1978 by an NRTL.
- 2.7.3.** Panel and Frame: Minimum thickness 0.0428-inch (1.1-mm) stainless steel.
- 2.7.4.** Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.
- 2.7.5.** Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).
- 2.7.6.** Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

2.8. FLEXIBLE CONNECTORS

- 2.8.1.** Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.8.1.1.** Ductmate Industries, Inc.
 - 2.8.1.2.** Duro Dyne Inc.
 - 2.8.1.3.** Ventfabrics, Inc.
- 2.8.2.** Materials: Flame-retardant or noncombustible fabrics.
- 2.8.3.** Coatings and Adhesives: Comply with UL 181, Class 1.
- 2.8.4.** Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) inches (146 mm) wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide. Provide metal compatible with connected ducts.
- 2.8.5.** Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - 2.8.5.1.** Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - 2.8.5.2.** Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 2.8.5.3.** Minimum Additional Travel: 50 percent of the required deflection at rated load.

- 2.8.5.4.** Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 2.8.5.5.** Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- 2.8.5.6.** Elastomeric Element: Molded, oil-resistant rubber or neoprene.
- 2.8.5.7.** Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.9. FLEXIBLE DUCTS

- 2.9.1.** Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.9.1.1.** Flexmaster U.S.A., Inc.
 - 2.9.1.2.** McGill AirFlow LLC.
 - 2.9.1.3.** Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- 2.9.2.** Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
 - 2.9.2.1.** Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 - 2.9.2.2.** Maximum Air Velocity: 4000 fpm (20 m/s).
 - 2.9.2.3.** Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
- 2.9.3.** Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
 - 2.9.3.1.** Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
 - 2.9.3.2.** Maximum Air Velocity: 4000 fpm (20 m/s).
 - 2.9.3.3.** Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).

2.9.4. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

2.9.4.1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.

2.9.4.2. Maximum Air Velocity: 4000 fpm (20 m/s).

2.9.4.3. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).

2.9.5. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

2.9.5.1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.

2.9.5.2. Maximum Air Velocity: 4000 fpm (20 m/s).

2.9.5.3. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).

2.9.6. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; polyethylene vapor-barrier film.

2.9.6.1. Pressure Rating: 8-inch wg (2280 Pa) positive or negative.

2.9.6.2. Maximum Air Velocity: 5000 fpm (25 m/s).

2.9.6.3. Temperature Range: Minus 20 to plus 250 deg F (Minus 29 to plus 121 deg C).

2.9.7. Flexible Duct Connectors:

2.9.7.1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

2.9.7.2. Non-Clamp Connectors: Liquid adhesive plus tape.

2.10. DUCT ACCESSORY HARDWARE

2.10.1. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

- 2.10.2.** Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

3. PART 3 - EXECUTION

3.1. INSTALLATION

- 3.1.1.** Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- 3.1.2.** Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- 3.1.3.** Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- 3.1.4.** Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
- 3.1.4.1.** Coordinate subparagraphs below with Division 23 Section "Metal Ducts." Install steel volume dampers in steel ducts.
- 3.1.4.2.** Install aluminum volume dampers in aluminum ducts.
- 3.1.5.** Set dampers to fully open position before testing, adjusting, and balancing.
- 3.1.6.** Install test holes at fan inlets and outlets and elsewhere as indicated.
- 3.1.7.** Install fire and smoke dampers according to UL listing.
- 3.1.8.** Install duct security bars. Construct duct security bars from 0.164-inch (4.18-mm) steel sleeve, continuously welded at all joints and 1/2-inch- (13-mm-) diameter steel bars, 6 inches (150 mm) o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch (63-by-63-by-6-mm) steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch (300-by-300-mm) hinged access panel with cam lock in duct in each side of sleeve.

- 3.1.9.** Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 3.1.9.1.** On both sides of duct coils.
 - 3.1.9.2.** Downstream from manual volume dampers, control dampers, turning vanes, and equipment.
 - 3.1.9.3.** Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 3.1.9.4.** At each change in direction and at maximum 50-foot (15-m) spacing.
 - 3.1.9.5.** Upstream of turning vanes.
 - 3.1.9.6.** Elsewhere as indicated.
- 3.1.10.** Install access doors with swing against duct static pressure.
- 3.1.11.** Access Door Sizes:
 - 3.1.11.1.** One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
 - 3.1.11.2.** Two-Hand Access: 12 by 6 inches (300 by 150 mm).
 - 3.1.11.3.** Head and Hand Access: 18 by 10 inches (460 by 250 mm).
 - 3.1.11.4.** Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
 - 3.1.11.5.** Body Access: 25 by 14 inches (635 by 355 mm).
 - 3.1.11.6.** Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
- 3.1.12.** Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- 3.1.13.** Install flexible connectors to connect ducts to equipment.

- 3.1.14.** For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- 3.1.15.** Connect diffusers to low-pressure ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.
- 3.1.16.** Connect flexible ducts to metal ducts with draw bands.
- 3.1.17.** Install duct test holes where required for testing and balancing purposes.
- 3.1.18.** Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

3.2. FIELD QUALITY CONTROL

3.2.1. Tests and Inspections:

- 3.2.1.1.** Operate dampers to verify full range of movement.
- 3.2.1.2.** Inspect locations of access doors and verify that purpose of access door can be performed.
- 3.2.1.3.** Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
- 3.2.1.4.** Inspect turning vanes for proper and secure installation.
- 3.2.1.5.** Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes:

- 1.2.1.1.** Ceiling-mounted, 4-way, adjustable modular core diffusers.

- 1.2.1.2.** Return air registers.

- 1.2.2.** Related Sections include the following:

- 1.2.2.1.** Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3. SUBMITTALS

- 1.3.1.** Product Data: For each product indicated, include the following:

- 1.3.1.1.** Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

- 1.3.1.2.** Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

- 2.1.1.** In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

- 2.1.1.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.

- 2.1.1.2.** Products: Subject to compliance with requirements, provide one of the products specified, or approved equal.

2.2. CEILING DIFFUSERS – 4-WAY ADJUSTABLE MODULAR CORE DIFFUSERS

2.2.1. Manufacturer (Model)

2.2.1.1. Krueger (Model 1240)

2.2.1.2. Price Industries (Model PDMC)

2.2.1.3. Titus (Model PMC)

2.3. RETURN AIR REGISTERS

2.3.1. Manufacturer (Model)

2.3.1.1. Krueger (Model EG-10)

2.3.1.2. Price Industries (Model 80/81/82)

2.3.1.3. Titus (Model 50F)

2.3.2. Material: Aluminum.

2.3.3. Finish: Baked enamel, color selected by Architect.

2.3.4. Face Style: Four egg crate.

2.4. SOURCE QUALITY CONTROL

2.4.1. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

3. PART 3 - EXECUTION

3.1. EXAMINATION

3.1.1. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

3.1.2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. INSTALLATION

3.2.1. Install diffusers, registers, and grilles level and plumb.

3.2.2. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

3.2.3. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3. ADJUSTING

3.3.1. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1. This Section includes the following:

- 1.2.1.1. Building wires and cables rated 600 V and less.
- 1.2.1.2. Connectors, splices, and terminations rated 600 V and less.
- 1.2.1.3. Sleeves and sleeve seals for cables.

1.3. DEFINITIONS

- 1.3.1. EPDM: Ethylene-propylene-diene terpolymer rubber.

- 1.3.2. NBR: Acrylonitrile-butadiene rubber.

1.4. SUBMITTALS

- 1.4.1. Product Data: For each type of product indicated.

- 1.4.2. Qualification Data: For testing agency.

- 1.4.3. Field quality-control test reports.

1.5. QUALITY ASSURANCE

- 1.5.1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

- 1.5.1.1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

1.5.2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5.3. Comply with NFPA 70.

1.6. COORDINATION

1.6.1. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

2. PART 2 - PRODUCTS

2.1. CONDUCTORS AND CABLES

2.1.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.1.1.1. Alcan Products Corporation; Alcan Cable Division.

2.1.1.2. American Insulated Wire Corp.; a Leviton Company.

2.1.1.3. General Cable Corporation.

2.1.1.4. Senator Wire & Cable Company.

2.1.1.5. Southwire Company.

2.1.2. Copper Conductors: Comply with NEMA WC 70.

2.1.3. Conductor Insulation: Comply with NEMA WC 70 for Types THW, THHN-THWN, XHHW and SO.

2.1.4. Multiconductor Cable: Comply with NEMA WC 70.

2.2. CONNECTORS AND SPLICES

2.2.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.2.1.1. AFC Cable Systems, Inc.

2.2.1.2. Hubbell Power Systems, Inc.

2.2.1.3. O-Z/Gedney; EGS Electrical Group LLC.

2.2.1.4. 3M; Electrical Products Division.

2.2.1.5. Tyco Electronics Corp.

- 2.2.2.** Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3. SLEEVES FOR CABLES

- 2.3.1.** Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- 2.3.2.** Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- 2.3.3.** Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.
- 2.3.4.** Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4. SLEEVE SEALS

- 2.4.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.4.2.** Basis-of-Design Product: Subject to compliance with requirements, provide or a comparable product by one of the following:
- 2.4.2.1.** Advance Products & Systems, Inc.
- 2.4.2.2.** Calpico, Inc.
- 2.4.2.3.** Metraflex Co.
- 2.4.2.4.** Pipeline Seal and Insulator, Inc.
- 2.4.3.** Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
- 2.4.3.1.** Sealing Elements: EPDM, NBR, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
- 2.4.3.2.** Pressure Plates: Carbon steel. Include two for each sealing element.

- 2.4.3.3.** Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

3. PART 3 - EXECUTION

3.1. CONDUCTOR MATERIAL APPLICATIONS

- 3.1.1.** Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- 3.1.2.** Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2. CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- 3.2.1.** Service Entrance: Type THHN-THWN, single conductors in raceway.
- 3.2.2.** Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- 3.2.3.** Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
- 3.2.4.** Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- 3.2.5.** Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.
- 3.2.6.** Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway.
- 3.2.7.** Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- 3.2.8.** Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- 3.2.9.** Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- 3.2.10.** Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.
- 3.2.11.** Branch Circuits in Cable Tray: Type THHN-THWN, single conductors in raceway.

3.3. INSTALLATION OF CONDUCTORS AND CABLES

- 3.3.1.** Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- 3.3.2.** Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- 3.3.3.** Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- 3.3.4.** Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- 3.3.5.** Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- 3.3.6.** Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4. CONNECTIONS

- 3.4.1.** 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.
- 3.4.2.** Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

3.5. SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- 3.5.1.** Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- 3.5.2.** Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- 3.5.3.** Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- 3.5.4.** Rectangular Sleeve Minimum Metal Thickness:

- 3.5.4.1.** For sleeve rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
- 3.5.4.2.** For sleeve rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
- 3.5.5.** Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- 3.5.6.** Cut sleeves to length for mounting flush with both wall surfaces.
- 3.5.7.** Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- 3.5.8.** Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed.
- 3.5.9.** Seal space outside of sleeves with grout for penetrations of concrete and masonry.
- 3.5.10.** Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."
- 3.5.11.** Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."
- 3.5.12.** Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
- 3.5.13.** Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- 3.5.14.** Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6. SLEEVE-SEAL INSTALLATION

- 3.6.1.** Install to seal underground exterior-wall penetrations.
- 3.6.2.** Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7. FIRESTOPPING

- 3.7.1.** Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.8. FIELD QUALITY CONTROL

- 3.8.1.** Perform tests and inspections and prepare test reports.
- 3.8.2.** Tests and Inspections:
 - 3.8.2.1.** After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.
 - 3.8.2.2.** Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3.8.2.3.** Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
 - 3.8.2.3.1.** Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
 - 3.8.2.3.2.** Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

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3.8.2.3.3. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.8.3. Test Reports: Prepare a written report to record the following:

3.8.3.1. Test procedures used.

3.8.3.2. Test results that comply with requirements.

3.8.3.3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.8.4. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1. This Section includes methods and materials for grounding systems and equipment.

1.3. SUBMITTALS

- 1.3.1. Product Data: For each type of product indicated.
- 1.3.2. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
 - 1.3.2.1. Test wells.
 - 1.3.2.2. Ground rods.
 - 1.3.2.3. Ground rings.
 - 1.3.2.4. Grounding arrangements and connections for separately derived systems.
 - 1.3.2.5. Grounding for sensitive electronic equipment.
- 1.3.3. Qualification Data: For testing agency and testing agency's field supervisor.
- 1.3.4. Field quality-control test reports.
- 1.3.5. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
 - 1.3.5.1. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, grounding connections for separately derived systems NETA MTS, NFPA 70B.
 - 1.3.5.1.1. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.

1.3.5.1.2. Include recommended testing intervals.

1.4. QUALITY ASSURANCE

1.4.1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1.4.1.1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.

1.4.2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4.3. Comply with UL 467 for grounding and bonding materials and equipment.

2. PART 2 - PRODUCTS

2.1. CONDUCTORS

2.1.1. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

2.1.2. Bare Copper Conductors:

2.1.2.1. Solid Conductors: ASTM B 3.

2.1.2.2. Stranded Conductors: ASTM B 8.

2.1.2.3. Tinned Conductors: ASTM B 33.

2.1.2.4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.

2.1.2.5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

2.1.2.6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

- 2.1.2.7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- 2.1.3. Bare Grounding Conductor and Conductor Protector for Wood Poles:
 - 2.1.3.1. No. 4 AWG minimum, soft-drawn copper.
 - 2.1.3.2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
- 2.1.4. Grounding Bus: Rectangular bars of annealed copper, 4" x 12" in cross section, unless otherwise indicated; with insulators.
- 2.2. CONNECTORS
 - 2.2.1. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
 - 2.2.2. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 2.2.2.1. Pipe Connectors: Clamp type, sized for pipe.
 - 2.2.3. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- 2.3. GROUNDING ELECTRODES
 - 2.3.1. Ground Rods: Copper-clad, Zinc-coated steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.
 - 2.3.2. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with non-hazardous electrolytic chemical salts.
 - 2.3.2.1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
 - 2.3.2.2. Backfill Material: Electrode manufacturer's recommended material.

3. PART 3 - EXECUTION

3.1. APPLICATIONS

- 3.1.1.** Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- 3.1.2.** Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 3.1.2.1.** Bury at least 24 inches (600 mm) below grade.
 - 3.1.2.2.** Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- 3.1.3.** Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- 3.1.4.** Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 3.1.4.1.** Install bus on insulated spacers 1 inch (25 mm), minimum, from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
 - 3.1.4.2.** Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.
- 3.1.5.** Conductor Terminations and Connections:
 - 3.1.5.1.** Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 3.1.5.2.** Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
 - 3.1.5.3.** Connections to Ground Rods at Test Wells: Bolted connectors.
 - 3.1.5.4.** Connections to Structural Steel: Welded connectors.

3.2. GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- 3.2.1.** Comply with IEEE C2 grounding requirements.
- 3.2.2.** Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide 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 insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.
- 3.2.3.** Grounding Connections to Manhole Components: Bond 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 bonding 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.
- 3.2.4.** Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.3. EQUIPMENT GROUNDING

- 3.3.1.** Install insulated equipment grounding conductors with all feeders and branch circuits.
- 3.3.2.** Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 3.3.2.1.** Feeders and branch circuits.
 - 3.3.2.2.** Lighting circuits.
 - 3.3.2.3.** Receptacle circuits.
 - 3.3.2.4.** Single-phase motor and appliance branch circuits.

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- 3.3.2.5.** Three-phase motor and appliance branch circuits.
- 3.3.2.6.** Flexible raceway runs.
- 3.3.2.7.** Armored and metal-clad cable runs.
- 3.3.2.8.** Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
- 3.3.2.9.** Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
- 3.3.3.** Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- 3.3.4.** Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- 3.3.5.** Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- 3.3.6.** Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- 3.3.7.** Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

- 3.3.7.1.** Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch (6-by-50-by-300-mm) grounding bus.
- 3.3.7.2.** Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.4. INSTALLATION

- 3.4.1.** Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- 3.4.2.** Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting 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.
- 3.4.3.** Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
 - 3.4.3.1.** Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
 - 3.4.3.2.** For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- 3.4.4.** Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.
 - 3.4.4.1.** Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- 3.4.5.** Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

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- 3.4.5.1.** Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
- 3.4.5.2.** Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
- 3.4.5.3.** Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- 3.4.6.** Grounding and Bonding for Piping:
 - 3.4.6.1.** Metal Water Service Pipe: Install 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, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 3.4.6.2.** Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3.4.6.3.** Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- 3.4.7.** Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- 3.4.8.** Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.
- 3.4.9.** Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item, extending around the perimeter of building.
 - 3.4.9.1.** Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
 - 3.4.9.2.** Bury ground ring not less than 24 inches (600 mm) from building foundation.

3.4.10. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.

3.4.10.1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.

3.4.10.2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

3.5. FIELD QUALITY CONTROL

3.5.1. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

3.5.2. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

3.5.3. Perform the following tests and inspections and prepare test reports:

3.5.3.1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

3.5.3.2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

3.5.3.2.1. Measure ground resistance not less than two full days after last trace of precipitation and without 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.

3.5.3.2.2. Perform tests by fall-of-potential method according to IEEE 81.

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- 3.5.3.3.** Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- 3.5.4.** Report measured ground resistances that exceed the following values:

 - 3.5.4.1.** Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
 - 3.5.4.2.** Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
 - 3.5.4.3.** Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - 3.5.4.4.** Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.
 - 3.5.4.5.** Substations and Pad-Mounted Equipment: 5 ohms.
 - 3.5.4.6.** Manhole Grounds: 10 ohms.
- 3.5.5.** Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes the following:

1.2.1.1. Hangers and supports for electrical equipment and systems.

1.2.1.2. Construction requirements for concrete bases.

- 1.2.2.** Related Sections include the following:

1.2.2.1. Division 26 Section "Vibration And Seismic Controls For Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3. DEFINITIONS

1.3.1. EMT: Electrical metallic tubing.

1.3.2. IMC: Intermediate metal conduit.

1.3.3. RMC: Rigid metal conduit.

1.4. PERFORMANCE REQUIREMENTS

1.4.1. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.4.2. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

1.4.3. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4.4. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5. SUBMITTALS

1.5.1. Product Data: For the following:

1.5.1.1. Steel slotted support systems.

1.5.1.2. Nonmetallic slotted support systems.

1.5.2. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1.5.2.1. Trapeze hangers. Include Product Data for components.

1.5.2.2. Steel slotted channel systems. Include Product Data for components.

1.5.2.3. Nonmetallic slotted channel systems. Include Product Data for components.

1.5.2.4. Equipment supports.

1.5.3. Welding certificates.

1.6. QUALITY ASSURANCE

1.6.1. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.6.2. Comply with NFPA 70.

1.7. COORDINATION

1.7.1. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.7.2. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

2. PART 2 - PRODUCTS

2.1. SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

2.1.1. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

- 2.1.1.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.1.1.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.1.1.2.1.** Allied Tube & Conduit.
 - 2.1.1.2.2.** Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2.1.1.2.3.** ERICO International Corporation.
 - 2.1.1.2.4.** GS Metals Corp.
 - 2.1.1.2.5.** Thomas & Betts Corporation.
 - 2.1.1.2.6.** Unistrut; Tyco International, Ltd.
 - 2.1.1.2.7.** Wesanco, Inc.
- 2.1.1.3.** Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
- 2.1.1.4.** Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
- 2.1.1.5.** Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
- 2.1.1.6.** Channel Dimensions: Selected for applicable load criteria.
- 2.1.2.** Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least 1 surface.
 - 2.1.2.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.1.2.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.1.2.2.1.** Allied Tube & Conduit.

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- 2.1.7.1.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.1.7.1.2.1.** Hilti Inc.
 - 2.1.7.1.2.2.** ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 2.1.7.1.2.3.** MKT Fastening, LLC.
 - 2.1.7.1.2.4.** Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
- 2.1.7.2.** Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
- 2.1.7.2.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.1.7.2.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.1.7.2.2.1.** Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2.1.7.2.2.2.** Empire Tool and Manufacturing Co., Inc.
 - 2.1.7.2.2.3.** Hilti Inc.
 - 2.1.7.2.2.4.** ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 2.1.7.2.2.5.** MKT Fastening, LLC.
- 2.1.7.3.** Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

2.1.7.4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

2.1.7.5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

2.1.7.6. Toggle Bolts: All-steel springhead type.

2.1.7.7. Hanger Rods: Threaded steel.

2.2. FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

2.2.1. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

2.2.2. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

3. PART 3 - EXECUTION

3.1. APPLICATION

3.1.1. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

3.1.2. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC, as required, by scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in] NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

3.1.3. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

3.1.3.1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.1.4. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2. SUPPORT INSTALLATION

3.2.1. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

- 3.2.2.** Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- 3.2.3.** Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- 3.2.4.** Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 3.2.4.1.** To Wood: Fasten with lag screws or through bolts.
 - 3.2.4.2.** To New Concrete: Bolt to concrete inserts.
 - 3.2.4.3.** To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 3.2.4.4.** To Existing Concrete: Expansion anchor fasteners.
 - 3.2.4.5.** Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 - 3.2.4.6.** To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
 - 3.2.4.7.** To Light Steel: Sheet metal screws.
 - 3.2.4.8.** Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- 3.2.5.** Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3. INSTALLATION OF FABRICATED METAL SUPPORTS

- 3.3.1.** Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- 3.3.2.** Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- 3.3.3.** Field Welding: Comply with AWS D1.1/D1.1M.

3.4. CONCRETE BASES

- 3.4.1.** Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- 3.4.2.** Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- 3.4.3.** Anchor equipment to concrete base.
 - 3.4.3.1.** Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 3.4.3.2.** Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3.4.3.3.** Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5. PAINTING

- 3.5.1.** Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 3.5.1.1.** Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- 3.5.2.** Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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- 3.5.3.** Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- 1.2.2.** Related Sections include the following:
- 1.2.2.1.** Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3. DEFINITIONS

- 1.3.1.** EMT: Electrical metallic tubing.
- 1.3.2.** ENT: Electrical nonmetallic tubing.
- 1.3.3.** EPDM: Ethylene-propylene-diene terpolymer rubber.
- 1.3.4.** FMC: Flexible metal conduit.
- 1.3.5.** IMC: Intermediate metal conduit.
- 1.3.6.** LFMC: Liquidtight flexible metal conduit.
- 1.3.7.** LFNC: Liquidtight flexible nonmetallic conduit.
- 1.3.8.** NBR: Acrylonitrile-butadiene rubber.
- 1.3.9.** RNC: Rigid nonmetallic conduit.

1.4. SUBMITTALS

- 1.4.1.** Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- 1.4.2.** Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
- 1.4.2.1.** Custom enclosures and cabinets.

- 1.4.2.2.** For handholes and boxes for underground wiring, including the following:
 - 1.4.2.2.1.** Duct entry provisions, including locations and duct sizes.
 - 1.4.2.2.2.** Frame and cover design.
 - 1.4.2.2.3.** Grounding details.
 - 1.4.2.2.4.** Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
 - 1.4.2.2.5.** Joint details.
- 1.4.3.** Samples for Initial Selection: For wireways nonmetallic wireways and surface raceways with factory-applied texture and color finishes.
 - 1.4.3.1.** Size: As shown on plans.
- 1.4.4.** Samples for Verification: For each type of exposed finish required for wireways nonmetallic wireways and surface raceways, prepared on Samples of size indicated below.
 - 1.4.4.1.** Size: As shown on plans.
- 1.4.5.** Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1.4.5.1.** Structural members in the paths of conduit groups with common supports.
 - 1.4.5.2.** HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.
- 1.4.6.** Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
 - 1.4.6.1.** Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 1.4.6.1.1.** The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified."

- [illegible]

- 2.1.4.** IMC: ANSI C80.6.
- 2.1.5.** PVC-coated rigid steel conduit.
 - 2.1.5.1.** Comply with NEMA RN 1.
 - 2.1.5.2.** Coating Thickness: 0.040 inch (1 mm), minimum.
- 2.1.6.** EMT: ANSI C80.3.
- 2.1.7.** FMC: Zinc-coated steel.
- 2.1.8.** LFMC: Flexible steel conduit with PVC jacket.
- 2.1.9.** Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 2.1.9.1.** Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - 2.1.9.2.** Fittings for EMT: Steel or die-cast, set-screw or compression type.
 - 2.1.9.3.** Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- 2.1.10.** Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2. NONMETALLIC CONDUIT AND TUBING

- 2.2.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.2.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.2.2.1.** AFC Cable Systems, Inc.
 - 2.2.2.2.** Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 2.2.2.3.** Amco Corporation.
 - 2.2.2.4.** CANTEX Inc.

- 2.2.2.5. CertainTeed Corp.; Pipe & Plastics Group.
 - 2.2.2.6. Condux International, Inc.
 - 2.2.2.7. ElecSYS, Inc.
 - 2.2.2.8. Electri-Flex Co.
 - 2.2.2.9. Lamson & Sessions; Carlon Electrical Products.
 - 2.2.2.10. Manhattan/CDT/Cole-Flex.
 - 2.2.2.11. RACO; a Hubbell Company.
 - 2.2.2.12. Thomas & Betts Corporation.
 - 2.2.3. ENT: NEMA TC 13.
 - 2.2.4. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
 - 2.2.5. LFNC: UL 1660.
 - 2.2.6. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
 - 2.2.7. Fittings for LFNC: UL 514B.
 - 2.3. OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS
 - 2.3.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.3.1.1. Arnco Corporation.
 - 2.3.1.2. Endot Industries Inc.
 - 2.3.1.3. IPEX Inc.
 - 2.3.1.4. Lamson & Sessions; Carlon Electrical Products.
 - 2.3.2. Description: Comply with UL 2024; flexible type, approved for general-use installation.
 - 2.4. METAL WIREWAYS
 - 2.4.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.4.1.1. Cooper B-Line, Inc.
 - 2.4.1.2. Hoffman.

2.4.1.3. Square D; Schneider Electric.

2.4.2. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, 3R, unless otherwise indicated.

2.4.3. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.4.4. Wireway Covers: Hinged type, Flanged-and-gasketed type.

2.4.5. Finish: Manufacturer's standard enamel finish.

2.5. NONMETALLIC WIREWAYS

2.5.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.5.2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.5.2.1. Hoffman.

2.5.2.2. Lamson & Sessions; Carlon Electrical Products.

2.5.3. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.

2.5.4. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.6. SURFACE RACEWAYS

2.6.1. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.

2.6.1.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.6.1.2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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2.7. BOXES, ENCLOSURES, AND CABINETS

- 2.7.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.7.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.7.2.1.** Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.

- 2.7.2.2.** EGS/Appleton Electric.
- 2.7.2.3.** Erickson Electrical Equipment Company.
- 2.7.2.4.** Hoffman.
- 2.7.2.5.** Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
- 2.7.2.6.** O-Z/Gedney; a unit of General Signal.
- 2.7.2.7.** RACO; a Hubbell Company.
- 2.7.2.8.** Robroy Industries, Inc.; Enclosure Division.
- 2.7.2.9.** Scott Fetzer Co.; Adalet Division.
- 2.7.2.10.** Spring City Electrical Manufacturing Company.
- 2.7.2.11.** Thomas & Betts Corporation.
- 2.7.2.12.** Walker Systems, Inc.; Wiremold Company (The).
- 2.7.2.13.** Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- 2.7.3.** Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- 2.7.4.** Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- 2.7.5.** Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- 2.7.6.** Metal Floor Boxes: Cast metal, fully adjustable, rectangular.
- 2.7.7.** Nonmetallic Floor Boxes: Nonadjustable, round.
- 2.7.8.** Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- 2.7.9.** Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized with gasketed cover.
- 2.7.10.** Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
 - 2.7.10.1.** Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2.7.10.2.** Nonmetallic Enclosures: Plastic.
- 2.7.11.** Cabinets:

- 2.7.11.1.** NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
- 2.7.11.2.** Hinged door in front cover with flush latch and concealed hinge.
- 2.7.11.3.** Key latch to match panelboards.
- 2.7.11.4.** Metal barriers to separate wiring of different systems and voltage.
- 2.7.11.5.** Accessory feet where required for freestanding equipment.

2.8. HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

2.8.1. Description: Comply with SCTE 77.

- 2.8.1.1.** Color of Frame and Cover: Gray.
- 2.8.1.2.** Configuration: Units shall be designed for flush burial and have closed bottom, unless otherwise indicated.
- 2.8.1.3.** Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- 2.8.1.4.** Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- 2.8.1.5.** Cover Legend: Molded lettering, as indicated for each service.
- 2.8.1.6.** Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- 2.8.1.7.** Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.8.2. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.

- 2.8.2.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.8.2.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.8.2.3.** Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 2.8.2.3.1.** Armorcast Products Company.
 - 2.8.2.3.2.** Carson Industries LLC.
 - 2.8.2.3.3.** CDR Systems Corporation.
 - 2.8.2.3.4.** NewBasis.

2.9. SLEEVES FOR RACEWAYS

- 2.9.1.** Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- 2.9.2.** Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- 2.9.3.** Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.
- 2.9.4.** Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.10. SLEEVE SEALS

- 2.10.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.10.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.10.3.** Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

- 2.10.3.1.** Advance Products & Systems, Inc.
- 2.10.3.2.** Calpico, Inc.
- 2.10.3.3.** Metraflex Co.
- 2.10.3.4.** Pipeline Seal and Insulator, Inc.
- 2.10.4.** Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 2.10.4.1.** Sealing Elements: EPDM, NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 2.10.4.2.** Pressure Plates Carbon steel. Include two for each sealing element.
 - 2.10.4.3.** Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.11. SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- 2.11.1.** Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 2.11.1.1.** Tests of materials shall be performed by a independent testing agency.
 - 2.11.1.2.** Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 2.11.1.3.** Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

3. PART 3 - EXECUTION

3.1. RACEWAY APPLICATION

- 3.1.1.** Outdoors: Apply raceway products as specified below, unless otherwise indicated:
 - 3.1.1.1.** Exposed Conduit: Rigid steel conduit, IMC.

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- 3.1.1.2.** Concealed Conduit, Aboveground: Rigid steel conduit, IMC, EMT.
- 3.1.1.3.** Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
- 3.1.1.4.** Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- 3.1.1.5.** Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- 3.1.1.6.** Application of Handholes and Boxes for Underground Wiring:
 - 3.1.1.6.1.** Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Non-deliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
 - 3.1.1.6.2.** Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Non-deliberate Loading by Vehicles: Polymer-concrete units.
 - 3.1.1.6.3.** Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
- 3.1.2.** Comply with the following indoor applications, unless otherwise indicated:
 - 3.1.2.1.** Exposed, Not Subject to Physical Damage: EMT.
 - 3.1.2.2.** Exposed, Not Subject to Severe Physical Damage: EMT.
 - 3.1.2.3.** Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
 - 3.1.2.3.1.** Loading dock.
 - 3.1.2.3.2.** Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - 3.1.2.3.3.** Mechanical rooms.

- ### 3.2. INSTALLATION

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- 3.2.2.** Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- 3.2.3.** Complete raceway installation before starting conductor installation.
- 3.2.4.** Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- 3.2.5.** Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- 3.2.6.** Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- 3.2.7.** Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- 3.2.8.** Raceways Embedded in Slabs:
 - 3.2.8.1.** Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 3.2.8.2.** Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3.2.8.3.** Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.
- 3.2.9.** Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- 3.2.10.** Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- 3.2.11.** Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
- 3.2.12.** Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:

- 3.2.12.1.** 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
- 3.2.12.2.** 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
- 3.2.12.3.** Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- 3.2.13.** Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
 - 3.2.13.1.** Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 3.2.13.2.** Where otherwise required by NFPA 70.
- 3.2.14.** Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).
 - 3.2.14.1.** Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
 - 3.2.14.1.1.** Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - 3.2.14.1.2.** Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - 3.2.14.1.3.** Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - 3.2.14.1.4.** Attics: 135 deg F (75 deg C) temperature change.

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- 3.3.1.3.** After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
- 3.3.1.4.** Install manufactured PVC coated rigid steel elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
- 3.3.1.5.** Install manufactured PVC coated rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - 3.3.1.5.1.** Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - 3.3.1.5.2.** For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

3.4. INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- 3.4.1.** Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- 3.4.2.** Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- 3.4.3.** Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

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- 3.4.4.** Install handholes and boxes with bottom below the frost line below grade.
- 3.4.5.** Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- 3.4.6.** Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5. SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- 3.5.1.** Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- 3.5.2.** Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- 3.5.3.** Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- 3.5.4.** Rectangular Sleeve Minimum Metal Thickness:
 - 3.5.4.1.** For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - 3.5.4.2.** For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
- 3.5.5.** Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- 3.5.6.** Cut sleeves to length for mounting flush with both surfaces of walls.
- 3.5.7.** Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

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- 3.5.8. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway unless sleeve seal is to be installed
- 3.5.9. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
- 3.5.10. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- 3.5.11. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."
- 3.5.12. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- 3.5.13. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- 3.5.14. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.6. SLEEVE-SEAL INSTALLATION

- 3.6.1. Install to seal underground, exterior wall penetrations.
- 3.6.2. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7. FIRESTOPPING

- 3.7.1. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.8. PROTECTION

3.8.1. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

3.8.1.1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

3.8.1.2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes the following:
 - 1.2.1.1.** Identification for raceway and metal-clad cable.
 - 1.2.1.2.** Identification for conductors and communication and control cable.
 - 1.2.1.3.** Underground-line warning tape.
 - 1.2.1.4.** Warning labels and signs.
 - 1.2.1.5.** Instruction signs.
 - 1.2.1.6.** Equipment identification labels.
 - 1.2.1.7.** Miscellaneous identification products.

1.3. SUBMITTALS

- 1.3.1.** Product Data: For each electrical identification product indicated.
- 1.3.2.** Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.
- 1.3.3.** Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.4. QUALITY ASSURANCE

- 1.4.1.** Comply with ANSI A13.1 and ANSI C2.
- 1.4.2.** Comply with NFPA 70.

- 1.4.3. Comply with 29 CFR 1910.145.

1.5. COORDINATION

- 1.5.1. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- 1.5.2. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- 1.5.3. Coordinate installation of identifying devices with location of access panels and doors.
- 1.5.4. Install identifying devices before installing acoustical ceilings and similar concealment.

2. PART 2 - PRODUCTS

2.1. RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- 2.1.1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- 2.1.2. Color for Printed Legend:
 - 2.1.2.1. Power Circuits: Black letters on an orange field.
 - 2.1.2.2. Legend: Indicate system or service and voltage, if applicable.
- 2.1.3. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

- 2.1.4.** Snap-Around Labels: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- 2.1.5.** Snap-Around, Color-Coding Bands: Slit, pre-tensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- 2.1.6.** Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.
- 2.2. CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS**
 - 2.2.1.** Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
 - 2.2.2.** Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
 - 2.2.3.** Aluminum Wraparound Marker Labels: Cut from 0.014-inch- (0.35-mm-) thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.
 - 2.2.4.** Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking nylon tie fastener.
 - 2.2.5.** Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
 - 2.2.5.1.** Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.3. UNDERGROUND-LINE WARNING TAPE

2.3.1. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.

2.3.1.1. Not less than 6 inches (150 mm) wide by 4 mils (0.102 mm) thick.

2.3.1.2. Compounded for permanent direct-burial service.

2.3.1.3. Embedded continuous metallic strip or core.

2.3.1.4. Printed legend shall indicate type of underground line.

2.4. WARNING LABELS AND SIGNS

2.4.1. Comply with NFPA 70 and 29 CFR 1910.145.

2.4.2. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

2.4.3. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).

2.4.4. Metal-Backed, Butyrate Warning Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).

2.4.5. Warning label and sign shall include, but are not limited to, the following legends:

2.4.5.1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

- 2.4.5.2.** Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.5. INSTRUCTION SIGNS

- 2.5.1.** Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
 - 2.5.1.1.** Engraved legend with black letters on white face.
 - 2.5.1.2.** Punched or drilled for mechanical fasteners.
 - 2.5.1.3.** Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6. EQUIPMENT IDENTIFICATION LABELS

- 2.6.1.** Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
- 2.6.2.** Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and ultraviolet-resistant seal for label.
- 2.6.3.** Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
- 2.6.4.** Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
- 2.6.5.** Stenciled Legend: In non-fading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.7. MISCELLANEOUS IDENTIFICATION PRODUCTS

- 2.7.1.** Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.

- 2.7.1.1.** Minimum Width: 3/16 inch (5 mm).
- 2.7.1.2.** Tensile Strength: 50 lb (22.6 kg), minimum.
- 2.7.1.3.** Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
- 2.7.1.4.** Color: Black, except where used for color-coding.
- 2.7.2.** Paint: Paint materials and application requirements are specified in Division 09 painting Sections.
 - 2.7.2.1.** Exterior Concrete, Stucco, and Masonry:
 - 2.7.2.1.1.** Semi gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
 - 2.7.2.1.1.1.** Primer: Exterior concrete and masonry primer.
 - 2.7.2.1.1.2.** Finish Coats: Exterior semi gloss acrylic enamel.
 - 2.7.2.2.** Exterior Concrete Unit Masonry:
 - 2.7.2.2.1.** Semi gloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
 - 2.7.2.2.1.1.** Block Filler: Concrete unit masonry block filler.
 - 2.7.2.2.1.2.** Finish Coats: Exterior semi gloss acrylic enamel.
 - 2.7.2.3.** Exterior Ferrous Metal:
 - 2.7.2.3.1.** Semi gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
 - 2.7.2.3.1.1.** Primer: Exterior ferrous-metal primer.
 - 2.7.2.3.1.2.** Finish Coats: Exterior semi gloss alkyd enamel.

2.7.2.4. Exterior Zinc-Coated Metal (except Raceways):

2.7.2.4.1. Semi gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.

2.7.2.4.1.1. Primer: Exterior zinc-coated metal primer.

2.7.2.4.1.2. Finish Coats: Exterior semi gloss alkyd enamel.

2.7.2.5. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):

2.7.2.5.1. Semi gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.

2.7.2.5.1.1. Primer: Interior concrete and masonry primer.

2.7.2.5.1.2. Finish Coats: Interior semi gloss alkyd enamel.

2.7.2.6. Interior Concrete Unit Masonry:

2.7.2.6.1. Semi gloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.

2.7.2.6.1.1. Block Filler: Concrete unit masonry block filler.

2.7.2.6.1.2. Finish Coats: Interior semi gloss acrylic enamel.

2.7.2.7. Interior Gypsum Board:

2.7.2.7.1. Semi gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.

2.7.2.7.1.1. Primer: Interior gypsum board primer.

2.7.2.7.1.2. Finish Coats: Interior semi gloss acrylic enamel.

2.7.2.8. Interior Ferrous Metal:

2.7.2.8.1. Semi gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.

2.7.2.8.1.1. Primer: Interior ferrous-metal primer.

2.7.2.8.1.2. Finish Coats: Interior semi gloss acrylic enamel.

2.7.2.9. Interior Zinc-Coated Metal (except Raceways):

2.7.2.9.1. Semi gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.

2.7.2.9.1.1. Primer: Interior zinc-coated metal primer.

2.7.2.9.1.2. Finish Coats: Interior semi gloss acrylic enamel.

2.7.3. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

3. PART 3 - EXECUTION

3.1. APPLICATION

3.1.1. Raceways and Duct Banks More Than 600 V Concealed within Buildings: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:

3.1.1.1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.

- 3.1.1.2.** Wall surfaces directly external to raceways concealed within wall.

- 3.1.1.3.** Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

- 3.1.2.** Accessible Raceways and Metal-Clad Cables More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches (50 mm) high, with snap-around labels. Repeat legend at 10-foot (3-m) maximum intervals.

- 3.1.3.** Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A: Identify with orange snap-around label.

- 3.1.4.** Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, snap-around, color-coding bands:

- #### 3.1.4.1. Fire Alarm System: Red.

- 3.1.4.2.** Fire-Suppression Supervisory and Control System: Red and yellow.

- 3.1.4.3. Combined Fire Alarm and Security System:** Red and blue.

- 3.1.4.4.** Security System: Blue and yellow.

- 3.1.4.5. Mechanical and Electrical Supervisory System:** Green and blue.

- 3.1.4.6. Telecommunication System:** Green and yellow.

- 3.1.4.7.** Control Wiring: Green and red.

- 3.1.5.** Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

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- 3.1.6.** Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.
- 3.1.7.** Conductors to Be Extended in the Future: Attach marker tape to conductors and list source and circuit number.
- 3.1.8.** Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
 - 3.1.8.1.** Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 3.1.8.2.** Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3.1.8.3.** Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- 3.1.9.** Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- 3.1.10.** Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
 - 3.1.10.1.** Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
 - 3.1.10.1.1.** Power transfer switches.

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3.1.10.1.2. Controls with external control power connections.

3.1.10.2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

3.1.11. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

3.1.11.1. Labeling Instructions:

3.1.11.1.1. Indoor Equipment: Adhesive film label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where 2 lines of text are required, use labels 2 inches (50 mm) high.

3.1.11.1.2. Outdoor Equipment: Engraved, laminated acrylic or melamine label.

3.1.11.1.3. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

3.1.11.2. Equipment to Be Labeled:

3.1.11.2.1. Panelboards, electrical cabinets, and enclosures.

3.1.11.2.2. Electrical switchgear and switchboards.

3.1.11.2.3. Transformers.

3.1.11.2.4. Electrical substations.

- 3.1.11.2.5.** Emergency system boxes and enclosures.
- 3.1.11.2.6.** Disconnect switches.
- 3.1.11.2.7.** Enclosed circuit breakers.
- 3.1.11.2.8.** Remote-controlled switches, dimmer modules, and control devices.
- 3.1.11.2.9.** Voice and data cable terminal equipment.
- 3.1.11.2.10.** Master clock and program equipment.
- 3.1.11.2.11.** Intercommunication and call system master and staff stations.
- 3.1.11.2.12.** Television/audio components, racks, and controls.
- 3.1.11.2.13.** Fire-alarm control panel and annunciators.
- 3.1.11.2.14.** Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
- 3.1.11.2.15.** Monitoring and control equipment.
- 3.1.11.2.16.** Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.2. INSTALLATION

- 3.2.1.** Verify identity of each item before installing identification products.
- 3.2.2.** Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- 3.2.3.** Apply identification devices to surfaces that require finish after completing finish work.

- 3.2.4.** Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- 3.2.5.** Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
- 3.2.6.** System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- 3.2.7.** Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service feeder and branch-circuit conductors.
 - 3.2.7.1.** Color shall be factory applied.
 - 3.2.7.2.** Colors for 208/120-V Circuits:
 - 3.2.7.2.1.** Phase A: Black.
 - 3.2.7.2.2.** Phase B: Red.
 - 3.2.7.2.3.** Phase C: Blue.
 - 3.2.7.3.** Colors for 480/277-V Circuits:
 - 3.2.7.3.1.** Phase A: Brown.
 - 3.2.7.3.2.** Phase B: Orange.
 - 3.2.7.3.3.** Phase C: Yellow.
 - 3.2.7.4.** Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

- 3.2.8.** Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- 3.2.9.** Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches (400 mm) overall.
- 3.2.10.** Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- 1.1.2.** Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2. SUMMARY

- 1.2.1.** The purpose of this Section is to define Contractor responsibilities in the commissioning process, which are being directed by the Contractor. Other electrical system testing is required under other Division 26 Specification Sections. National Electrical Installation Standards (NEIS) NECA 90-2004, "Recommended Practice for Commissioning Building Electrical Systems", 27th Volume of the NEIS Series, provides additional guidance for the commissioning of electrical systems.
- 1.2.2.** Commissioning requires the participation of the Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. General Commissioning requirements and coordination are detailed in Division 01. Division 26 shall be familiar with all parts of Division 01 and the Commissioning Plan issued by the Contractor and shall execute all Commissioning responsibilities assigned to them in the Contract Documents and include the cost of Commissioning in the Contract price.
- 1.2.3.** Electrical systems to be commissioned include the following:
 - 1.2.3.1.** Secondary Service Electrical Systems.
 - 1.2.3.2.** Motor Control Centers.
 - 1.2.3.3.** Distribution and Branch Circuit Panelboards.
 - 1.2.3.4.** Lighting Fixtures and Controls Including Energy Management System (EMS)
 - 1.2.3.5.** Elevator Systems.
 - 1.2.3.6.** Equipment Monitoring.
 - 1.2.3.7.** Fire Alarm Equipment/Fire Alarm Equipment Monitoring System.
 - 1.2.3.8.** AC Motors.

1.2.3.9. Grounding Equipment and Building Grounding System.

1.2.3.10. Intrusion System.

1.3. REFERENCE STANDARDS

1.3.1. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

1.3.2. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

1.3.3. All materials, installation and workmanship shall comply with the applicable requirements and standards.

1.4. DEFINITIONS

1.4.1. Commissioning: A systematic process confirming that building systems have been installed, properly started, and consistently operated in strict accordance with the Contract Documents, that all systems are complete and functioning in accordance with the Contract Documents at Substantial Completion, and that Contractor has provided Owner adequate system documentation and training. Commissioning includes deferred and/or seasonal tests as approved by Owner.

1.4.2. Commissioning Plan: Document prepared by Contractor and approved by Owner that provides the structure, schedule, and coordination plan for the Commissioning process from the construction phase through the warranty period. The Commissioning Plan must satisfy the Owner's test requirements.

1.4.3. Commissioning Team: Working group made up of representative(s) from the Architect/Engineer (A/E), Contractor, Owner's Test, Adjust, and Balance (TAB) Firm, Building Automation System (BAS) provider, specialty manufacturers and suppliers, and Owner. Contractor will provide ad-hoc representation of Subcontractors on the Commissioning Team as required for implementation of the Commissioning Plan.

1.4.4. Deferred Tests: Functional Performance or Integrated System Tests performed after Substantial Completion due to partial occupancy, partial equipment acceptance, seasonal requirements, design, or other Site conditions that prohibit the test from being performed prior to Substantial Completion.

1.4.5. Deficiency: Condition of a component, piece of equipment or system that is not in compliance with Contract Documents.

- 1.4.6. Factory Testing: Testing of equipment at the factory, by factory personnel with an Owner's representative present if deemed necessary by Owner.
- 1.4.7. Functional Performance Test Procedures: Commissioning protocols and detailed test procedures and instructions in tabular and script-type format that fully describe system configuration and steps required to determine if the system is performing and functioning properly. Contractor prepares these procedures to document Functional Performance Tests.
- 1.4.8. Functional Performance Test (FPT): Test of dynamic function and operation of equipment and systems executed by Contractor. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, life safety conditions, power failure, etc. Systems are run through all specified sequences of operation. Components are verified to be responding in accordance with Contract Documents. Functional Performance Tests are executed after start-ups and Prefunctional Checklists are complete.
- 1.4.9. Integrated System Test: Test of dynamic function and operation of multiple systems. Integrated System Tests are tested under various modes, such as fire alarm and emergency situations, life safety conditions, power failure, etc. Systems are integrally operated through all specified sequences of operation. Components are verified to be responding in accordance with Contract Documents. Integrated System Tests are executed after Functional Performance Tests are complete and prior to Substantial Completion. Integrated System Tests provide verification that the integrated systems will properly function according to the Contract Documents.
- 1.4.10. Integrated System Test Procedures: Commissioning protocols and detailed test procedures and instructions in tabular and script-type format that fully describe system configurations and steps required to determine if the interacting systems are performing and functioning properly. Contractor prepares these procedures to document Integrated System Tests.
- 1.4.11. Prefunctional Checklist: A list of static inspections and material or component tests that verify proper installation of equipment (e.g., belt tension, oil levels, labels affixed, gages in place, sensors calibrated, etc.). The word Prefunctional refers to before Functional tests. Prefunctional Checklists must include the manufacturer's Start-up checklist(s). Contractor shall sign Prefunctional Checklists as complete and submit with the Request for Start-up/Functional Performance Test Form.

- 1.4.12. Start-up: The activities where equipment is initially energized, tested, and operated. Start-up is completed prior to Functional Performance Tests.
- 1.4.13. Test Requirements: Requirements specifying what systems, modes and functions, etc. must be tested. Test requirements are not detailed test procedures. Test requirements and acceptance criteria are specified in the Contract Documents.

1.5. SUBMITTALS

- 1.5.1. Contractor shall prepare Pre-functional Checklists and Functional Performance Test (FPT) procedures and execute and document results. All Pre-functional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms to the Owner for review and approval.
- 1.5.2. Contractor shall provide Owner with documentation required for Commissioning work. At minimum, documentation shall include: Detailed Start-up procedures, Full sequences of operation, Operating and Maintenance data, Performance data, Functional Performance Test Procedures, Control Drawings, and details of Owner-Contracted tests.
- 1.5.3. Contractor shall submit to Owner installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.
- 1.5.4. Contractor shall review and approve other relative documentation for impact on FPT's of the systems:
 - 1.5.4.1. Shop Drawings and product submittal data related to systems or equipment to be commissioned. The Subcontractor responsible for the FPT shall review and incorporate comments from the Owner and A/E via the Contractor.
 - 1.5.4.2. Incorporate manufacturer's Start-up procedures with Pre-functional checklists.
 - 1.5.4.3. Draft Electrical Testing Agency (ETA) Reports: Review and provide comments to Owner.
 - 1.5.4.4. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPT's.

- 1.5.4.5. Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's.
- 1.5.4.6. Final ETA Reports: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's.
- 1.5.4.7. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: To validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

2. PART 2 - PRODUCTS

2.1. GENERAL

- 2.1.1. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2. TEST EQUIPMENT

- 2.2.1. Provide all specialized tools, test equipment and instruments required to execute Start-up, checkout, and testing of equipment.
- 2.2.2. All specialized tools, test equipment, and instruments required to execute Start-up, checkout, and testing of equipment shall be of sufficient quality and accuracy to test and/or measure system performance within specified tolerances. A testing laboratory must have calibrated test equipment within the previous twelve (12) months. Calibration shall be NIST traceable. Contractor must calibrate test equipment and instruments according to manufacturer's recommended intervals and whenever the test equipment is dropped or damaged. Calibration tags must be affixed to the test equipment or certificates readily available.
- 2.2.3. Infrared Thermographic Scanner:

- 2.2.3.1.** Infrared scanning equipment shall be an AGA (or approved equal) thermovision set capable of viewing an entire bus or equipment assembly at one time and have a sensitivity of 0.2 degrees C with a liquid nitrogen reference.
- 2.2.3.2.** All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified.

3. PART 3- EXECUTION

3.1. PREPARATION

3.1.1. Construction Phase:

- 3.1.1.1.** In each purchase order or subcontract that is written for changes in scope, include the following requirements for submittal data, Commissioning documentation, testing assistance, Operating and Maintenance (O&M) data, and training, as a minimum.
- 3.1.1.2.** Attend Pre-Commissioning Meeting(s), Pre-Installation Meeting(s), and other Project meetings scheduled by the Contractor to facilitate the Commissioning process.
- 3.1.1.3.** Provide manufacturer's data sheets and shop drawing submittals of equipment.
- 3.1.1.4.** Provide additional requested documentation to the Contractor, prior to O&M manual submittals, for development of Pre-functional Checklist and Functional Performance Tests procedures.
 - 3.1.1.4.1.** Typically, this will include detailed manufacturer's installation and Start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified.
 - 3.1.1.4.2.** In addition, the installation, Start-up, and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Contractor.

- 3.1.1.4.3.** This information and data request may be made prior to normal submittals.
- 3.1.1.5.** With input from the BAS Provider and A/E, Clarify the operation and control of commissioned equipment in areas where the Specifications, BAS control drawings, or equipment documentation are not sufficient for writing detailed test procedures.
- 3.1.1.6.** Prepare the specific Functional Performance Test procedures and have them reviewed by the school district prior. To ensure that Functional Performance Test procedures address feasibility, safety, and equipment protection and provide necessary written alarm limits to be used during the tests.
- 3.1.1.7.** Develop the Commissioning Plan using manufacturer's Start-up procedures and the Pre-functional Checklists. Submit manufacturer's detailed Start-up procedures and the Commissioning Plan and procedures and other requested equipment documentation to Owner for review.
- 3.1.1.8.** During the Start-up and initial checkout process, execute and document related portions of the Pre-functional Checklists for all commissioned equipment.
- 3.1.1.9.** Perform and clearly document all completed Pre-functional Checklists and Start-up procedures. Provide a copy to the Owner prior to the Functional Performance Test.
- 3.1.1.10.** Address current A/E and Owner punch list items before Functional Performance Tests. Air and water test, adjust and balance shall be completed with discrepancies and problems remedied before Functional Performance Tests of the respective air or water related systems are executed.
- 3.1.1.11.** Provide skilled technicians to execute starting of equipment and to assist in execution of Functional Performance Tests. Ensure that they are available and present during the agreed-upon schedules and for a sufficient duration to complete the necessary tests, adjustments, and problem solving.
- 3.1.1.12.** Correct deficiencies (differences between specified and observed performance) as interpreted by the Owner's Project Manager and A/E and retest the system and equipment.

- 3.1.1.13.** Compile all Commissioning records and documentation to be included in a Commissioning and Closeout Manual.
- 3.1.1.14.** Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
- 3.1.1.15.** During construction, maintain as-built marked-up Drawings and Specifications of all Contract Documents and Contractor-generated coordination Drawings. Update after completion of Commissioning activities (include deferred tests). The as-built drawings and specifications shall be delivered to the Owner both in electronic format and hard copies as required by the Owner.
- 3.1.1.16.** Provide training of the Owner's operating personnel as specified.
- 3.1.1.17.** Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
- 3.1.2.** Warranty Phase:
 - 3.1.2.1.** Execute seasonal or deferred tests, witnessed by the Owner, according to the Specifications.
 - 3.1.2.1.1.** Complete deferred tests as part of this Contract during the Warranty Period. Schedule this activity with Owner. Perform tests and document and correct deficiencies. Owner may observe the tests and review and approve test documentation and deficiency corrections.
 - 3.1.2.1.2.** If any check or test cannot be completed prior to Substantial Completion due to the building structure, required occupancy condition, or other condition, execution of such test may be delayed to later in the Warranty Period, upon approval of the Owner. Contractor shall reschedule and conduct these unforeseen deferred tests in the same manner as deferred tests.

- 3.1.2.2.** Correct deficiencies and make necessary adjustments to O&M manuals, Commissioning documentation, and as-built drawings for applicable issues identified in any seasonal testing.

3.1.3. Electrical Testing Agency (ETA):

- 3.1.3.1.** When requested by Owner, the Contractor shall retain an independent Electrical Testing Agency (ETA). This generally requires checking and testing of the electrical power distribution equipment per National Electrical Testing Association (NETA).
- 3.1.3.2.** Attend Pre-Commissioning Meeting(s), Pre-Installation Meeting(s), and other Project meetings scheduled by the Contractor to facilitate the Commissioning process.
- 3.1.3.3.** Obtain all required manufacturer's data to facilitate tests.
- 3.1.3.4.** Provide assistance to the Contractor in preparation of the specific Pre-functional Checklist and Functional Performance Test procedures. Generally ETA shall provide their standard forms to document the NETA tests to be incorporated into the Pre-functional Checklist and Functional Performance Tests record.
- 3.1.3.5.** During related tests, execute and document the tests in the approved forms and/or test record.
- 3.1.3.6.** Perform and clearly document all completed Start-up and system operational checkout procedures, providing a copy to the Contractor.
- 3.1.3.7.** Clearly indicate any deficiencies identified during testing and add to an action list for resolution and tracking. The field technicians shall keep a running log of events and issues. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, Contract interpretation requests and lists of completed tests to the Contractor at least twice a week and provide technical assistance in the resolution of deficiencies.
- 3.1.3.8.** Provide skilled technicians to execute testing. Ensure that they are available and present during the agreed-upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.

- 3.1.3.9.** Warranty Phase: Perform thermographic imaging of loaded panel at time designated by Electrical Subcontractor or Contractor.

3.2. INSTALLATION

- 3.2.1.** Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- 3.2.2.** All installation shall be in accordance with manufacturer's published recommendations.

3.3. TESTING

- 3.3.1.** Pre-functional Checklists and Start-up:
 - 3.3.1.1.** Follow the Start-up and initial checkout procedures listed in this Section and in Division 01. Start-up and complete systems and sub-systems so they are fully functional, meeting the requirements of the Contract Documents.
 - 3.3.1.2.** Pre-functional Checklists shall be complete prior to commencement of a Functional Performance test.
 - 3.3.1.3.** Present a commissioning program guideline with specific pre-functional checklists to owner for review and approval prior to starting commissioning.
- 3.3.2.** Functional Performance Tests:
 - 3.3.2.1.** Functional Performance Tests are conducted after system Start-up and checkout is satisfactorily completed.
- 3.3.3.** Coordination Between Testing Parties:
 - 3.3.3.1.** Factory Start-ups: Factory Start-ups are specified for certain equipment. Factory Start-ups generally are Start-up related activities that will be reviewed and checked prior to Functional Performance Tests. All costs associated with factory Start-ups shall be included with the contract price unless otherwise noted. Notify the Commissioning Team of the factory Start-up schedule and coordinate these factory Start-ups with witnessing parties. The Commissioning Team members may witness these Start-ups at their discretion.

- 3.3.3.2.** Independent Testing Agencies: For systems that specify testing by an independent testing agency, the cost of the test shall be included in the Contract price unless otherwise noted. Testing performed by independent agencies may cover aspects required in the Pre-functional Checklists, Start-ups, and Functional Performance Tests. Coordinate with the independent testing agency so that Owner and/or A/E can witness the test to ensure that applicable aspects of the test meet requirements.

3.4. TRAINING

- 3.4.1.** Submit a written training plan to the Owner and Architect/Engineer for review and approval. Contractor's training plan shall cover the following elements:
 - 3.4.1.1.** Equipment included in training.
 - 3.4.1.2.** Intended audience.
 - 3.4.1.3.** Location of training.
 - 3.4.1.4.** Objectives.
 - 3.4.1.5.** Subjects covered.
 - 3.4.1.6.** Duration of training on each subject.
 - 3.4.1.7.** Instructor for each subject.
 - 3.4.1.8.** Methods (classroom lecture, video, Site walk-through, actual operational demonstrations, written handouts, etc.).
 - 3.4.1.9.** Instructors and qualifications.
- 3.4.2.** Contractor shall have the following training responsibilities:
 - 3.4.2.1.** Provide a training plan ten (10) calendar days prior to the scheduled training, in accordance with Division 01.
 - 3.4.2.2.** Provide Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned mechanical equipment or system.

- 3.4.2.3.** Training shall start with classroom sessions, if necessary, followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including Start-up, shutdown, fire/smoke alarm, power failure, etc.
- 3.4.2.4.** During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
- 3.4.2.5.** The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This representative may be the Start-up technician for the piece of equipment, the installing contractor, or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
- 3.4.2.6.** The training sessions shall follow the outline in the Table of Contents of the O&M manual and illustrate whenever possible the use of the O&M manuals for reference.
- 3.4.2.7.** Training shall include:

 - 3.4.2.7.1.** Usage of the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - 3.4.2.7.2.** Review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include Start-up, operation in all modes possible, shutdown, seasonal changeover and any emergency procedures.
 - 3.4.2.7.3.** Discussion of relevant health and safety issues and concerns.
 - 3.4.2.7.4.** Discussion of warranties and guarantees.
 - 3.4.2.7.5.** Common troubleshooting problems and solutions.

- 3.4.2.7.6.** Explanation of information included in the O&M manuals and the location of all plans and manuals in the facility.

- 3.4.2.7.7.** Discussion of any peculiarities of equipment installation or operation.

- 3.4.2.8.** Hands-on training shall include Start-up, operation in all modes possible, including manual, shutdown, and any emergency procedures and maintenance of all pieces of equipment

- 3.4.2.9.** Training shall occur after Functional Performance Tests are complete and shall be scheduled with the Owner's Project Manager.

- 3.4.3.** Provide training on each system/piece of equipment according to the following schedule:

<u>HOURS</u>	<u>SYSTEM</u>
_____	NORMAL POWER
_____	LIGHTING
_____	FIRE ALARM SYSTEM
_____	LIGHTING CONTROLS
_____	SECURITY SYSTEM
_____	TELECOMMUNICATIONS AND DATA
_____	PAGING SYSTEM

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes the following lighting control devices:

- 1.2.1.1.** Time switches.
- 1.2.1.2.** Outdoor photoelectric switches.
- 1.2.1.3.** Indoor occupancy sensors.
- 1.2.1.4.** Lighting contactors.
- 1.2.1.5.** Emergency shunt relays.

- 1.2.2.** Related Sections include the following:

- 1.2.2.1.** Division 26 Sections "Modular Dimming Controls" for architectural dimming system equipment.
- 1.2.2.2.** Division 26 Section "Network Lighting Controls" for low-voltage, manual and programmable lighting control systems.
- 1.2.2.3.** Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

- 1.2.3.** Related Sections include the following:

- 1.2.3.1.** Division 13 Section "Lighting Controls" for low-voltage, manual and programmable lighting control systems.
- 1.2.3.2.** Division 16 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3. DEFINITIONS

1.3.1. LED: Light-emitting diode.

1.3.2. PIR: Passive infrared.

1.4. SUBMITTALS

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

1.4.2. Shop Drawings: Show installation details for occupancy and light-level sensors.

1.4.2.1. Interconnection diagrams showing field-installed wiring.

1.4.3. Field quality-control test reports.

1.4.4. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5. QUALITY ASSURANCE

1.5.1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6. COORDINATION

1.6.1. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

2. PART 2 - PRODUCTS

2.1. TIME SWITCHES

2.1.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- 2.1.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.1.3.** Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 2.1.3.1.** Intermatic, Inc.
 - 2.1.3.2.** Leviton Mfg. Company Inc.
 - 2.1.3.3.** Paragon Electric Co.; Invensys Climate Controls.
 - 2.1.3.4.** Square D; Schneider Electric.
 - 2.1.3.5.** TORK.
 - 2.1.3.6.** Watt Stopper (The).
- 2.1.4.** Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
- 2.1.5.** Electromechanical-Dial Time Switches: Type complying with UL 917.
 - 2.1.5.1.** Contact Configuration: SPST, DPST, SPDT, DPDT.
 - 2.1.5.2.** Contact Rating: 20-A ballast load, 120/240-V ac.
 - 2.1.5.3.** Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
 - 2.1.5.4.** Astronomic time dial.
 - 2.1.5.5.** Eight-Day Program: Uniquely programmable for each weekday and holidays.
 - 2.1.5.6.** Skip-a-day mode.
 - 2.1.5.7.** Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.2. OUTDOOR PHOTOELECTRIC SWITCHES

- 2.2.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.2.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.2.3.** Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 2.2.3.1.** Grasslin Controls Corporation; a GE Industrial Systems Company.
 - 2.2.3.2.** Intermatic, Inc.
 - 2.2.3.3.** Novitas, Inc.
 - 2.2.3.4.** Paragon Electric Co.; Invensys Climate Controls.
 - 2.2.3.5.** Square D; Schneider Electric.
 - 2.2.3.6.** TORK.
 - 2.2.3.7.** Watt Stopper (The).
- 2.2.4.** Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
 - 2.2.4.1.** Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
 - 2.2.4.2.** Time Delay: 15-second minimum, to prevent false operation.

- 2.2.4.3.** Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
- 2.2.4.4.** Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
- 2.2.5.** Description: Solid state, with SPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.
 - 2.2.5.1.** Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
 - 2.2.5.2.** Time Delay: 30-second minimum, to prevent false operation.
 - 2.2.5.3.** Lightning Arrester: Air-gap type.
 - 2.2.5.4.** Mounting: Twist lock complying with IEEE C136.10, with base.

2.3. INDOOR OCCUPANCY SENSORS

- 2.3.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.3.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.3.3.** Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 2.3.3.1.** Hubbell Lighting.
 - 2.3.3.2.** Leviton Mfg. Company Inc.
 - 2.3.3.3.** Lithonia Lighting; Acuity Lighting Group, Inc.

- 2.3.3.4.** Novitas, Inc.
- 2.3.3.5.** RAB Lighting, Inc.
- 2.3.3.6.** Sensor Switch, Inc.
- 2.3.3.7.** TORK.
- 2.3.3.8.** Watt Stopper (The).
- 2.3.4.** General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
 - 2.3.4.1.** Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - 2.3.4.2.** Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 - 2.3.4.3.** Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 - 2.3.4.4.** Mounting:
 - 2.3.4.4.1.** Sensor: Suitable for mounting in any position on a standard outlet box.
 - 2.3.4.4.2.** Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - 2.3.4.4.3.** Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - 2.3.4.5.** Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

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- 2.4.3.1. Hubbell Lighting.
- 2.4.3.2. Lithonia Lighting; Acuity Lighting Group, Inc.
- 2.4.3.3. RAB Lighting, Inc.
- 2.4.3.4. TORK.
- 2.4.3.5. Watt Stopper (The).
- 2.4.4. Performance Requirements: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F (minus 40 to plus 54 deg C), rated as rain tight according to UL 773A.
 - 2.4.4.1. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - 2.4.4.2. Mounting:
 - 2.4.4.2.1. Sensor: Suitable for mounting in any position on a standard outdoor junction box.
 - 2.4.4.2.2. Relay: Internally mounted in a standard weatherproof electrical enclosure.
 - 2.4.4.2.3. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - 2.4.4.3. Bypass Switch: Override the on function in case of sensor failure.
 - 2.4.4.4. Automatic Light-Level Sensor: Adjustable from 1 to 20 fc (11 to 215 lx); keep lighting off during daylight hours.
- 2.4.5. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).

- 2.4.6.** Detection Coverage: Up to 35 feet (11 m), with a field of view of 90 degrees.
- 2.4.7.** Lighting Fixture Mounted Sensor: Suitable for switching 300 W of tungsten load at 120- or 277-V ac.
- 2.4.8.** Individually Mounted Sensor: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 - 2.4.8.1.** Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 - 2.4.8.2.** Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

2.5. LIGHTING CONTACTORS

- 2.5.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.5.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2.5.3.** Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 2.5.3.1.** Allen-Bradley/Rockwell Automation.
 - 2.5.3.2.** ASCO Power Technologies, LP; a division of Emerson Electric Co.
 - 2.5.3.3.** Eaton Electrical Inc.; Cutler-Hammer Products.
 - 2.5.3.4.** Square D; Schneider Electric.
 - 2.5.3.5.** TORK.

2.5.3.6. Touch-Plate, Inc.

2.5.3.7. Watt Stopper (The).

2.5.4. Description: Electrically operated and mechanically held, combination type with fusible switch, complying with NEMA ICS 2 and UL 508.

2.5.4.1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).

2.5.4.2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.

2.5.4.3. Enclosure: Comply with NEMA 250.

2.5.4.4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.6. EMERGENCY SHUNT RELAY

2.6.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.6.2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.6.3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

2.6.3.1. Lighting Control and Design, Inc.

2.6.4. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual switching contacts; complying with UL 924.

2.6.4.1. Coil Rating: 120 V.

2.7. CONDUCTORS AND CABLES

- 2.7.1.** Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- 2.7.2.** Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- 2.7.3.** Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3. PART 3 - EXECUTION

3.1. SENSOR INSTALLATION

- 3.1.1.** Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2. CONTACTOR INSTALLATION

- 3.2.1.** Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3. WIRING INSTALLATION

- 3.3.1.** Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).
- 3.3.2.** Wiring within Enclosures: Comply with NECA 1. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

3.3.3. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

3.3.4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4. IDENTIFICATION

3.4.1. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

3.4.1.1. Identify controlled circuits in lighting contactors.

3.4.1.2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

3.4.2. Label time switches and contactors with a unique designation.

3.5. FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

3.5.1.1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.

3.5.1.2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

3.5.2. Lighting control devices that fail tests and inspections are defective work.

3.6. ADJUSTING

3.6.1. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7. DEMONSTRATION

- 3.7.1.** Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls."
- 3.7.2.** Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1. This Section includes the following:
 - 1.2.1.1. Distribution panelboards.
 - 1.2.1.2. Lighting and appliance branch-circuit panelboards.
 - 1.2.1.3. Load centers.
 - 1.2.1.4. Transient voltage suppression panelboards.

1.3. DEFINITIONS

- 1.3.1. EMI: Electromagnetic interference.
- 1.3.2. GFCI: Ground-fault circuit interrupter.
- 1.3.3. RFI: Radio-frequency interference.
- 1.3.4. RMS: Root mean square.
- 1.3.5. SPDT: Single pole, double throw.

1.4. SUBMITTALS

- 1.4.1. Product Data: For each type of panelboard, over current protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- 1.4.2. Shop Drawings: For each panelboard and related equipment.
 - 1.4.2.1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:

- 1.4.2.1.1.** Enclosure types and details for types other than NEMA 250, Type 1.
- 1.4.2.1.2.** Bus configuration, current, and voltage ratings.
- 1.4.2.1.3.** Short-circuit current rating of panelboards and over current protective devices.
- 1.4.2.1.4.** UL listing for series rating of installed devices.
- 1.4.2.1.5.** Features, characteristics, ratings, and factory settings of individual over current protective devices and auxiliary components.

1.4.2.2. Wiring Diagrams: Power, signal, and control wiring.

- 1.4.3.** Manufacturer Seismic Qualification Certification: Submit certification that panelboards, over current protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:

1.4.3.1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

- 1.4.3.1.1.** The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
- 1.4.3.1.2.** The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

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- 1.5.1.1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
 - 1.5.2. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
 - 1.5.3. Source Limitations: Obtain panelboards, over current protective devices, components, and accessories through one source from a single manufacturer.
 - 1.5.4. Product Options: Drawings indicate size, profiles, and dimensional requirements of panelboards and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
 - 1.5.5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 - 1.5.6. Comply with NEMA PB 1.
 - 1.5.7. Comply with NFPA 70.
- 1.6. PROJECT CONDITIONS
 - 1.6.1. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1.6.1.1. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
 - 1.6.1.2. Altitude: Not exceeding 6600 feet (2000 m).
 - 1.6.2. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1.6.2.1. Ambient temperatures within limits specified.

1.6.2.2. Altitude not exceeding 6600 feet (2000 m).

1.6.3. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1.6.3.1. Notify Architect no fewer than seven days in advance of proposed interruption of electrical service.

1.6.3.2. Do not proceed with interruption of electrical service without Architect's written permission.

1.7. COORDINATION

1.7.1. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.7.2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8. EXTRA MATERIALS

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

1.8.1.1. Keys: Six spares for each type of panelboard cabinet lock.

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

2.1.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.1.2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.1.2.1. Panelboards, Over current Protective Devices, Controllers, Contactors, and Accessories:

2.1.2.1.1. Square D.

2.1.2.1.2. General Electric Co. Electrical Distribution.

2.1.2.1.3. Siemens Energy & Automation, Inc.

2.1.2.2. Transient Voltage Suppression Panelboards:

2.1.2.2.1. Current Technology.

2.1.2.2.2. Liebert Corporation.

2.2. MANUFACTURED UNITS

2.2.1. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

2.2.2. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1.

2.2.2.1. Rated for environmental conditions at installed location.

2.2.2.1.1. Outdoor Locations: NEMA 250, Type 3R.

2.2.2.1.2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.

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- 2.2.3.4.** Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
 - 2.2.3.5.** Split Bus: Vertical buses divided into individual vertical sections.
 - 2.2.4.** Conductor Connectors: Suitable for use with conductor material.
 - 2.2.4.1.** Main and Neutral Lugs: Compression type.
 - 2.2.4.2.** Ground Lugs and Bus Configured Terminators: Compression type.
 - 2.2.4.3.** Feed-Through Lugs: Compression type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 2.2.4.4.** Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
 - 2.2.5.** Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.
 - 2.2.6.** Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- 2.3.** PANELBOARD SHORT-CIRCUIT RATING
 - 2.3.1.** UL label indicating series-connected rating with integral or remote upstream over current protective devices. Include size and type of upstream device allowable, branch devices allowable, and UL series-connected short-circuit rating.
 - 2.3.2.** Fully rated to interrupt symmetrical short-circuit current available at terminals.
- 2.4.** DISTRIBUTION PANELBOARDS
 - 2.4.1.** Doors: Secured with vault-type latch with tumbler lock; keyed alike. Omit for fused-switch panelboards.

2.4.2. Main Over current Protective Devices:

2.4.3. Branch Over current Protective Devices:

2.4.3.1. For Circuit-Breaker Frame Sizes 125 A and Smaller: circuit breakers.

2.4.3.2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.4.3.3. Fused switches.

2.5. LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

2.5.1. Branch Over current Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

2.5.2. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.6. LOAD CENTERS

2.6.1. Over current Protective Devices: Plug-in, full-module circuit breaker.

2.6.2. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

2.7. TRANSIENT VOLTAGE SUPPRESSION PANELBOARDS

2.7.1. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

2.7.2. Main Over current Devices: Thermal-magnetic circuit breaker.

2.7.3. Branch Over current Protective Devices: Bolt-on circuit breakers.

2.7.4. Bus: Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.

- 2.7.5.** Transient Voltage Suppression Device: IEEE C62.41, integrally mounted, plug-in-style, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules.
- 2.7.5.1.** Minimum Single-Impulse Current Ratings:
- 2.7.5.1.1.** Line to Neutral: 100,000 A.
 - 2.7.5.1.2.** Line to Ground: 100,000 A.
 - 2.7.5.1.3.** Neutral to Ground: 50,000 A.
- 2.7.5.2.** Protection modes shall be as follows:
- 2.7.5.2.1.** Line to neutral.
 - 2.7.5.2.2.** Line to ground.
 - 2.7.5.2.3.** Neutral to ground.
- 2.7.5.3.** EMI/RFI Noise Attenuation Using 50-ohm Insertion Loss Test: 55 dB at 100 kHz.
- 2.7.5.4.** Maximum Category C Combination Wave Clamping Voltage: 600 V, line to neutral and line to ground on 120/208 V systems.
- 2.7.5.5.** Maximum UL 1449 Clamping Levels: 400 V, line to neutral and line to ground on 120/208 V systems.
- 2.7.5.6.** Withstand Capabilities: 3000 Category C surges with less than 5 percent change in clamping voltage.
- 2.7.5.7.** Accessories:
- 2.7.5.7.1.** Form-C contacts, one normally open and one normally closed, for remote monitoring of system operation. Contacts to reverse position on failure of any surge diversion module.
 - 2.7.5.7.2.** Audible alarm activated on failure of any surge diversion module.

- 2.7.5.7.3.** Six-digit transient-counter set to total transient surges that deviate from the sine-wave envelope by more than 125 V.

2.8. OVERCURRENT PROTECTIVE DEVICES

- 2.8.1.** Molded-Case Circuit Breaker: UL 489, with interrupting capacity to meet available fault currents.

- 2.8.1.1.** 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.

- 2.8.1.2.** Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

- 2.8.1.3.** Electronic trip-unit circuit breakers shall have RMS sensing; field-replaceable rating plug; and with the following field-adjustable settings:

- 2.8.1.3.1.** Instantaneous trip.

- 2.8.1.3.2.** Long- and short-time pickup levels.

- 2.8.1.3.3.** Long- and short-time time adjustments.

- 2.8.1.3.4.** Ground-fault pickup level, time delay, and I²t response.

- 2.8.1.3.5.** Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

- 2.8.1.3.6.** Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.

2.8.1.3.7. GFCI Circuit Breakers: Single- and two-pole configurations with 5 mA trip sensitivity.

2.8.2. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

2.8.2.1. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.

2.8.2.2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

2.8.2.3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2.8.2.4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."

2.8.2.5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.

2.8.2.6. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.

2.8.2.7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

2.8.2.8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.8.2.9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

2.8.2.10. Multipole units enclosed in a single housing or factory-assembled to operate as a single unit.

2.8.3. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

2.8.4. Fuses are specified in Division 26 Section "Fuses."

2.9. CONTROLLERS

2.9.1. Motor Controllers: NEMA ICS 2, Class A, combination controller equipped for panelboard mounting and including the following accessories:

2.9.1.1. Individual control-power transformers.

2.9.1.2. Fuses for control-power transformers.

2.9.1.3. Bimetallic-element overload relay.

2.9.1.4. Indicating lights.

2.9.1.5. Seal-in contact.

2.9.1.6. Six convertible auxiliary contacts.

2.9.1.7. Push buttons.

2.9.1.8. Selector switches.

2.9.2. Contactors: NEMA ICS 2, Class A, combination controller equipped for panelboard mounting and including the following accessories:

2.9.2.1. Individual control-power transformers.

2.9.2.2. Fuses for control-power transformers.

2.9.2.3. Indicating lights.

2.9.2.4. Seal-in contact.

2.9.2.5. Six convertible auxiliary contacts.

2.9.2.6. Push buttons.

- [illegible]

- 3.1.4.** Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- 3.1.5.** Install over current protective devices and controllers.
 - 3.1.5.1.** Set field-adjustable switches and circuit-breaker trip ranges.
- 3.1.6.** Install filler plates in unused spaces.
- 3.1.7.** Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- 3.1.8.** Arrange conductors in gutters into groups and bundle and wrap with wire ties[after completing load balancing.

3.2. IDENTIFICATION

- 3.2.1.** Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- 3.2.2.** Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- 3.2.3.** Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3. CONNECTIONS

- 3.3.1.** Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- 3.3.2.** Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4. FIELD QUALITY CONTROL

- 3.4.1.** Prepare for acceptance tests as follows:

- 3.4.1.1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 3.4.1.2. Test continuity of each circuit.
 - 3.4.2. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
 - 3.4.3. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
 - 3.4.4. Perform the following field tests and inspections and prepare test reports:
 - 3.4.4.1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 - 3.4.4.2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3.4.5. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 - 3.4.5.1. Measure as directed during period of normal system loading.
 - 3.4.5.2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3.4.5.3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.

- 3.4.5.4.** Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.
 - 3.4.6.** Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scanning of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.
 - 3.4.6.1.** Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - 3.4.6.2.** Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3.4.6.3.** Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5. CLEANING

- 3.5.1.** On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes the following:

- 1.2.1.1.** Receptacles, receptacles with integral GFCI, and associated device plates.
- 1.2.1.2.** Twist-locking receptacles.
- 1.2.1.3.** Receptacles with integral surge suppression units.
- 1.2.1.4.** Wall-box motion sensors.
- 1.2.1.5.** Isolated-ground receptacles.
- 1.2.1.6.** Snap switches and wall-box dimmers.
- 1.2.1.7.** Solid-state fan speed controls.
- 1.2.1.8.** Wall-switch and exterior occupancy sensors.
- 1.2.1.9.** Communications outlets.
- 1.2.1.10.** Cord and plug sets.
- 1.2.1.11.** Floor service outlets, service poles, and multi-outlet assemblies.

- 1.2.2.** Related Sections include the following:

- 1.2.2.1.** Division 27 Section "Communications Horizontal Cabling" for workstation outlets.

1.3. DEFINITIONS

- 1.3.1.** EMI: Electromagnetic interference.
- 1.3.2.** GFCI: Ground-fault circuit interrupter.
- 1.3.3.** Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- 1.3.4.** RFI: Radio-frequency interference.

1.3.5. TVSS: Transient voltage surge suppressor.

1.3.6. UTP: Unshielded twisted pair.

1.4. SUBMITTALS

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

1.4.2. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

1.4.3. Samples: One for each type of device and wall plate specified, in each color specified.

1.4.4. Field quality-control test reports.

1.4.5. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5. QUALITY ASSURANCE

1.5.1. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

1.5.2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5.3. Comply with NFPA 70.

1.6. COORDINATION

1.6.1. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1.6.1.1. Cord and Plug Sets: Match equipment requirements.

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

2.1.1. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

- 2.1.1.1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
- 2.1.1.2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
- 2.1.1.3. Leviton Mfg. Company Inc. (Leviton).
- 2.1.1.4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2. STRAIGHT BLADE RECEPTACLES

- 2.2.1. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - 2.2.1.1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.2.1.2. Products: Subject to compliance with requirements, provide one of the following:
 - 2.2.1.2.1. Cooper; 5351 (single), 5352 (duplex).
 - 2.2.1.2.2. Hubbell; HBL5351 (single), CR5352 (duplex).
 - 2.2.1.2.3. Leviton; 5891 (single), 5352 (duplex).
 - 2.2.1.2.4. Pass & Seymour; 5381 (single), 5352 (duplex).
- 2.2.2. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - 2.2.2.1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.2.2.2. Products: Subject to compliance with requirements, provide one of the following:
 - 2.2.2.2.1. Hubbell; CR 5253IG.
 - 2.2.2.2.2. Leviton; 5362-IG.
 - 2.2.2.2.3. Pass & Seymour; IG6300.

2.2.2.3. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.2.3. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

2.2.3.1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2.2.3.2. Products: Subject to compliance with requirements, provide one of the following:

2.2.3.2.1. Cooper; TR8300.

2.2.3.2.2. Hubbell; HBL8300SG.

2.2.3.2.3. Leviton; 8300-SGG.

2.2.3.2.4. Pass & Seymour; 63H.

2.3. GFCI RECEPTACLES

2.3.1. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

2.3.2. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

2.3.2.1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2.3.2.2. Products: Subject to compliance with requirements, provide one of the following:

2.3.2.2.1. Cooper; GF20.

2.3.2.2.2. Pass & Seymour; 2084.

2.4. TVSS RECEPTACLES

2.4.1. General Description: Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 1449, with integral TVSS in line to ground, line to neutral, and neutral to ground.

- 2.4.1.1.** TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 volts and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
 - 2.4.1.2.** Active TVSS Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."
 - 2.4.2.** Duplex TVSS Convenience Receptacles:
 - 2.4.2.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.4.2.2.** Products: Subject to compliance with requirements, provide one of the following:
 - 2.4.2.2.1.** Cooper; 5362BLS.
 - 2.4.2.2.2.** Hubbell; HBL5362SA.
 - 2.4.2.2.3.** Leviton; 5380.
 - 2.4.2.3.** Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R.
 - 2.4.3.** Isolated-Ground, Duplex Convenience Receptacles:
 - 2.4.3.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.4.3.2.** Products: Subject to compliance with requirements, provide one of the following:
 - 2.4.3.2.1.** Cooper; IG5362BLS.
 - 2.4.3.2.2.** Hubbell; IG5362SA.
 - 2.4.3.2.3.** Leviton; 5380-IG.
 - 2.4.3.3.** Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.5. TWIST-LOCKING RECEPTACLES

2.5.1. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.

2.5.1.1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2.5.1.2. Products: Subject to compliance with requirements, provide one of the following:

2.5.1.2.1. Cooper; L520R.

2.5.1.2.2. Hubbell; HBL2310.

2.5.1.2.3. Leviton; 2310.

2.5.1.2.4. Pass & Seymour; L520-R.

2.5.2. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:

2.5.2.1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2.5.2.2. Products: Subject to compliance with requirements, provide one of the following:

2.5.2.2.1. Hubbell; IG2310.

2.5.2.2.2. Leviton; 2310-IG.

2.5.2.3. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.6. CORD AND PLUG SETS

2.6.1. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

2.6.1.1. 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.

- 2.6.1.2.** Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7. SNAP SWITCHES

- 2.7.1.** Comply with NEMA WD 1 and UL 20.

- 2.7.2.** Switches, 120/277 V, 20 A:

- 2.7.2.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

- 2.7.2.2.** Products: Subject to compliance with requirements, provide one of the following:

- 2.7.2.2.1.** Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).

- 2.7.2.2.2.** Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).

- 2.7.2.2.3.** Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).

- 2.7.2.2.4.** Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).

- 2.7.3.** Pilot Light Switches, 20 A:

- 2.7.3.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

- 2.7.3.2.** Products: Subject to compliance with requirements, provide one of the following:

- 2.7.3.2.1.** Cooper; 2221PL for 120 V and 277 V.

- 2.7.3.2.2.** Hubbell; HPL1221PL for 120 V and 277 V.

- 2.7.3.2.3.** Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.

- 2.7.3.2.4.** Pass & Seymour; PS20AC1-PLR for 120 V.

- 2.7.3.3.** Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

- 2.7.4.** Key-Operated Switches, 120/277 V, 20 A:
- 2.7.4.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.7.4.2.** Products: Subject to compliance with requirements, provide one of the following:
 - 2.7.4.2.1.** Cooper; 2221L.
 - 2.7.4.2.2.** Hubbell; HBL1221L.
 - 2.7.4.2.3.** Leviton; 1221-2L.
 - 2.7.4.2.4.** Pass & Seymour; PS20AC1-L.
 - 2.7.4.3.** Description: Single pole, with factory-supplied key in lieu of switch handle.
- 2.7.5.** Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
- 2.7.5.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.7.5.2.** Products: Subject to compliance with requirements, provide one of the following:
 - 2.7.5.2.1.** Cooper; 1995.
 - 2.7.5.2.2.** Hubbell; HBL1557.
 - 2.7.5.2.3.** Leviton; 1257.
 - 2.7.5.2.4.** Pass & Seymour; 1251.
- 2.7.6.** Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
- 2.7.6.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.7.6.2.** Products: Subject to compliance with requirements, provide one of the following:

- 2.7.6.2.1.** Cooper; 1995L.
- 2.7.6.2.2.** Hubbell; HBL1557L.
- 2.7.6.2.3.** Leviton; 1257L.
- 2.7.6.2.4.** Pass & Seymour; 1251L.

2.8. WALL-BOX DIMMERS

- 2.8.1.** Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
- 2.8.2.** Control: Continuously adjustable slider with single-pole or three-way switching. Comply with UL 1472.
- 2.8.3.** Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
 - 2.8.3.1.** 600 W; dimmers shall require no derating when ganged with other devices.
- 2.8.4.** Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.9. FAN SPEED CONTROLS

- 2.9.1.** Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.
 - 2.9.1.1.** Continuously adjustable rotary knob, 5A.
 - 2.9.1.2.** Three-speed adjustable rotary knob, 1.5A.

2.10. OCCUPANCY SENSORS

- 2.10.1.** Wall-Switch Sensors:
 - 2.10.1.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.10.1.2.** Products: Subject to compliance with requirements, provide one of the following:
 - 2.10.1.2.1.** Cooper; 6111 for 120 V, 6117 for 277 V.

2.10.1.2.2. Hubbell; WS1277.

2.10.1.2.3. Leviton; ODS 10-ID.

2.10.1.2.4. Pass & Seymour; WS3000.

2.10.1.2.5. Watt Stopper (The); WS-200.

2.10.1.3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).

2.10.2. Wall-Switch Sensors:

2.10.2.1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2.10.2.2. Products: Subject to compliance with requirements, provide one of the following:

2.10.2.2.1. Hubbell; AT120 for 120 V, AT277 for 277 V.

2.10.2.2.2. Leviton; ODS 15-ID.

2.10.2.3. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).

2.10.3. Long-Range Wall-Switch Sensors:

2.10.3.1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2.10.3.2. Products: Subject to compliance with requirements, provide one of the following:

2.10.3.2.1. Hubbell; ATP1600WRP.

2.10.3.2.2. Leviton; ODWWV-IRW.

2.10.3.2.3. Pass & Seymour; WA1001.

2.10.3.2.4. Watt Stopper (The); CX-100.

2.10.3.3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).

2.10.4. Long-Range Wall-Switch Sensors:

2.10.4.1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2.10.4.2. Products: Subject to compliance with requirements, provide one of the following:

2.10.4.2.1. Hubbell; ATD1600WRP.

2.10.4.2.2. Leviton; ODW12-MRW.

2.10.4.2.3. Watt Stopper (The); DT-200.

2.10.4.3. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft. (111 sq. m).

2.10.5. Wide-Range Wall-Switch Sensors:

2.10.5.1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2.10.5.2. Products: Subject to compliance with requirements, provide one of the following:

2.10.5.2.1. Hubbell; ATP120HBRP.

2.10.5.2.2. Leviton; ODWHB-IRW.

2.10.5.2.3. Pass & Seymour; HS1001.

2.10.5.2.4. Watt Stopper (The); CX-100-3.

2.10.5.3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).

2.10.6. Exterior Occupancy Sensors:

- 2.10.6.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
- 2.10.6.2.** Products: Subject to compliance with requirements, provide one of the following:
 - 2.10.6.2.1.** Leviton; PS200-10.
 - 2.10.6.2.2.** Watt Stopper (The); EW-100-120.
- 2.10.6.3.** Description: Passive-infrared type, 120/277 V, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and 110-foot (34-m) detection range. Minimum switch rating: 1000-W incandescent, 500-VA fluorescent.

2.11. COMMUNICATIONS OUTLETS

2.11.1. Telephone Outlet:

- 2.11.1.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
- 2.11.1.2.** Products: Subject to compliance with requirements, provide one of the following:
 - 2.11.1.2.1.** Cooper; 3560-6.
 - 2.11.1.2.2.** Leviton; 40649.
- 2.11.1.3.** Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e. Comply with UL 1863.

2.11.2. Combination TV and Telephone Outlet:

- 2.11.2.1.** Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
- 2.11.2.2.** Products: Subject to compliance with requirements, provide one of the following:
 - 2.11.2.2.1.** Cooper; 3562.
 - 2.11.2.2.2.** Leviton; 40595.

- 2.11.2.3.** Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

2.12. WALL PLATES

- 2.12.1.** Single and combination types to match corresponding wiring devices.
- 2.12.1.1.** Plate-Securing Screws: Metal with head color to match plate finish.
- 2.12.1.2.** Material for Finished Spaces: Smooth, high-impact thermoplastic, 0.035-inch- (1-mm-) thick, satin-finished stainless steel.
- 2.12.1.3.** Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
- 2.12.1.4.** Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."
- 2.12.2.** Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

2.13. FLOOR SERVICE FITTINGS

- 2.13.1.** Type: Modular, flush-type, dual-service units suitable for wiring method used.
- 2.13.2.** Compartments: Barrier separates power from voice and data communication cabling.
- 2.13.3.** Service Plate: Rectangular, solid brass with satin finish.
- 2.13.4.** Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.
- 2.13.5.** Voice and Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 Category 5e jacks for UTP cable.

2.14. MULTI-OUTLET ASSEMBLIES

- 2.14.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.14.2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.14.2.1. Hubbell Incorporated; Wiring Device-Kellems.

2.14.2.2. Wiremold Company (The).

2.14.3. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

2.14.4. Raceway Material: Metal, with manufacturer's standard finish.

2.14.5. Wire: No. 12 AWG.

2.15. SERVICE POLES

2.15.1. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.

2.15.1.1. Poles: Nominal 2.5-inch- (65-mm-) square cross section, with height adequate to extend from floor to at least 6 inches (150 mm) above ceiling, and with separate channels for power wiring and voice and data communication cabling.

2.15.1.2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.

2.15.1.3. Finishes: Manufacturer's standard painted finish and trim combination.

2.15.1.4. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, 4-pair, Category 3 or 5 voice and data communication cables.

2.15.1.5. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R units.

2.15.1.6. Voice and Data Communication Outlets: Two RJ-45 Category 5e jacks.

2.16. FINISHES

2.16.1. Color: Wiring device catalog numbers in Section Text do not designate device color.

- 2.16.1.1.** Wiring Devices Connected to Normal Power System: White, unless otherwise indicated or required by NFPA 70 or device listing.
- 2.16.1.2.** Wiring Devices Connected to Emergency Power System: Red.
- 2.16.1.3.** TVSS Devices: Blue.
- 2.16.1.4.** Isolated-Ground Receptacles: Orange.

3. PART 3 - EXECUTION

3.1. INSTALLATION

- 3.1.1.** Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- 3.1.2.** Coordination with Other Trades:
 - 3.1.2.1.** Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 - 3.1.2.2.** Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3.1.2.3.** Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 3.1.2.4.** Install wiring devices after all wall preparation, including painting, is complete.
- 3.1.3.** Conductors:
 - 3.1.3.1.** Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 - 3.1.3.2.** Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3.1.3.3.** The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

3.1.3.4. Existing Conductors:

- 3.1.3.4.1.** Cut back and pigtail, or replace all damaged conductors.
- 3.1.3.4.2.** Straighten conductors that remain and remove corrosion and foreign matter.
- 3.1.3.4.3.** Pigtailling existing conductors is permitted provided the outlet box is large enough.

3.1.4. Device Installation:

- 3.1.4.1.** Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
- 3.1.4.2.** Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
- 3.1.4.3.** Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
- 3.1.4.4.** Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
- 3.1.4.5.** When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
- 3.1.4.6.** Use a torque screwdriver when a torque is recommended or required by the manufacturer.
- 3.1.4.7.** When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
- 3.1.4.8.** Tighten unused terminal screws on the device.
- 3.1.4.9.** When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

3.1.5. Receptacle Orientation:

- 3.1.5.1.** Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the left.

- 3.1.6.** Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- 3.1.7.** Dimmers:
 - 3.1.7.1.** Install dimmers within terms of their listing.
 - 3.1.7.2.** Verify that dimmers used for fan speed control are listed for that application.
 - 3.1.7.3.** Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
- 3.1.8.** Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.
- 3.1.9.** Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.
- 3.2.** IDENTIFICATION
 - 3.2.1.** Comply with Division 26 Section "Identification for Electrical Systems."
 - 3.2.1.1.** Receptacles: Identify panel board and circuit number from which served. Use hot, stamped or engraved machine printing with white-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.
- 3.3.** FIELD QUALITY CONTROL
 - 3.3.1.** Perform tests and inspections and prepare test reports.
 - 3.3.1.1.** Test Instruments: Use instruments that comply with UL 1436.
 - 3.3.1.2.** Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
 - 3.3.2.** Tests for Convenience Receptacles:
 - 3.3.2.1.** Line Voltage: Acceptable range is 105 to 132 V.

- 3.3.2.2.** Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
- 3.3.2.3.** Ground Impedance: Values of up to 2 ohms are acceptable.
- 3.3.2.4.** GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
- 3.3.2.5.** Using the test plug, verify that the device and its outlet box are securely mounted.
- 3.3.2.6.** The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes the following:

- 1.2.1.1.** Cartridge fuses rated 600 V and less for use in switches, panelboards.
- 1.2.1.2.** Spare-fuse cabinets.

1.3. SUBMITTALS

- 1.3.1.** Product Data: Include the following for each fuse type indicated:

- 1.3.1.1.** Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
- 1.3.1.2.** Let-through current curves for fuses with current-limiting characteristics.
- 1.3.1.3.** Time-current curves, coordination charts and tables, and related data.
- 1.3.1.4.** Fuse size for elevator feeders and elevator disconnect switches.

- 1.3.2.** Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

- 1.3.2.1.** For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
- 1.3.2.2.** Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

- 1.3.3.** Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.

1.3.3.1. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1.3.3.1.1. Let-through current curves for fuses with current-limiting characteristics.

1.3.3.1.2. Time-current curves, coordination charts and tables, and related data.

1.3.3.1.3. Ambient temperature adjustment information.

1.4. QUALITY ASSURANCE

1.4.1. Source Limitations: Obtain fuses from a single manufacturer.

1.4.2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4.3. Comply with NEMA FU 1.

1.4.4. Comply with NFPA 70.

1.5. PROJECT CONDITIONS

1.5.1. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6. COORDINATION

1.6.1. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

1.7. EXTRA MATERIALS

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

1.7.1.1. Fuses: Quantity equal to 10 percent of each fuse type and size, but no fewer than 2 of each type and size.

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

2.1.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.1.1.1. Cooper Bussman, Inc.

2.1.1.2. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.

2.1.1.3. Ferraz Shawmut, Inc.

2.1.1.4. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.2. CARTRIDGE FUSES

2.2.1. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

2.3. SPARE-FUSE CABINET

2.3.1. Cabinet: Wall-mounted, 0.05-inch- (1.27-mm-) thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

2.3.1.1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.

2.3.1.2. Finish: Gray, baked enamel.

2.3.1.3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.

2.3.1.4. Fuse Pullers: For each size of fuse.

3. PART 3 - EXECUTION

3.1. EXAMINATION

3.1.1. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

3.1.2. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

3.1.3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. FUSE APPLICATIONS

3.2.1. Motor Branch Circuits: Class RK1, time delay.

3.2.2. Other Branch Circuits: Class RK1, time delay.

3.3. INSTALLATION

3.3.1. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.3.2. Install spare-fuse cabinet(s).

3.4. IDENTIFICATION

3.4.1. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes the following individually mounted, enclosed switches and circuit breakers:
- 1.2.1.1.** Fusible switches.
 - 1.2.1.2.** Non-fusible switches.
 - 1.2.1.3.** Bolted-pressure contact switches.
 - 1.2.1.4.** High-pressure, butt-type contact switches.
 - 1.2.1.5.** Molded-case circuit breakers.
 - 1.2.1.6.** Molded-case switches.
 - 1.2.1.7.** Enclosures.

1.3. DEFINITIONS

- 1.3.1.** GD: General duty.
- 1.3.2.** GFCI: Ground-fault circuit interrupter.
- 1.3.3.** HD: Heavy duty.
- 1.3.4.** RMS: Root mean square.
- 1.3.5.** SPDT: Single pole, double throw.

1.4. SUBMITTALS

- 1.4.1.** Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- 1.4.1.1.** Enclosure types and details for types other than NEMA 250, Type 1.
 - 1.4.1.2.** Current and voltage ratings.

- 1.4.1.3. Short-circuit current rating.
- 1.4.1.4. UL listing for series rating of installed devices.
- 1.4.1.5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- 1.4.2. Shop Drawings: Diagram power, signal, and control wiring.
- 1.4.3. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:
 - 1.4.3.1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 1.4.3.1.1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - 1.4.3.1.2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 1.4.3.2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 1.4.3.3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 1.4.4. Qualification Data: For testing agency.
- 1.4.5. Field quality-control test reports including the following:
 - 1.4.5.1. Test procedures used.
 - 1.4.5.2. Test results that comply with requirements.
 - 1.4.5.3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

- 1.4.6. Manufacturer's field service report.
- 1.4.7. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1.4.7.1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - 1.4.7.2. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5. QUALITY ASSURANCE

- 1.5.1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1.5.1.1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- 1.5.2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- 1.5.3. Comply with NFPA 70.
- 1.5.4. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.6. PROJECT CONDITIONS

- 1.6.1. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1.6.1.1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).

1.6.1.2. Altitude: Not exceeding 6600 feet (2010 m).

1.7. COORDINATION

1.7.1. 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.

1.8. EXTRA MATERIALS

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

1.8.1.1. Spares: For the following:

1.8.1.1.1. Potential Transformer Fuses.

1.8.1.1.2. Control-Power Fuses.

1.8.1.1.3. Fuses and Fusible Devices for Fused Circuit Breakers.

1.8.1.1.4. Fuses for Fusible Switches.

1.8.1.1.5. Fuses for Fused Power Circuit Devices.

1.8.1.2. Spare Indicating Lights: Six of each type installed.

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

2.1.1. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

2.1.1.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.1.1.2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2. FUSIBLE AND NONFUSIBLE SWITCHES

2.2.1. Manufacturers:

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CIRCUIT BREAKERS

- 2.2.1.1. General Electric Co.; Electrical Distribution & Control Division.
 - 2.2.1.2. Square D/Group Schneider.
 - 2.2.2. Fusible Switch, 600A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
 - 2.2.3. Non-fusible Switch, 600A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
 - 2.2.4. Accessories:
 - 2.2.4.1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2.2.4.2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
 - 2.2.4.3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.
- 2.3. MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES
 - 2.3.1. Manufacturers:
 - 2.3.1.1. General Electric Co.; Electrical Distribution & Control Division.
 - 2.3.1.2. Square D/Group Schneider.
 - 2.3.2. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
 - 2.3.2.1. 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.
 - 2.3.2.2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 2.3.2.3. Electronic Trip-Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:

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CIRCUIT BREAKERS

- [illegible]

2.4. ENCLOSURES

- 2.4.1.1.** Outdoor Locations: NEMA 250, Type 3R.

- 2.4.1.2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
- 2.4.1.3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
- 2.4.1.4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

3. PART 3 - EXECUTION

3.1. EXAMINATION

- 3.1.1. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.
- 3.1.2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. CONCRETE BASES

- 3.2.1. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.
- 3.2.2. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems," and concrete materials and installation requirements are specified in Division 03.

3.3. INSTALLATION

- 3.3.1. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.
- 3.3.2. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.
- 3.3.3. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- 3.3.4. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.4. IDENTIFICATION

- 3.4.1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

- 3.4.2.** Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Division 26 Section "Identification for Electrical Systems."

3.5. FIELD QUALITY CONTROL

- 3.5.1.** Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- 3.5.2.** Prepare for acceptance testing as follows:
- 3.5.2.1.** Inspect mechanical and electrical connections.
 - 3.5.2.2.** Verify switch and relay type and labeling verification.
 - 3.5.2.3.** Verify rating of installed fuses.
 - 3.5.2.4.** Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.
- 3.5.3.** Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- 3.5.4.** Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- 3.5.5.** Perform the following field tests and inspections and prepare test reports:
- 3.5.5.1.** Test mounting and anchorage devices according to requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
 - 3.5.5.2.** Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 - 3.5.5.3.** Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3.5.5.4.** Infrared Scanning:

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- 3.5.5.4.1.** Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
- 3.5.5.4.2.** Follow-Up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.
- 3.5.5.4.3.** Instruments, Equipment and Reports:
 - 3.5.5.4.3.1.** Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3.5.5.4.3.2.** Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6. ADJUSTING

- 3.6.1.** Set field-adjustable switches and circuit-breaker trip ranges.

3.7. CLEANING

- 3.7.1.** On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.
- 3.7.2.** Inspect exposed surfaces and repair damaged finishes.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** Section includes the following enclosed controllers rated 600 V and less:

- 1.2.1.1.** Full-voltage manual.
- 1.2.1.2.** Full-voltage magnetic.
- 1.2.1.3.** Reduced-voltage magnetic.
- 1.2.1.4.** Reduced-voltage solid state.
- 1.2.1.5.** Multispeed.

- 1.2.2.** Related Section:

- 1.2.2.1.** Division 26 Section "Variable-Frequency Motor Controllers" for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1.3. DEFINITIONS

- 1.3.1.** CPT: Control power transformer.
- 1.3.2.** MCCB: Molded-case circuit breaker.
- 1.3.3.** MCP: Motor circuit protector.
- 1.3.4.** N.C.: Normally closed.
- 1.3.5.** N.O.: Normally open.
- 1.3.6.** OCPD: Over current protective device.
- 1.3.7.** SCR: Silicon-controlled rectifier.

1.4. PERFORMANCE REQUIREMENTS

- 1.4.1.** Seismic Performance: Enclosed controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

- 1.4.1.1.** The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5. SUBMITTALS

- 1.5.1.** Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.
- 1.5.2.** Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
 - 1.5.2.1.** Show tabulations of the following:
 - 1.5.2.1.1.** Each installed unit's type and details.
 - 1.5.2.1.2.** Factory-installed devices.
 - 1.5.2.1.3.** Nameplate legends.
 - 1.5.2.1.4.** Short-circuit current rating of integrated unit.
 - 1.5.2.1.5.** Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
 - 1.5.2.1.6.** Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.
 - 1.5.2.2.** Wiring Diagrams: For power, signal, and control wiring.
- 1.5.3.** Qualification Data: For qualified testing agency.
- 1.5.4.** Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.
 - 1.5.4.1.** Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 1.5.4.2.** Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

- 1.5.4.3.** Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - 1.5.5.** Field quality-control reports.
 - 1.5.6.** Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1.5.6.1.** Routine maintenance requirements for enclosed controllers and installed components.
 - 1.5.6.2.** Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
 - 1.5.6.3.** Manufacturer's written instructions for setting field-adjustable overload relays.
 - 1.5.6.4.** Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.
 - 1.5.7.** Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
 - 1.5.8.** Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

2. PART 2 - QUALITY ASSURANCE

- 2.1.1.** Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 2.1.1.1.** Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- 2.1.2.** Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2.1.3.** Comply with NFPA 70.

- 2.1.4.** IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

2.2. DELIVERY, STORAGE, AND HANDLING

- 2.2.1.** Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- 2.2.2.** If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; connect factory-installed space heaters to temporary electrical service.

2.3. PROJECT CONDITIONS

- 2.3.1.** Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
- 2.3.1.1.** Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
- 2.3.1.2.** Altitude: Not exceeding 6600 feet (2010 m).
- 2.3.2.** Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
- 2.3.2.1.** Notify Architect no fewer than two days in advance of proposed interruption of electrical systems.
- 2.3.2.2.** Indicate method of providing temporary utilities.
- 2.3.2.3.** Do not proceed with interruption of electrical systems without Architect's written permission.
- 2.3.2.4.** Comply with NFPA 70E.

2.4. COORDINATION

- 2.4.1.** Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- 2.4.2.** Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- 2.4.3.** Coordinate installation of roof curbs, equipment supports, and roof penetrations.

2.5. EXTRA MATERIALS

- 2.5.1.** Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 2.5.1.1.** Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2.5.1.2.** Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 - 2.5.1.3.** Indicating Lights: Two of each type and color installed.
 - 2.5.1.4.** Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
 - 2.5.1.5.** Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

3. PART 3 - PRODUCTS

3.1. FULL-VOLTAGE CONTROLLERS

- 3.1.1.** General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- 3.1.2.** Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
 - 3.1.2.1.** Manufacturers: Subject to compliance with requirements:

- 3.1.2.2.** Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 3.1.2.2.1.** Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3.1.2.2.2.** General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3.1.2.2.3.** Rockwell Automation, Inc.; Allen-Bradley brand.
 - 3.1.2.2.4.** Siemens Energy & Automation, Inc.
 - 3.1.2.2.5.** Square D; a brand of Schneider Electric.
- 3.1.2.3.** Configuration: Non-reversing.
- 3.1.2.4.** Flush mounting.
- 3.1.2.5.** Red pilot light.
- 3.1.2.6.** Additional Nameplates: FORWARD and REVERSE for reversing switches.
- 3.1.3.** Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
 - 3.1.3.1.** Manufacturers: Subject to compliance with requirements:
 - 3.1.3.2.** Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 3.1.3.2.1.** Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3.1.3.2.2.** General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3.1.3.2.3.** Rockwell Automation, Inc.; Allen-Bradley brand.
 - 3.1.3.2.4.** Siemens Energy & Automation, Inc.
 - 3.1.3.2.5.** Square D; a brand of Schneider Electric.
 - 3.1.3.3.** Configuration: Non-reversing.

- 3.1.3.4.** Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
 - 3.1.3.5.** Flush mounting.
 - 3.1.3.6.** Red pilot light.
 - 3.1.3.7.** Additional Nameplates: HIGH and LOW for two-speed controllers.
- Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
- 3.1.4.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 3.1.4.2.** Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 3.1.4.2.1.** Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3.1.4.2.2.** General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3.1.4.2.3.** Rockwell Automation, Inc.; Allen-Bradley brand.
 - 3.1.4.2.4.** Siemens Energy & Automation, Inc.
 - 3.1.4.2.5.** Square D; a brand of Schneider Electric.
 - 3.1.4.3.** Configuration: Non-reversing.
 - 3.1.4.4.** Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type; melting alloy type.
 - 3.1.4.5.** Flush mounting.
 - 3.1.4.6.** Red pilot light.

- 3.1.4.7.** Additional Nameplates: HIGH and LOW for two-speed controllers.
 - 3.1.4.8.** N.O. auxiliary contact.
- Magnetic Controllers: Full voltage, across the line, electrically held.
- 3.1.5.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 3.1.5.2.** Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 3.1.5.2.1.** Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3.1.5.2.2.** General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3.1.5.2.3.** Rockwell Automation, Inc.; Allen-Bradley brand.
 - 3.1.5.2.4.** Siemens Energy & Automation, Inc.
 - 3.1.5.2.5.** Square D; a brand of Schneider Electric.
 - 3.1.5.2.6.** Configuration: Non-reversing.
 - 3.1.5.2.7.** Contactor Coils: Pressure-encapsulated type.
 - 3.1.5.2.8.** Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 - 3.1.5.3.** Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 - 3.1.5.4.** Control Circuits: 24-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT control power source of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 3.1.5.4.1.** CPT Spare Capacity: 50 VA.
 - 3.1.5.5.** Melting Alloy Overload Relays:

- 3.1.5.5.1. Inverse-time-current characteristic.
 - 3.1.5.5.2. Class 10 tripping characteristic.
 - 3.1.5.5.3. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 3.1.5.6. Bimetallic Overload Relays:
 - 3.1.5.6.1. Inverse-time-current characteristic.
 - 3.1.5.6.2. Class 10 tripping characteristic.
 - 3.1.5.6.3. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 3.1.5.6.4. Ambient compensated.
 - 3.1.5.6.5. Automatic resetting.
 - 3.1.5.7. Solid-State Overload Relay:
 - 3.1.5.7.1. Switch or dial selectable for motor running overload protection.
 - 3.1.5.7.2. Sensors in each phase.
 - 3.1.5.7.3. Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - 3.1.5.7.4. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - 3.1.5.7.5. Analog communication module.
 - 3.1.5.8. N.C., isolated overload alarm contact.
 - 3.1.5.9. External overload reset push button.
 - 3.1.6. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
 - 3.1.6.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 3.1.6.2.** Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 3.1.6.2.1.** Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3.1.6.2.2.** General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3.1.6.2.3.** Rockwell Automation, Inc.; Allen-Bradley brand.
 - 3.1.6.2.4.** Siemens Energy & Automation, Inc.
 - 3.1.6.2.5.** Square D; a brand of Schneider Electric.
- 3.1.6.3.** Fusible Disconnecting Means:
 - 3.1.6.3.1.** NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
 - 3.1.6.3.2.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3.1.6.3.3.** Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
- 3.1.6.4.** Non-fusible Disconnecting Means:
 - 3.1.6.4.1.** NEMA KS 1, heavy-duty, horsepower-rated, non-fusible switch.
 - 3.1.6.4.2.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3.1.6.4.3.** Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
- 3.1.6.5.** MCP Disconnecting Means:
 - 3.1.6.5.1.** IUL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 3.1.6.5.2.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

- 3.1.6.5.3.** Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
- 3.1.6.5.4.** N.C. alarm contact that operates only when MCP has tripped.
- 3.1.6.5.5.** Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3.1.6.6. MCCB Disconnecting Means:

- 3.1.6.6.1.** UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
- 3.1.6.6.2.** Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- 3.1.6.6.3.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 3.1.6.6.4.** Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
- 3.1.6.6.5.** N.C. alarm contact that operates only when MCCB has tripped.

3.2. REDUCED-VOLTAGE MAGNETIC CONTROLLERS

- 3.2.1.** General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed-transition; adjustable time delay on transition.
- 3.2.2.** Reduced-Voltage Magnetic Controllers: Reduced voltage, electrically held.
 - 3.2.2.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 3.2.2.2.** Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 3.2.2.2.1.** Eaton Electrical Inc.; Cutler-Hammer Business Unit.

- 3.2.2.2.2.** General Electric Company; GE Consumer & Industrial - Electrical Distribution.
- 3.2.2.2.3.** Rockwell Automation, Inc.; Allen-Bradley brand.
- 3.2.2.2.4.** Siemens Energy & Automation, Inc.
- 3.2.2.2.5.** Square D; a brand of Schneider Electric.
- 3.2.2.3.** Configuration:
 - 3.2.2.3.1.** Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
 - 3.2.2.3.2.** Part-Winding Controller: Separate START and RUN contactors, field-selectable for 1/2- or 2/3-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
 - 3.2.2.3.3.** Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral over temperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
- 3.2.2.4.** Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
 - 3.2.2.4.1.** Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
- 3.2.2.5.** Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
- 3.2.2.6.** Control Circuits: 24-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 3.2.2.6.1.** CPT Spare Capacity: 50 VA.
- 3.2.2.7.** Melting Alloy Overload Relays:

- 3.2.2.7.1. Inverse-time-current characteristic.
 - 3.2.2.7.2. Class 10 tripping characteristic.
 - 3.2.2.7.3. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 3.2.2.8. Bimetallic Overload Relays:
 - 3.2.2.8.1. Inverse-time-current characteristic.
 - 3.2.2.8.2. Class 10 tripping characteristic.
 - 3.2.2.8.3. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 3.2.2.8.4. Ambient compensated.
 - 3.2.2.8.5. Automatic resetting.
 - 3.2.2.9. Solid-State Overload Relay:
 - 3.2.2.9.1. Switch or dial selectable for motor running overload protection.
 - 3.2.2.9.2. Sensors in each phase.
 - 3.2.2.9.3. Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - 3.2.2.9.4. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - 3.2.2.9.5. Analog communication module.
 - 3.2.2.10. N.C., isolated overload alarm contact.
 - 3.2.2.11. External overload reset push button.
 - 3.2.3. Combination Reduced-Voltage Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.
 - 3.2.3.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

3.2.3.2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

3.2.3.2.1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

3.2.3.2.2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3.2.3.2.3. Rockwell Automation, Inc.; Allen-Bradley brand.

3.2.3.2.4. Siemens Energy & Automation, Inc.

3.2.3.2.5. Square D; a brand of Schneider Electric.

3.2.3.3. Fusible Disconnecting Means:

3.2.3.3.1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.

3.2.3.3.2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3.2.3.3.3. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

3.2.3.4. Non-fusible Disconnecting Means:

3.2.3.4.1. NEMA KS 1, heavy-duty, horsepower-rated, non-fusible switch.

3.2.3.4.2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3.2.3.4.3. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

3.2.3.5. MCP Disconnecting Means:

3.2.3.5.1. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

3.2.3.5.2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

- 3.2.3.5.3.** Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
- 3.2.3.5.4.** N.O. alarm contact that operates only when MCP has tripped.
- 3.2.3.5.5.** Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3.2.3.6. MCCB Disconnecting Means:

- 3.2.3.6.1.** UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
- 3.2.3.6.2.** Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- 3.2.3.6.3.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 3.2.3.6.4.** Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
- 3.2.3.6.5.** N.O. alarm contact that operates only when MCCB has tripped.

3.3. REDUCED-VOLTAGE SOLID-STATE CONTROLLERS

- 3.3.1.** General Requirements for Reduced-Voltage Solid-State Controllers: Comply with UL 508.
- 3.3.2.** Reduced-Voltage Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.
 - 3.3.2.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 3.3.2.2.** Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

- 3.3.2.2.1.** Eaton Electrical Inc.; Cutler-Hammer Business Unit.
- 3.3.2.2.2.** General Electric Company; GE Consumer & Industrial - Electrical Distribution.
- 3.3.2.2.3.** Rockwell Automation, Inc.; Allen-Bradley brand.
- 3.3.2.2.4.** Siemens Energy & Automation, Inc.
- 3.3.2.2.5.** Square D; a brand of Schneider Electric.
- 3.3.2.3.** Configuration: Standard duty.
- 3.3.2.4.** Starting Mode: Voltage ramping.
- 3.3.2.5.** Stopping Mode: Coast to stop.
- 3.3.2.6.** Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
- 3.3.2.7.** Shorting and Input Isolation Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil transient suppressors.
- 3.3.2.8.** Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
- 3.3.2.9.** Control Circuits: 24-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 3.3.2.9.1.** CPT Spare Capacity: 100 VA.
- 3.3.2.10.** Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
- 3.3.2.11.** SCR bridge shall consist of at least two SCRs per phase, providing stable and smooth acceleration with external feedback from the motor or driven equipment.

- 3.3.2.12.** Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
- 3.3.2.12.1.** Adjusting motor full-load amperes, as a percentage of the controller's rating.
 - 3.3.2.12.2.** Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
 - 3.3.2.12.3.** Adjusting linear acceleration and deceleration ramps, in seconds.
 - 3.3.2.12.4.** Initial torque, as a percentage of the nominal motor torque.
 - 3.3.2.12.5.** Adjusting torque limit, as a percentage of the nominal motor torque.
 - 3.3.2.12.6.** Adjusting maximum start time, in seconds.
 - 3.3.2.12.7.** Adjusting voltage boost, as a percentage of the nominal supply voltage.
 - 3.3.2.12.8.** Selecting stopping mode, and adjusting parameters.
 - 3.3.2.12.9.** Selecting motor thermal overload protection class between 5 and 30.
 - 3.3.2.12.10.** Activating and de-activating protection modes.
 - 3.3.2.12.11.** Selecting or activating communication modes.
- 3.3.2.13.** Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
- 3.3.2.13.1.** Controller Condition: Ready, starting, running, stopping.
 - 3.3.2.13.2.** Motor Condition: Amperes, voltage, power factor, power, and thermal state.

3.3.2.13.3. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, over current, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.

3.3.2.14. Controller Diagnostics and Protection:

3.3.2.14.1. Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller over temperature and motor-overload alarm and trip; settings selectable via the keypad.

3.3.2.14.2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.

3.3.2.14.3. Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component or when the motor is stopped.

3.3.2.14.4. Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.

3.3.2.15. Remote Output Features:

3.3.2.15.1. All outputs prewired to terminal blocks.

3.3.2.15.2. Form C status contacts that change state when controller is running.

3.3.2.15.3. Form C alarm contacts that change state when a fault condition occurs.

3.3.2.16. Optional Features:

3.3.2.16.1. Analog output for field-selectable assignment of motor operating characteristics; 0 to 10-V dc.

3.3.2.16.2. Additional field assignable Form C contacts, as indicated, for alarm outputs.

- 3.3.2.16.3.** Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
- 3.3.2.16.4.** Full-voltage bypass contactor operating automatically. Power contacts shall be totally enclosed, double break, and silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.
- 3.3.2.16.5.** Melting Alloy Overload Relays:
 - 3.3.2.16.5.1.** Inverse-time-current characteristic.
 - 3.3.2.16.5.2.** Class 10 tripping characteristic.
 - 3.3.2.16.5.3.** Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
- 3.3.2.16.6.** Bimetallic Overload Relays:
 - 3.3.2.16.6.1.** Inverse-time-current characteristic.
 - 3.3.2.16.6.2.** Class 10 tripping characteristic.
 - 3.3.2.16.6.3.** Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 3.3.2.16.6.4.** Ambient compensated.
 - 3.3.2.16.6.5.** Automatic resetting.
- 3.3.2.16.7.** Solid-State Overload Relay:
 - 3.3.2.16.7.1.** Switch or dial selectable for motor running overload protection.
 - 3.3.2.16.7.2.** Sensors in each phase.

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3.3.3.4. MCP Disconnecting Means:

- 3.3.3.4.1.** UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- 3.3.3.4.2.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 3.3.3.4.3.** Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
- 3.3.3.4.4.** N.C. alarm contact that operates only when MCP has tripped.
- 3.3.3.4.5.** Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3.3.3.5. MCCB Disconnecting Means:

- 3.3.3.5.1.** UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
- 3.3.3.5.2.** Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- 3.3.3.5.3.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 3.3.3.5.4.** Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
- 3.3.3.5.5.** N.C. alarm contact that operates only when MCCB has tripped.

3.3.3.6. Molded-Case Switch Disconnecting Means:

- 3.3.3.6.1.** UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
- 3.3.3.6.2.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 3.3.3.6.3.** Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
- 3.3.3.6.4.** N.C. alarm contact that operates only when molded-case switch has tripped.

3.4. MULTISPEED MAGNETIC CONTROLLERS

- 3.4.1.** General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- 3.4.2.** Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held.
 - 3.4.2.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 3.4.2.2.** Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 3.4.2.2.1.** Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3.4.2.2.2.** General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3.4.2.2.3.** Rockwell Automation, Inc.; Allen-Bradley brand.
 - 3.4.2.2.4.** Siemens Energy & Automation, Inc.
 - 3.4.2.2.5.** Square D; a brand of Schneider Electric.
 - 3.4.2.3.** Configuration: Non-reversing.
 - 3.4.2.4.** Contactor Coils: Pressure-encapsulated type .

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- 3.4.3.3.1.** NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
- 3.4.3.3.2.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 3.4.3.3.3.** Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
- 3.4.3.4.** Non-fusible Disconnecting Means:
 - 3.4.3.4.1.** NEMA KS 1, heavy-duty, horsepower-rated, non-fusible switch.
 - 3.4.3.4.2.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3.4.3.4.3.** Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
- 3.4.3.5.** MCP Disconnecting Means:
 - 3.4.3.5.1.** UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 3.4.3.5.2.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3.4.3.5.3.** Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - 3.4.3.5.4.** N.C. alarm contact that operates only when MCP has tripped.
 - 3.4.3.5.5.** Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
- 3.4.3.6.** MCCB Disconnecting Means:
 - 3.4.3.6.1.** UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.

- 3.4.3.6.2.** Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- 3.4.3.6.3.** Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 3.4.3.6.4.** Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
- 3.4.3.6.5.** N.C. alarm contact that operates only when MCCB has tripped.

3.5. ENCLOSURES

- 3.5.1.** Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
 - 3.5.1.1.** Dry and Clean Indoor Locations: Type 1.
 - 3.5.1.2.** Outdoor Locations: Type 3R.
 - 3.5.1.3.** Kitchen Areas: Type 4X, stainless steel.
 - 3.5.1.4.** Other Wet or Damp Indoor Locations: Type 4.
 - 3.5.1.5.** Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
 - 3.5.1.6.** Hazardous Areas Indicated on Drawings: Type 7.

3.6. ACCESSORIES

- 3.6.1.** General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
 - 3.6.1.1.** Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, type.
 - 3.6.1.1.1.** Push Buttons: Covered Unguarded types; maintained as indicated.
 - 3.6.1.1.2.** Pilot Lights: LED types; colors as indicated;
 - 3.6.1.1.3.** Selector Switches: Rotary type.
 - 3.6.1.2.** Elapsed Time Meters: Heavy duty with digital readout in hours; resettable.

- 3.6.1.3.** Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.
- 3.6.2.** N.C. auxiliary contact(s).
- 3.6.3.** Control Relays: Auxiliary and adjustable solid-state time-delay relays.
- 3.6.4.** Phase-Failure, Phase-Reversal, and Under voltage and Over voltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable under voltage, overvoltage, and time-delay settings.
- 3.6.5.** Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- 3.6.6.** Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- 3.6.7.** Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
- 3.6.8.** Cover gaskets for Type 1 enclosures.
- 3.6.9.** Terminals for connecting power factor correction capacitors to the line side of overload relays.
- 3.6.10.** Spare control wiring terminal blocks, quantity as indicated; wired.

4. PART 4 - EXECUTION

4.1. EXAMINATION

- 4.1.1.** Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- 4.1.2.** Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
- 4.1.3.** Proceed with installation only after unsatisfactory conditions have been corrected.

4.2. INSTALLATION

- 4.2.1.** Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."
- 4.2.2.** Floor-Mounted Controllers: Install enclosed controllers on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
 - 4.2.2.1.** Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 4.2.2.2.** For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 4.2.2.3.** Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4.2.2.4.** Install anchor bolts to elevations required for proper attachment to supported equipment.
- 4.2.3.** Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- 4.2.4.** Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- 4.2.5.** Install fuses in each fusible-switch enclosed controller.
- 4.2.6.** Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."
- 4.2.7.** Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- 4.2.8.** Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

4.2.9. Install power factor correction capacitors. Connect to the line side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.

4.2.10. Comply with NECA 1.

4.3. IDENTIFICATION

4.3.1. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

4.3.1.1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

4.3.1.2. Label each enclosure with engraved nameplate.

4.3.1.3. Label each enclosure-mounted control and pilot device.

4.4. CONTROL WIRING INSTALLATION

4.4.1. Install wiring between enclosed controllers and remote devices. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."

4.4.2. Bundle, train, and support wiring in enclosures.

4.4.3. Connect selector switches and other automatic-control selection devices where applicable.

4.4.3.1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.

4.4.3.2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

4.5. FIELD QUALITY CONTROL

4.5.1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

4.5.2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

4.5.3. Perform tests and inspections.

4.5.3.1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

4.5.4. Acceptance Testing Preparation:

4.5.4.1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.

4.5.4.2. Test continuity of each circuit.

4.5.5. Tests and Inspections:

4.5.5.1. Inspect controllers, wiring, components, connections, and equipment installation.

4.5.5.2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.

4.5.5.3. Test continuity of each circuit.

4.5.5.4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).

4.5.5.5. Test each motor for proper phase rotation.

4.5.5.6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

4.5.5.7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4.5.5.8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

4.5.5.8.1. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.

- 4.5.5.8.2.** Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multi-pole enclosed controller 11 months after date of Substantial Completion.
 - 4.5.5.8.3.** Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- 4.5.5.9.** Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- 4.5.6.** Enclosed controllers will be considered defective if they do not pass tests and inspections.
- 4.5.7.** Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- 4.6. ADJUSTING**
 - 4.6.1.** Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
 - 4.6.2.** Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
 - 4.6.3.** Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cool down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.
 - 4.6.4.** Set the taps on reduced-voltage autotransformer controllers at 50 percent.
 - 4.6.5.** Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage solid-state controllers.

- 4.6.6. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Over current Protective Device Coordination Study."

4.7. PROTECTION

- 4.7.1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
- 4.7.2. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

4.8. DEMONSTRATION

- 4.8.1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage solid-state controllers.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1. This Section includes the following:

- 1.2.1.1. Interior lighting fixtures, lamps, and ballasts.

- 1.2.1.2. Emergency lighting units.

- 1.2.1.3. Exit signs.

- 1.2.1.4. Lighting fixture supports.

- 1.2.2. Related Sections include the following:

- 1.2.2.1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multi-pole lighting relays and contactors.

- 1.2.2.2. Division 26 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

1.3. DEFINITIONS

- 1.3.1. BF: Ballast factor.

- 1.3.2. CRI: Color-rendering index.

- 1.3.3. CU: Coefficient of utilization.

- 1.3.4. HID: High-intensity discharge.

- 1.3.5. LER: Luminaire efficacy rating.

- 1.3.6. Luminaire: Complete lighting fixture, including ballast housing if provided.

- 1.3.7. RCR: Room cavity ratio.

1.4. SUBMITTALS

- 1.4.1. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

- 1.4.1.1. Physical description of lighting fixture including dimensions.
- 1.4.1.2. Emergency lighting units including battery and charger.
- 1.4.1.3. Ballast.
- 1.4.1.4. Energy-efficiency data.
- 1.4.1.5. Air and Thermal Performance Data: For air-handling lighting fixtures. Furnish data required in "Submittals" Article in Division 23 Section "Diffusers, Registers, and Grilles."
- 1.4.1.6. Sound Performance Data: For air-handling lighting fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division 23 Section "Diffusers, Registers, and Grilles."
- 1.4.1.7. Life, output, and energy-efficiency data for lamps.
- 1.4.1.8. Photometric data, in IESNA format, based on laboratory tests of each lighting fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - 1.4.1.8.1. For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by the manufacturer.
 - 1.4.1.8.2. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
- 1.4.2. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
 - 1.4.2.1. Wiring Diagrams: Power and control wiring.
- 1.4.3. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1.4.3.1. Lighting fixtures.

- 1.4.3.2. Suspended ceiling components.
 - 1.4.3.3. Structural members to which suspension systems for lighting fixtures will be attached.
 - 1.4.3.4. Other items in finished ceiling including the following:
 - 1.4.3.4.1. Air outlets and inlets.
 - 1.4.3.4.2. Speakers.
 - 1.4.3.4.3. Sprinklers.
 - 1.4.3.4.4. Smoke and fire detectors.
 - 1.4.3.4.5. Occupancy sensors.
 - 1.4.3.4.6. Access panels.
 - 1.4.3.5. Perimeter moldings.
 - 1.4.4. Samples for Verification: Interior lighting fixtures designated for sample submission in Interior Lighting Fixture Schedule. Each sample shall include the following:
 - 1.4.4.1. Lamps: Specified units installed.
 - 1.4.4.2. Accessories: Cords and plugs.
 - 1.4.5. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.
 - 1.4.6. Qualification Data: For agencies providing photometric data for lighting fixtures.
 - 1.4.7. Field quality-control test reports.
 - 1.4.8. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
 - 1.4.9. Warranties: Special warranties specified in this Section.
 - 1.5. QUALITY ASSURANCE
 - 1.5.1. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

- 1.5.2. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.
- 1.5.3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- 1.5.4. Comply with NFPA 70.
- 1.5.5. FMG Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.
- 1.5.6. Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections.
 - 1.5.6.1. Obtain Architect's approval of fixtures for mockups before starting installations.
 - 1.5.6.2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 1.5.6.3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6. COORDINATION

- 1.6.1. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7. WARRANTY

- 1.7.1. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1.7.1.1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.

- 1.7.1.2. Warranty Period for Emergency Fluorescent Ballast: Seven years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.
 - 1.7.2. Special Warranty for Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.
 - 1.7.2.1. Warranty Period for Electronic Ballasts: Five years from date of Substantial Completion.
 - 1.7.2.2. Warranty Period for Electromagnetic Ballasts: Three years from date of Substantial Completion.
 - 1.7.3. Special Warranty for T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
 - 1.7.3.1. Warranty Period: Two year(s) from date of Substantial Completion.
- 1.8. EXTRA MATERIALS
 - 1.8.1. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1.8.1.1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 1.8.1.2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 1.8.1.3. Battery and Charger Data: One for each emergency lighting unit.
 - 1.8.1.4. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 1.8.1.5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

- 2.1.1.** In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
- 2.1.2.** In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
 - 2.1.2.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2.1.2.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - 2.1.2.3.** Basis-of-Design Product: The design for each lighting fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2. LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- 2.2.1.** Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- 2.2.2.** Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
- 2.2.3.** Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- 2.2.4.** HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.
- 2.2.5.** Metal Parts: Free of burrs and sharp corners and edges.
- 2.2.6.** Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- 2.2.7.** Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

- 2.2.8.** Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 2.2.8.1.** White Surfaces: 85 percent.
 - 2.2.8.2.** Specular Surfaces: 83 percent.
 - 2.2.8.3.** Diffusing Specular Surfaces: 75 percent.
 - 2.2.8.4.** Laminated Silver Metallized Film: 90 percent.
- 2.2.9.** Plastic Diffusers, Covers, and Globes:
 - 2.2.9.1.** Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - 2.2.9.1.1.** Lens Thickness: At least 0.125 inch minimum unless different thickness is indicated.
 - 2.2.9.1.2.** UV stabilized.
 - 2.2.9.2.** Glass: Annealed crystal glass, unless otherwise indicated.
- 2.2.10.** Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic-interference as required by MIL-STD-461E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.
- 2.2.11.** Air-Handling Fluorescent Fixtures: For use with plenum ceiling for air return and heat extraction and for attaching an air-diffuser-boot assembly specified in Division 23 Section "Diffusers, Registers, and Grilles."
 - 2.2.11.1.** Air Supply Units: Slots in one or both side trims join with air-diffuser-boot assemblies.
 - 2.2.11.2.** Heat Removal Units: Air path leads through lamp cavity.
 - 2.2.11.3.** Combination Heat Removal and Air Supply Unit: Heat is removed through lamp cavity at both ends of the fixture door with air supply same as for air supply units.
 - 2.2.11.4.** Dampers: Operable from outside fixture for control of return-air volume.
 - 2.2.11.5.** Static Fixture: Air supply slots are blanked off, and fixture appearance matches active units.

2.3. BALLASTS FOR LINEAR FLUORESCENT LAMPS

2.3.1. Electronic Ballasts: Comply with ANSI C82.11; instant-start type, unless otherwise indicated, and designed for type and quantity of lamps served. Ballasts shall be designed for full light output unless dimmer or bi-level control is indicated.

2.3.1.1. Sound Rating: A.

2.3.1.2. Total Harmonic Distortion Rating: Less than 10 percent.

2.3.1.3. Transient Voltage Protection: IEEE C62.41, Category A or better.

2.3.1.4. Operating Frequency: 20 kHz or higher.

2.3.1.5. Lamp Current Crest Factor: 1.7 or less.

2.3.1.6. BF: 0.85 or higher.

2.3.1.7. Power Factor: 0.95 or higher.

2.3.1.8. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C 82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.

2.3.2. Electronic Programmed-Start Ballasts for T5 Lamps: Comply with ANSI C82.11 and the following:

2.3.2.1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.

2.3.2.2. Automatic lamp starting after lamp replacement.

2.3.2.3. Sound Rating: A.

2.3.2.4. Total Harmonic Distortion Rating: Less than 20 percent.

2.3.2.5. Transient Voltage Protection: IEEE C62.41, Category A or better.

2.3.2.6. Operating Frequency: 20 kHz or higher.

2.3.2.7. Lamp Current Crest Factor: 1.7 or less.

2.3.2.8. BF: 0.95 or higher, unless otherwise indicated.

2.3.2.9. Power Factor: 0.95, or higher.

- 2.3.3.** Electromagnetic Ballasts: Comply with ANSI C82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.
 - 2.3.3.1.** Ballast Manufacturer Certification: Indicated by label.
- 2.3.4.** Single Ballasts for Multiple Lighting Fixtures: Factory-wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
- 2.3.5.** Ballasts for Low-Temperature Environments:
 - 2.3.5.1.** Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.
 - 2.3.5.2.** Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.
- 2.3.6.** Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.
- 2.3.7.** Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
 - 2.3.7.1.** Dimming Range: 100 to 5 percent of rated lamp lumens.
 - 2.3.7.2.** Ballast Input Watts: Can be reduced to 20 percent of normal.
 - 2.3.7.3.** Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
- 2.3.8.** Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.
 - 2.3.8.1.** Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
 - 2.3.8.1.1.** High-Level Operation: 100 percent of rated lamp lumens.
 - 2.3.8.1.2.** Low-Level Operation: 50 percent of rated lamp lumens.
 - 2.3.8.2.** Ballast shall provide equal current to each lamp in each operating mode.

- 2.3.8.3.** Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

2.4. BALLASTS FOR COMPACT FLUORESCENT LAMPS

- 2.4.1.** Description: Electronic programmed rapid-start type, complying with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

- 2.4.1.1.** Lamp end-of-life detection and shutdown circuit.
- 2.4.1.2.** Automatic lamp starting after lamp replacement.
- 2.4.1.3.** Sound Rating: A.
- 2.4.1.4.** Total Harmonic Distortion Rating: Less than 20 percent.
- 2.4.1.5.** Transient Voltage Protection: IEEE C62.41, Category A or better.
- 2.4.1.6.** Operating Frequency: 20 kHz or higher.
- 2.4.1.7.** Lamp Current Crest Factor: 1.7 or less.
- 2.4.1.8.** BF: 0.95 or higher, unless otherwise indicated.
- 2.4.1.9.** Power Factor: 0.98 or higher.
- 2.4.1.10.** Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
- 2.4.1.11.** Ballast Case Temperature: 75 deg C, maximum.

- 2.4.2.** Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.

- 2.4.2.1.** Dimming Range: 100 to 5 percent of rated lamp lumens.
- 2.4.2.2.** Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

2.5. BALLASTS FOR HID LAMPS

- 2.5.1.** Electromagnetic Ballast for Metal-Halide Lamps: Comply with ANSI C82.4 and UL 1029. Include the following features, unless otherwise indicated:

- 2.5.1.1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
- 2.5.1.2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
- 2.5.1.3. Normal Ambient Operating Temperature: 104 deg F (40 deg C).
- 2.5.1.4. Open-circuit operation that will not reduce average life.
- 2.5.1.5. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.
- 2.5.2. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:
 - 2.5.2.1. Lamp end-of-life detection and shutdown circuit.
 - 2.5.2.2. Sound Rating: A.
 - 2.5.2.3. Total Harmonic Distortion Rating: Less than 15 percent.
 - 2.5.2.4. Transient Voltage Protection: IEEE C62.41, Category A or better.
 - 2.5.2.5. Lamp Current Crest Factor: 1.5 or less.
 - 2.5.2.6. Power Factor: .90 or higher.
 - 2.5.2.7. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 - 2.5.2.8. Protection: Class P thermal cutout.
 - 2.5.2.9. Retain subparagraph and associated subparagraphs below for bi-level ballasts.
 - 2.5.2.10. Bi-Level Dimming Ballast: Ballast circuit and leads provide for remote control of the light output of the associated fixture between high- and low-level and off.
 - 2.5.2.10.1. High-Level Operation: 100 percent of rated lamp lumens.
 - 2.5.2.10.2. Low-Level Operation: 35 percent of rated lamp lumens.

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2.6. EXIT SIGNS

2.6.1. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

2.6.2. Internally Lighted Signs:

2.6.2.1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.

2.6.2.2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

2.6.2.2.1. Battery: Sealed, maintenance-free, nickel-cadmium type.

2.6.2.2.2. Charger: Fully automatic, solid-state type with sealed transfer relay.

2.6.2.2.3. Operation: 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.

2.6.2.2.4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

2.6.2.2.5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

2.6.2.2.6. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

2.6.2.2.7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.7. FLUORESCENT LAMPS

- 2.7.1.** Low-Mercury Lamps: Comply with EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.
- 2.7.2.** T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches (1220 mm), 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500K, and average rated life 20,000 hours, unless otherwise indicated.
- 2.7.3.** T8 rapid-start lamps, rated 17 W maximum, nominal length of 24 inches (610 mm), 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500K, and average rated life of 20,000 hours, unless otherwise indicated.
- 2.7.4.** T5 rapid-start lamps, rated 28 W maximum, nominal length of 45.2 inches (1150 mm), 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3000K, and average rated life of 20,000 hours, unless otherwise indicated.
- 2.7.5.** T5HO rapid-start, high-output lamps, rated 54 W maximum, nominal length of 45.2 inches (1150 mm), 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 4100K, and average rated life of 20,000 hours, unless otherwise indicated.
- 2.7.6.** Compact Fluorescent Lamps: 4-Pin, CRI 80 (minimum), color temperature 3500K, average rated life of 10,000 hours at 3 hours operation per start, and suitable for use with dimming ballasts, unless otherwise indicated.

2.8. HID LAMPS

- 2.8.1.** High-Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minimum), color temperature 1900K, and average rated life of 24,000 hours, minimum.
 - 2.8.1.1.** Dual-Arc Tube Lamps: Arranged so only one of two arc tubes is lighted at one time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate 8 to 15 percent of normal light output.
- 2.8.2.** Metal-Halide Lamps: ANSI C78.1372, with a minimum CRI 65, and color temperature 4000K.

2.9. LIGHTING FIXTURE SUPPORT COMPONENTS

- 2.9.1.** Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

- 2.9.2.** Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- 2.9.3.** Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- 2.9.4.** Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.
- 2.9.5.** Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.
- 2.9.6.** Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- 2.9.7.** Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

3. PART 3 - EXECUTION

3.1. INSTALLATION

- 3.1.1.** Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- 3.1.2.** Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 - 3.1.2.1.** Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
 - 3.1.2.2.** Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 - 3.1.2.3.** Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
 - 3.1.2.4.** Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
- 3.1.3.** Suspended Lighting Fixture Support:

- 3.1.3.1.** Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
 - 3.1.3.2.** Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 - 3.1.3.3.** Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
- 3.1.4.** Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.
- 3.1.5.** Adjust aimable lighting fixtures to provide required light intensities.
- 3.1.6.** Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- 3.2.** FIELD QUALITY CONTROL
 - 3.2.1.** Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
 - 3.2.2.** Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes the following:

- 1.2.1.1.** Exterior luminaires with lamps and ballasts.
- 1.2.1.2.** Luminaire-mounted photoelectric relays.
- 1.2.1.3.** Poles and accessories.
- 1.2.1.4.** Luminaire lowering devices.

- 1.2.2.** Related Sections include the following:

- 1.2.2.1.** Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3. DEFINITIONS

- 1.3.1.** CRI: Color-rendering index.
- 1.3.2.** HID: High-intensity discharge.
- 1.3.3.** Luminaire: Complete lighting fixture, including ballast housing if provided.
- 1.3.4.** Pole: Luminaire support structure, including tower used for large area illumination.
- 1.3.5.** Standard: Same definition as "Pole" above.

1.4. STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- 1.4.1.** Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4.
- 1.4.2.** Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS-4.
- 1.4.3.** Ice Load: Load of 3 lbf/sq. ft. (143.6 Pa), applied as stated in AASHTO LTS-4.

1.4.4. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.

1.4.4.1. Wind speed for calculating wind load for poles exceeding 50 feet (15 m) in height is 110 mph (177 km/h).

1.4.4.2. Wind speed for calculating wind load for poles 50 feet (15 m) or less in height is 110 mph (177 km/h).

1.5. SUBMITTALS

1.5.1. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1.5.1.1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.

1.5.1.2. Details of attaching luminaires and accessories.

1.5.1.3. Details of installation and construction.

1.5.1.4. Luminaire materials.

1.5.1.5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.

1.5.1.5.1. For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

1.5.1.5.2. Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

1.5.1.6. Photoelectric relays.

1.5.1.7. Ballasts, including energy-efficiency data.

1.5.1.8. Lamps, including life, output, and energy-efficiency data.

1.5.1.9. Materials, dimensions, and finishes of poles.

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- 1.6.3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- 1.6.4. Comply with IEEE C2, "National Electrical Safety Code."
- 1.6.5. Comply with NFPA 70.

1.7. DELIVERY, STORAGE, AND HANDLING

- 1.7.1. Package aluminum poles for shipping according to ASTM B 660.
- 1.7.2. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- 1.7.3. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below ground line.
- 1.7.4. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.
- 1.7.5. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.8. WARRANTY

- 1.8.1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1.9. EXTRA MATERIALS

- 1.9.1. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1.9.1.1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.

- 1.9.1.2.** Glass and Plastic Lenses, Covers, and Other Optical Parts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
- 1.9.1.3.** Ballasts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
- 1.9.1.4.** Globes and Guards: 10 for every 20 of each type and rating installed. Furnish at least one of each type.

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

- 2.1.1.** In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
- 2.1.2.** In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
 - 2.1.2.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2.1.2.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - 2.1.2.3.** Basis of Design Product: The design of each item of exterior luminaire and its support is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2. LUMINAIRES, GENERAL REQUIREMENTS

- 2.2.1.** Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- 2.2.2.** Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- 2.2.3.** Metal Parts: Free of burrs and sharp corners and edges.
- 2.2.4.** Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

- 2.2.5.** Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- 2.2.6.** Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
- 2.2.7.** Exposed Hardware Material: Stainless steel.
- 2.2.8.** Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- 2.2.9.** Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
- 2.2.10.** Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 2.2.10.1.** White Surfaces: 85 percent.
 - 2.2.10.2.** Specular Surfaces: 83 percent.
 - 2.2.10.3.** Diffusing Specular Surfaces: 75 percent.
- 2.2.11.** Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- 2.2.12.** Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- 2.2.13.** Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

- 2.2.13.1.** Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
- 2.2.13.2.** Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - 2.2.13.2.1.** Color: As selected from manufacturer's standard catalog of colors.
 - 2.2.13.2.2.** Color: Match Architect's sample of manufacturer's standard color.
 - 2.2.13.2.3.** Color: As selected by Architect from manufacturer's full range.
- 2.2.14.** Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- 2.3. FLUORESCENT BALLASTS AND LAMPS**
 - 2.3.1.** Low-Temperature Ballast Capability: Rated by its manufacturer for reliable starting and operation of indicated lamp(s) at temperatures 0 deg F (minus 18 deg C) and higher.
 - 2.3.2.** Ballast Characteristics:
 - 2.3.2.1.** Power Factor: 90 percent, minimum.
 - 2.3.2.2.** Sound Rating: A.
 - 2.3.2.3.** Total Harmonic Distortion Rating: Less than 10 percent.
 - 2.3.2.4.** Electromagnetic Ballasts: Comply with ANSI C82.1, energy-saving, high power factor, Class P, automatic-reset thermal protection.
 - 2.3.2.5.** Case Temperature for Compact Lamp Ballasts: 65 deg C, maximum.
 - 2.3.2.6.** Transient-Voltage Protection: Comply with IEEE C62.41 Category A or better.

- 2.3.3.** Low-Temperature Lamp Capability: Rated for reliable starting and operation with ballast provided at temperatures 0 deg F (minus 18 deg C).
- 2.3.4.** Fluorescent Lamps: Low-mercury type. Comply with the EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.

2.4. BALLASTS FOR HID LAMPS

- 2.4.1.** Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features, unless otherwise indicated:
 - 2.4.1.1.** Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
 - 2.4.1.2.** Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C).
 - 2.4.1.3.** Normal Ambient Operating Temperature: 104 deg F (40 deg C).
 - 2.4.1.4.** Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.
- 2.4.2.** Auxiliary, Instant-On, Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent of light output.
- 2.4.3.** High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.
 - 2.4.3.1.** Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
 - 2.4.3.1.1.** Restrike Range: 105- to 130-V ac.
 - 2.4.3.1.2.** Maximum Voltage: 250-V peak or 150-V ac RMS.

- 2.4.3.2. Minimum Starting Temperature: Minus 40 deg F (Minus 40 deg C).

2.5. HID LAMPS

- 2.5.1. High-Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minimum), color temperature 1900K, and average rated life of 24,000 hours, minimum.
 - 2.5.1.1. Dual-Arc Tube Lamp: Arranged so only one of two arc tubes is lighted at one time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate 8 to 15 percent of normal light output.
- 2.5.2. Metal-Halide Lamps: ANSI C78.1372, with a minimum CRI 65, and color temperature 4000K.
- 2.5.3. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000K.
- 2.5.4. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and color temperature 4000K.

2.6. POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

- 2.6.1. Structural Characteristics: Comply with AASHTO LTS-4.
 - 2.6.1.1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
 - 2.6.1.2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- 2.6.2. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.
- 2.6.3. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 - 2.6.3.1. Materials: Shall not cause galvanic action at contact points.

- [illegible]

- 2.7.5.** Steps: Fixed steel, with non-slip treads, positioned for 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet (3 m) above finished grade.
- 2.7.6.** Intermediate Handhole and Cable Support: Weather tight, 3-by-5-inch (76-by-127-mm) handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.
- 2.7.7.** Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- 2.7.8.** Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- 2.7.9.** Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.
- 2.7.10.** Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- 2.7.11.** Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.
- 2.7.12.** Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 2.7.12.1.** Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
 - 2.7.12.2.** Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
 - 2.7.12.3.** Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - 2.7.12.3.1.** Color: As selected by Architect from manufacturer's full range.

2.8. POLE ACCESSORIES

- 2.8.1.** Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.
 - 2.8.1.1.** Surface mounted, 12 inches above finished grade.
 - 2.8.1.2.** Nonmetallic polycarbonate plastic or reinforced fiberglass cover, that when mounted results in NEMA 250, Type 3R enclosure.
 - 2.8.1.3.** With cord opening.
 - 2.8.1.4.** With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.
- 2.8.2.** Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.
- 2.8.3.** Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.
- 2.8.4.** Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept ballast(s).
 - 2.8.4.1.** Banner Arms.
 - 2.8.4.2.** Flag Holders.
 - 2.8.4.3.** Ladder Rests.

3. PART 3 - EXECUTION

3.1. LUMINAIRE INSTALLATION

- 3.1.1.** Install lamps in each luminaire.
- 3.1.2.** Fasten luminaire to indicated structural supports.
 - 3.1.2.1.** Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- 3.1.3.** Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources.

3.2. POLE INSTALLATION

- 3.2.1.** Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- 3.2.2.** Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:
 - 3.2.2.1.** Fire Hydrants and Storm Drainage Piping: 60 inches.
 - 3.2.2.2.** Water, Gas, Electric, Communication, and Sewer Lines: 10 feet.
 - 3.2.2.3.** Trees: 15 feet.
- 3.2.3.** Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- 3.2.4.** Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
- 3.2.5.** Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
- 3.2.6.** Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
- 3.2.7.** Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.
- 3.2.8.** Raise and set poles using web fabric slings (not chain or cable).

3.3. CORROSION PREVENTION

- 3.3.1.** Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

- 3.3.2.** Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4. GROUNDING

- 3.4.1.** Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 3.4.1.1.** Install grounding electrode for each pole, unless otherwise indicated.
 - 3.4.1.2.** Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- 3.4.2.** Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.5. FIELD QUALITY CONTROL

- 3.5.1.** Inspect each installed fixture for damage. Replace damaged fixtures and components.
- 3.5.2.** Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
 - 3.5.2.1.** Verify operation of photoelectric controls.
- 3.5.3.** Illumination Tests:
 - 3.5.3.1.** Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):
 - 3.5.3.1.1.** IESNA LM-5, "Photometric Measurements of Area and Sports Lighting."
 - 3.5.3.1.2.** IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
 - 3.5.3.1.3.** IESNA LM-52, "Photometric Measurements of Roadway Sign Installations."
 - 3.5.3.1.4.** IESNA LM-64, "Photometric Measurements of Parking Areas."

3.5.3.1.5. IESNA LM-72, "Directional Positioning of Photometric Data."

- 3.5.4.** Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.6. DEMONSTRATION

- 3.6.1.** Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

1.2.1. Section Includes:

- 1.2.1.1.** Metal conduits and fittings.
- 1.2.1.2.** Nonmetallic conduits and fittings.
- 1.2.1.3.** Optical-fiber-cable pathways and fittings.
- 1.2.1.4.** Metal wireways and auxiliary gutters.
- 1.2.1.5.** Nonmetallic wireways and auxiliary gutters.
- 1.2.1.6.** Surface pathways.
- 1.2.1.7.** Boxes, enclosures, and cabinets.
- 1.2.1.8.** Handholes and boxes for exterior underground cabling.

1.2.2. Related Requirements:

- 1.2.2.1.** Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
- 1.2.2.2.** Division 26 Section "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
- 1.2.2.3.** Division 28 Section "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3. DEFINITIONS

- 1.3.1.** ARC: Aluminum rigid conduit.
- 1.3.2.** GRC: Galvanized rigid steel conduit.
- 1.3.3.** IMC: Intermediate metal conduit.

1.4. ACTION SUBMITTALS

- 1.4.1.** Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- 1.4.2.** LEED Submittals:
 - 1.4.2.1.** Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
 - 1.4.2.2.** Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- 1.4.3.** Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.
- 1.4.4.** Samples: For wireways, nonmetallic wireways and surface pathways, and for each color and texture specified, long.

1.5. INFORMATIONAL SUBMITTALS

- 1.5.1.** Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1.5.1.1.** Structural members in paths of pathway groups with common supports.
 - 1.5.1.2.** HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- 1.5.2.** Qualification Data: For professional engineer.
- 1.5.3.** Seismic Qualification Certificates: For pathway racks, enclosures, cabinets, equipment racks and their mounting provisions, including those for internal components, from manufacturer.
 - 1.5.3.1.** Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 1.5.3.2.** Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

1.5.3.3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.

1.5.3.4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.

1.5.4. Source quality-control reports.

2. PART 2 - PRODUCTS

2.1. METAL CONDUITS AND FITTINGS

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

2.1.1.1. AFC Cable Systems, Inc.

2.1.1.2. Allied Tube & Conduit; a Tyco International Ltd. Co.

2.1.1.3. Alpha Wire Company.

2.1.1.4. Anamet Electrical, Inc.

2.1.1.5. Electri-Flex Company.

2.1.1.6. O-Z/Gedney; a brand of EGS Electrical Group.

2.1.1.7. Picoma Industries; Subsidiary of Mueller Water Products, Inc.

2.1.1.8. Republic Conduit.

2.1.1.9. Robroy Industries.

2.1.1.10. Southwire Company.

2.1.1.11. Thomas & Betts Corporation.

2.1.1.12. Western Tube and Conduit Corporation.

2.1.1.13. Wheatland Tube Company; a division of John Maneely Company.

2.1.2. General Requirements for Metal Conduits and Fittings:

- 2.1.2.1.** Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2.1.2.2.** Comply with TIA-569-B.
- 2.1.3.** GRC: Comply with ANSI C80.1 and UL 6.
- 2.1.4.** ARC: Comply with ANSI C80.5 and UL 6A.
- 2.1.5.** IMC: Comply with ANSI C80.6 and UL 1242.
- 2.1.6.** PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
 - 2.1.6.1.** Comply with NEMA RN 1.
 - 2.1.6.2.** Coating Thickness: 0.040 inch (1 mm), minimum.
- 2.1.7.** EMT: Comply with ANSI C80.3 and UL 797.
- 2.1.8.** Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 2.1.8.1.** Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 - 2.1.8.2.** Fittings for EMT:
 - 2.1.8.2.1.** Material: Steel.
 - 2.1.8.2.2.** Type: Compression.
 - 2.1.8.3.** Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
 - 2.1.8.4.** Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- 2.1.9.** Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2. NONMETALLIC CONDUITS AND FITTINGS

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

- 2.2.1.1.** AFC Cable Systems, Inc.
- 2.2.1.2.** Allied Tube & Conduit; a Tyco International Ltd. Co.
- 2.2.1.3.** Anamet Electrical, Inc.
- 2.2.1.4.** Arnco Corporation.
- 2.2.1.5.** CANTEX Inc.
- 2.2.1.6.** CertainTeed Corp.
- 2.2.1.7.** Condux International, Inc.
- 2.2.1.8.** Electri-Flex Company.
- 2.2.1.9.** Kraloy.
- 2.2.1.10.** Lamson & Sessions; Carlon Electrical Products.
- 2.2.1.11.** Niedax-Kleinhuis USA, Inc.
- 2.2.1.12.** RACO; a Hubbell company.
- 2.2.1.13.** Thomas & Betts Corporation.

2.2.2. General Requirements for Nonmetallic Conduits and Fittings:

2.2.2.1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2.2.2. Comply with TIA-569-B.

2.2.3. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

2.2.4. Rigid HDPE: Comply with UL 651A.

2.2.5. Continuous HDPE: Comply with UL 651B.

2.2.6. RTRC: Comply with UL 1684A and NEMA TC 14.

- 2.2.7.** Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- 2.2.8.** Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 2.2.9.** Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3. OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- 2.3.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.3.1.1.** Alpha Wire Company.
 - 2.3.1.2.** Arnco Corporation.
 - 2.3.1.3.** Endot Industries Inc.
 - 2.3.1.4.** IPEX.
 - 2.3.1.5.** Lamson & Sessions; Carlon Electrical Products.
- 2.3.2.** Description: Comply with UL 2024; flexible-type pathway, approved for general-use installation unless otherwise indicated.
 - 2.3.2.1.** Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2.3.2.2.** Comply with TIA-569-B.

2.4. METAL WIREWAYS AND AUXILIARY GUTTERS

- 2.4.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.4.1.1.** Cooper B-Line, Inc.
 - 2.4.1.2.** Hoffman; a Pentair company.
 - 2.4.1.3.** Mono-Systems, Inc.

- 2.4.1.4.** Square D; a brand of Schneider Electric.
 - 2.4.2.** Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1, Type 3R unless otherwise indicated, and sized according to NFPA 70.
 - 2.4.2.1.** Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2.4.2.2.** Comply with TIA-569-B.
 - 2.4.3.** Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
 - 2.4.4.** Wireway Covers: Hinged type, unless otherwise indicated.
 - 2.4.5.** Finish: Manufacturer's standard enamel finish.
- 2.5.** NON-METALLIC WIREWAYS AND AUXILIARY GUTTERS
 - 2.5.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.5.1.1.** Allied Moulded Products, Inc.
 - 2.5.1.2.** Hoffman; a Pentair company.
 - 2.5.1.3.** Lamson & Sessions; Carlon Electrical Products.
 - 2.5.1.4.** Niedax-Kleinhuis USA, Inc.
 - 2.5.2.** General Requirements for Nonmetallic Wireways and Auxiliary Gutters:
 - 2.5.2.1.** Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2.5.2.2.** Comply with TIA-569-B.

- 2.5.3.** Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.
- 2.5.4.** Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
- 2.5.5.** Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.
- 2.5.6.** Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 2.5.7.** Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6. SURFACE PATHWAYS

- 2.6.1.** General Requirements for Surface Pathways:
 - 2.6.1.1.** Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2.6.1.2.** Comply with TIA-569-B.
- 2.6.2.** Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Prime coated, ready for field painting.
 - 2.6.2.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.6.2.1.1.** Mono-Systems, Inc.
 - 2.6.2.1.2.** Niedax-Kleinhuis USA, Inc.
 - 2.6.2.1.3.** Panduit Corp.

2.6.2.1.4. Wiremold / Legrand.

2.6.3. Surface Nonmetallic Pathways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from [manufacturer's standard] [custom] colors. Product shall comply with UL-94 V-0 requirements for self-extinguishing characteristics.

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

2.6.3.1.1. Hubbell Incorporated; Wiring Device-Kellems Division.

2.6.3.1.2. Lamson & Sessions; Carlon Electrical Products.

2.6.3.1.3. Mono-Systems, Inc.

2.6.3.1.4. Panduit Corp.

2.6.3.1.5. Wiremold / Legrand.

2.6.4. Tele-Power Poles:

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

2.6.4.1.1. Mono-Systems, Inc.

2.6.4.1.2. Panduit Corp.

2.6.4.1.3. Wiremold / Legrand.

2.6.4.2. Material: Galvanized steel with ivory baked-enamel finish.

2.6.4.3. Fittings and Accessories: Dividers, end caps, covers, cutouts, wiring harnesses, devices, mounting materials, and other fittings shall match and mate with tele-power pole as required for complete system.

2.7. BOXES, ENCLOSURES, AND CABINETS

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

2.7.1.1. Adalef.

2.7.1.2. Cooper Technologies Company; Cooper Crouse-Hinds.

2.7.1.3. EGS/Appleton Electric.

2.7.1.4. Erickson Electrical Equipment Company.

2.7.1.5. Hoffman; a Pentair company.

2.7.1.6. Hubbell Incorporated; Killark Division.

2.7.1.7. Lamson & Sessions; Carlon Electrical Products.

2.7.1.8. Milbank Manufacturing Co.

2.7.1.9. Molex; Woodhead Brand.

2.7.1.10. Mono-Systems, Inc.

2.7.1.11. O-Z/Gedney; a brand of EGS Electrical Group.

2.7.1.12. RACO; a Hubbell company.

2.7.1.13. Robroy Industries.

2.7.1.14. Spring City Electrical Manufacturing Company.

2.7.1.15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.

2.7.1.16. Thomas & Betts Corporation.

2.7.1.17. Wiremold / Legrand.

2.7.2. General Requirements for Boxes, Enclosures, and Cabinets:

2.7.2.1. Comply with TIA-569-B.

2.7.2.2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.

- 2.7.3.** Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- 2.7.4.** Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
- 2.7.5.** Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- 2.7.6.** Metal Floor Boxes:
 - 2.7.6.1.** Material: Cast metal.
 - 2.7.6.2.** Type: Fully adjustable.
 - 2.7.6.3.** Shape: Rectangular.
 - 2.7.6.4.** Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2.7.7.** Nonmetallic Floor Boxes: Nonadjustable, rectangular.
 - 2.7.7.1.** Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2.7.8.** Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- 2.7.9.** Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- 2.7.10.** Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).
- 2.7.11.** Gangable boxes are allowed.
- 2.7.12.** Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- 2.7.13.** Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R with continuous-hinge cover with flush latch unless otherwise indicated.
 - 2.7.13.1.** Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2.7.13.2.** Nonmetallic Enclosures:

2.7.13.2.1. Material: Plastic.

2.7.13.2.2. Finished inside with radio-frequency-resistant paint.

2.7.13.3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

2.7.14. Cabinets:

2.7.14.1. NEMA 250, Type 1, Type 3R, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.

2.7.14.2. Hinged door in front cover with flush latch and concealed hinge.

2.7.14.3. Key latch to match panelboards.

2.7.14.4. Metal barriers to separate wiring of different systems and voltage.

2.7.14.5. Accessory feet where required for freestanding equipment.

2.7.14.6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.8. HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND CABLING

2.8.1. General Requirements for Handholes and Boxes:

2.8.1.1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.

2.8.1.2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.8.1.3. Comply with TIA-569-B.

2.8.2. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

- 2.8.2.1.** Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- 2.8.2.2.** Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] or comparable product by one of the following:
 - 2.8.2.2.1.** Armorcast Products Company.
 - 2.8.2.2.2.** Carson Industries LLC.
 - 2.8.2.2.3.** CDR Systems Corporation; Hubbell Power Systems.
 - 2.8.2.2.4.** NewBasis.
 - 2.8.2.2.5.** Oldcastle Precast, Inc.; Christy Concrete Products.
 - 2.8.2.2.6.** Synertech Moulded Products; a division of Oldcastle Precast, Inc.
- 2.8.2.3.** Standard: Comply with SCTE 77.
- 2.8.2.4.** Configuration: Designed for flush burial with open bottom unless otherwise indicated.
- 2.8.2.5.** Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
- 2.8.2.6.** Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- 2.8.2.7.** Cover Legend: Molded lettering, "COMMUNICATIONS.".
- 2.8.2.8.** Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- 2.8.2.9.** Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.
- 2.8.3.** Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete.

- 2.8.3.1.** Manufacturers: Subject to compliance with requirements, [provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.8.3.2.1.** Armorcast Products Company.
 - 2.8.3.2.2.** Carson Industries LLC.
 - 2.8.3.2.3.** CDR Systems Corporation; Hubbell Power Systems.
 - 2.8.3.2.4.** NewBasis.
 - 2.8.3.2.5.** Nordic Fiberglass, Inc.
 - 2.8.3.2.6.** Oldcastle Precast, Inc.; Christy Concrete Products.
 - 2.8.3.2.7.** Synertech Moulded Products; a division of Oldcastle Precast, Inc.
- 2.8.3.3.** Standard: Comply with SCTE 77.
- 2.8.3.4.** Color of Frame and Cover: Gray.
- 2.8.3.5.** Configuration: Designed for flush burial with open bottom unless otherwise indicated.
- 2.8.3.6.** Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
- 2.8.3.7.** Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- 2.8.3.8.** Cover Legend: Molded lettering, "COMMUNICATIONS."
- 2.8.3.9.** Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- 2.8.3.10.** Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.9. SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

2.9.1. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

2.9.1.1. Tests of materials shall be performed by an independent testing agency.

2.9.1.2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.

2.9.1.3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

3. PART 3 - EXECUTION

3.1. PATHWAY APPLICATION

3.1.1. Outdoors: Apply pathway products as specified below unless otherwise indicated:

3.1.1.1. Exposed Conduit: RNC.

3.1.1.2. Concealed Conduit, Aboveground: RNC.

3.1.1.3. Underground Conduit: Type EPC-40-PVC, concrete encased.

3.1.1.4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

3.1.2. Indoors: Apply pathway products as specified below unless otherwise indicated:

3.1.2.1. Exposed, Not Subject to Physical Damage: EMT.

3.1.2.2. Exposed, Not Subject to Severe Physical Damage: EMT.

3.1.2.3. Exposed and Subject to Severe Physical Damage: IMC. Pathway locations include the following:

3.1.2.3.1. Loading dock.

3.1.2.3.2. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.

3.1.2.3.3. Mechanical rooms.

3.1.2.3.4. Gymnasiums

- 3.1.2.4.** Concealed in Ceilings and Interior Walls and Partitions: EMT, RNC.
- 3.1.2.5.** Damp or Wet Locations: GRC, IMC.
- 3.1.2.6.** Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
- 3.1.2.7.** Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway.
- 3.1.2.8.** Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: General-use, optical-fiber-cable pathway.
- 3.1.2.9.** Boxes and Enclosures: NEMA 250 Type 1, except use NEMA 250 Type 4 [stainless steel in institutional and commercial kitchens and damp or wet locations.
- 3.1.3.** Minimum Pathway Size: 3/4-inch (21-mm) trade size. Minimum size for optical-fiber cables is 1 inch [27 mm].
- 3.1.4.** Pathway Fittings: Compatible with pathways and suitable for use and location.
 - 3.1.4.1.** Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - 3.1.4.2.** PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 - 3.1.4.3.** EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
- 3.1.5.** Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- 3.1.6.** Install surface pathways only where indicated on Drawings.
- 3.1.7.** Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2. INSTALLATION

- 3.2.1. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- 3.2.2. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- 3.2.3. Complete pathway installation before starting conductor installation.
- 3.2.4. Comply with requirements in Division 26 Section "Hangers and Supports for Electrical Systems" for hangers and supports.
- 3.2.5. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- 3.2.6. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Utilize long radius ells for all optical-fiber cables.
- 3.2.7. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- 3.2.8. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- 3.2.9. Pathways Embedded in Slabs:
 - 3.2.9.1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot (3-m) intervals.
 - 3.2.9.2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 - 3.2.9.3. Arrange pathways to keep a minimum of 1 inch (25 mm) of concrete cover in all directions.
 - 3.2.9.4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 - 3.2.9.5. Change from ENT to GRC before rising above floor.

- 3.2.10.** Stub-ups to Above Recessed Ceilings:
 - 3.2.10.1.** Use EMT, IMC, or RMC for pathways.
 - 3.2.10.2.** Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- 3.2.11.** Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.
- 3.2.12.** Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- 3.2.13.** Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- 3.2.14.** Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- 3.2.15.** Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- 3.2.16.** Cut conduit perpendicular to the length. For conduits of 2-inch (53-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- 3.2.17.** Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.
- 3.2.18.** Surface Pathways:
 - 3.2.18.1.** Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
 - 3.2.18.2.** Install surface pathway with a minimum 2-inch (50-mm) radius control at bend points.

- 3.2.18.3.** Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

- 3.2.19.** Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

- 3.2.19.1. 3/4-Inch (21-mm) Trade Size and Smaller:** Install pathways in maximum lengths of 50 feet (15 m).

- 3.2.19.2. 1-Inch (27-mm) Trade Size and Larger:** Install pathways in maximum lengths of 75 feet (23 m).

- 3.2.19.3.** Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

- 3.2.20.** Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway sealing fittings according to NFPA 70.

- 3.2.21.** Install devices to seal pathway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

- 3.2.21.1.** Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.

- 3.2.21.2.** Where an underground service pathway enters a building or structure.

- 3.2.21.3.** Where otherwise required by NFPA 70.

- 3.2.22.** Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

- ### 3.2.23. Expansion-Joint Fittings:

- 3.2.23.1.** Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
- 3.2.23.2.** Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - 3.2.23.2.1.** Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - 3.2.23.2.2.** Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - 3.2.23.2.3.** Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - 3.2.23.2.4.** Attics: 135 deg F (75 deg C) temperature change.
- 3.2.23.3.** Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
- 3.2.23.4.** Install expansion fittings at all locations where conduits cross building or structure expansion joints.
- 3.2.23.5.** Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- 3.2.24.** Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

- 3.2.25.** Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- 3.2.26.** Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- 3.2.27.** Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- 3.2.28.** Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- 3.2.29.** Set metal floor boxes level and flush with finished floor surface.
- 3.2.30.** Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3. INSTALLATION OF UNDERGROUND CONDUIT

3.3.1. Direct-Buried Conduit:

- 3.3.1.1.** Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
- 3.3.1.2.** Install backfill as specified in Division 31 Section "Earth Moving."
- 3.3.1.3.** After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
- 3.3.1.4.** Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

- 3.3.1.5.** Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - 3.3.1.5.1.** Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
 - 3.3.1.5.2.** For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
- 3.3.1.6.** Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, but a minimum of 6 inches (150 mm) below grade. Align planks along centerline of conduit.
- 3.3.1.7.** Underground Warning Tape: Comply with requirements in Division 26 Section "Identification for Electrical Systems."

3.4. INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- 3.4.1.** Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- 3.4.2.** Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- 3.4.3.** Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- 3.4.4.** Install handholes with bottom below frost line, below grade.
- 3.4.5.** Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

- 3.4.6. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5. SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- 3.5.1. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 27 Section "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.6. FIRESTOPPING

- 3.6.1. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.7. PROTECTION

- 3.7.1. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 3.7.1.1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 3.7.1.2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

1.2.1. Section Includes:

- 1.2.1.1. Telecommunications mounting elements.
- 1.2.1.2. Backboards.
- 1.2.1.3. Telecommunications equipment racks and cabinets.
- 1.2.1.4. Telecommunications service entrance pathways.
- 1.2.1.5. Grounding.

1.2.2. Related Sections:

- 1.2.2.1. Division 27 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
- 1.2.2.2. Division 27 Section "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.
- 1.2.2.3. Division 28 Section "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.3. DEFINITIONS

- 1.3.1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
- 1.3.2. BICSI: Building Industry Consulting Service International.
- 1.3.3. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel not exceeding 6 inches (152 mm) in width.
- 1.3.4. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).

- 1.3.5. LAN: Local area network.
- 1.3.6. RCDD: Registered Communications Distribution Designer.
- 1.3.7. Solid-Bottom or Non-ventilated Cable Tray: A fabricated structure consisting of a bottom without ventilation openings within integral or separate longitudinal side rails.
- 1.3.8. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.

1.4. PERFORMANCE REQUIREMENTS

- 1.4.1. Seismic Performance: Floor-mounted cabinets and cable pathways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - 1.4.1.1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5. SUBMITTALS

- 1.5.1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- 1.5.2. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
 - 1.5.2.1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1.5.2.2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
 - 1.5.2.3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.
- 1.5.3. Qualification Data: For Installer,, qualified layout technician, installation supervisor, and field inspector.

1.5.4. Seismic Qualification Certificates: For floor-mounted cabinets, accessories, and components, from manufacturer.

1.5.4.1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

1.5.4.2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.

1.5.4.3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6. QUALITY ASSURANCE

1.6.1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1.6.1.1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.

1.6.1.2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

1.6.1.3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

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

1.6.3. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

1.6.4. Grounding: Comply with ANSI-J-STD-607-A.

1.7. PROJECT CONDITIONS

1.7.1. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weather tight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.8. COORDINATION

1.8.1. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1.8.1.1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.

1.8.1.2. Record agreements reached in meetings and distribute them to other participants.

1.8.1.3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.

1.8.1.4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.

1.8.2. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

2. PART 2 - PRODUCTS

2.1. PATHWAYS

2.1.1. General Requirements: Comply with TIA/EIA-569-A.

2.1.2. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.

2.1.2.1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.

2.1.2.2. Support brackets with cable tie slots for fastening cable ties to brackets.

2.1.2.3. Lacing bars, spools, J-hooks, and D-rings.

2.1.2.4. Straps and other devices.

2.1.3. Cable Trays:

2.1.3.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.1.3.1.1. Cable Management Solutions, Inc.

2.1.3.1.2. Cablofil Inc.

2.1.3.1.3. Cooper B-Line, Inc.

2.1.3.2. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick.

2.1.3.2.1. Basket Cable Trays: 6 inches wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).

2.1.3.2.2. Trough Cable Trays: Nominally 6 inches wide.

2.1.3.2.3. Ladder Cable Trays: Nominally 18 inches wide, and a rung spacing of 12 inches.

2.1.3.2.4. Channel Cable Trays: One-piece construction, nominally 4 inches wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.

2.1.3.2.5. Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches wide. Provide with solid covers.

2.1.4. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems."

2.1.4.1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.2. BACKBOARDS

2.2.1. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry."

2.3. EQUIPMENT FRAMES

2.3.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.3.1.1. AMP; a Tyco International Ltd. company.

2.3.1.2. Cooper B-Line, Inc.

2.3.1.3. Hubbell Premise Wiring.

2.3.1.4. Ortronics, Inc.

2.3.1.5. Panduit Corp.

2.3.2. General Frame Requirements:

2.3.2.1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.

2.3.2.2. Module Dimension: Width compatible with EIA 310 standard, 19-inch (480-mm) panel mounting.

2.3.2.3. Finish: Manufacturer's standard, baked-polyester powder coat.

2.3.3. Floor-Mounted Racks: Modular-type, steel construction.

2.3.3.1. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug and a power strip.

2.3.3.2. Baked-polyester powder coat finish.

2.3.4. Modular Freestanding Cabinets:

2.3.4.1. Removable and lockable side panels.

2.3.4.2. Hinged and lockable front and rear doors.

2.3.4.3. Adjustable feet for leveling.

2.3.4.4. Screened ventilation openings in the roof and rear door.

2.3.4.5. Cable access provisions in the roof and base.

- 2.3.4.6. Grounding bus bar.
 - 2.3.4.7. Rack-mounted, 550-cfm (260-L/s) fan with filter.
 - 2.3.4.8. Power strip.
 - 2.3.4.9. Baked-polyester powder coat finish.
 - 2.3.4.10. All cabinets keyed alike.
 - 2.3.5. Modular Wall Cabinets:
 - 2.3.5.1. Wall mounting.
 - 2.3.5.2. Steel construction.
 - 2.3.5.3. Treated to resist corrosion.
 - 2.3.5.4. Lockable front and rear doors.
 - 2.3.5.5. Louvered side panels.
 - 2.3.5.6. Cable access provisions top and bottom.
 - 2.3.5.7. Grounding lug.
 - 2.3.5.8. Rack-mounted, 250-cfm (118-L/s) fan.
 - 2.3.5.9. Power strip.
 - 2.3.5.10. All cabinets keyed alike.
 - 2.3.6. Cable Management for Equipment Frames:
 - 2.3.6.1. Metal, with integral wire retaining fingers.
 - 2.3.6.2. Baked-polyester powder coat finish.
 - 2.3.6.3. Vertical cable management panels shall have front and rear channels, with covers.
 - 2.3.6.4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.
- 2.4. POWER STRIPS
 - 2.4.1. Power Strips: Comply with UL 1363.
 - 2.4.1.1. Rack mounting.

- 2.4.1.2.** Six, 15-A, 120-V ac, NEMA WD 6 receptacles.
- 2.4.1.3.** LED indicator lights for power and protection status.
- 2.4.1.4.** LED indicator lights for reverse polarity and open outlet ground.
- 2.4.1.5.** Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
- 2.4.1.6.** Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
- 2.4.1.7.** Cord connected with 15-foot (4.5-m) line cord.
- 2.4.1.8.** Rocker-type on-off switch, illuminated when in on position.
- 2.4.1.9.** Peak Single-Impulse Surge Current Rating: 33 kA per phase.
- 2.4.1.10.** Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330V.

2.5. GROUNDING

- 2.5.1.** Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.
- 2.5.2.** Telecommunications Main Bus Bar:
 - 2.5.2.1.** Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
 - 2.5.2.2.** Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide (6 mm thick by 100 mm wide) with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.
 - 2.5.2.3.** Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
- 2.5.3.** Comply with ANSI-J-STD-607-A.

2.6. LABELING

- 2.6.1.** Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

3. PART 3 - EXECUTION

3.1. ENTRANCE FACILITIES

- 3.1.1.** Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
- 3.1.2.** Install underground pathways complying with recommendations in TIA/EIA-569-A, "Entrance Facilities" Article.

3.2. INSTALL UNDERGROUND ENTRANCE PATHWAY COMPLYING WITH DIVISION 26 SECTION "RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS."INSTALLATION

- 3.2.1.** Comply with NECA 1.
- 3.2.2.** Comply with BICSI TDMM for layout and installation of communications equipment rooms.
- 3.2.3.** Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
- 3.2.4.** Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3. FIRESTOPPING

- 3.3.1.** Comply with requirements in Division 07 Section "Penetration Firestopping." Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- 3.3.2.** Comply with BICSI TDMM, "Firestopping Systems" Article.

3.4. GROUNDING

- 3.4.1.** Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- 3.4.2.** Comply with ANSI-J-STD-607-A.

3.4.3. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

3.4.4. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.4.4.1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

3.5. IDENTIFICATION

3.5.1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Division 26 Section "Identification for Electrical Systems." Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

3.5.2. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion of TIA/EIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.

3.5.3. Labels shall be preprinted or computer-printed type.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

1.2.1. Section Includes:

- 1.2.1.1.** Pathways.
- 1.2.1.2.** UTP cable.
- 1.2.1.3.** 62.5/125-micrometer, optical fiber cabling.
- 1.2.1.4.** Coaxial cable.
- 1.2.1.5.** Cable connecting hardware, patch panels, and cross-connects.
- 1.2.1.6.** Cabling identification products.

1.2.2. Related Sections:

- 1.2.2.1.** Division 28 Section "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.3. DEFINITIONS

- 1.3.1.** BICSI: Building Industry Consulting Service International.
- 1.3.2.** Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- 1.3.3.** EMI: Electromagnetic interference.
- 1.3.4.** IDC: Insulation displacement connector.
- 1.3.5.** LAN: Local area network.
- 1.3.6.** RCDD: Registered Communications Distribution Designer.
- 1.3.7.** UTP: Unshielded twisted pair.

1.4. BACKBONE CABLING DESCRIPTION

- 1.4.1.** Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
- 1.4.2.** Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.5. PERFORMANCE REQUIREMENTS

- 1.5.1.** General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

1.6. SUBMITTALS

- 1.6.1.** Product Data: For each type of product indicated.
 - 1.6.1.1.** For coaxial cable, include the following installation data for each type used:
 - 1.6.1.1.1.** Nominal OD.
 - 1.6.1.1.2.** Minimum bending radius.
 - 1.6.1.1.3.** Maximum pulling tension.
- 1.6.2.** Shop Drawings:
 - 1.6.2.1.** System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 1.6.2.2.** System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - 1.6.2.3.** Cabling administration drawings and printouts.
 - 1.6.2.4.** Wiring diagrams to show typical wiring schematics including the following:
 - 1.6.2.4.1.** Cross-connects.
 - 1.6.2.4.2.** Patch panels.

- 1.6.2.4.3. Patch cords.
 - 1.6.2.5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
 - 1.6.2.6. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - 1.6.2.6.1. Vertical and horizontal offsets and transitions.
 - 1.6.2.6.2. Clearances for access above and to side of cable trays.
 - 1.6.2.6.3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - 1.6.2.6.4. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.
 - 1.6.3. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
 - 1.6.4. Source quality-control reports.
 - 1.6.5. Field quality-control reports.
 - 1.6.6. Maintenance Data: For splices and connectors to include in maintenance manuals.
 - 1.6.7. Software and Firmware Operational Documentation:
 - 1.6.7.1. Software operating and upgrade manuals.
 - 1.6.7.2. Program Software Backup: On magnetic media or compact disk, complete with data files.
 - 1.6.7.3. Device address list.
 - 1.6.7.4. Printout of software application and graphic screens.
- 1.7. QUALITY ASSURANCE
 - 1.7.1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

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- 1.7.1.1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings and field testing program development.
 - 1.7.1.2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
 - 1.7.1.3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
 - 1.7.2. Testing Agency Qualifications: An NRTL.
 - 1.7.2.1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
 - 1.7.3. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1.7.3.1. Flame-Spread Index: 25, or less.
 - 1.7.3.2. Smoke-Developed Index: 50, or less.
 - 1.7.4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 1.7.5. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
 - 1.7.6. Grounding: Comply with ANSI-J-STD-607-A.
 - 1.8. DELIVERY, STORAGE, AND HANDLING
 - 1.8.1. Test cables upon receipt at Project site.
 - 1.8.1.1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight.
 - 1.8.1.2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
 - 1.8.1.3. Test each pair of UTP cable for open and short circuits.

1.9. PROJECT CONDITIONS

- 1.9.1.** Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.10. COORDINATION

- 1.10.1.** Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.11. SOFTWARE SERVICE AGREEMENT

- 1.11.1.** Technical Support: Beginning with Substantial Completion, provide software support for two years.
- 1.11.2.** Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - 1.11.2.1.** Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.12. EXTRA MATERIALS

- 1.12.1.** Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1.12.1.1.** Patch-Panel Units: One of each type.
 - 1.12.1.2.** Connecting Blocks: One of each type.

2. PART 2 - PRODUCTS

2.1. PATHWAYS

- 2.1.1.** General Requirements: Comply with TIA/EIA-569-A.
- 2.1.2.** Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - 2.1.2.1.** Support brackets with cable tie slots for fastening cable ties to brackets.

2.1.2.2. Lacing bars, spools, J-hooks, and D-rings.

2.1.2.3. Straps and other devices.

2.1.3. Cable Trays:

2.1.3.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.1.3.1.1. Cable Management Solutions, Inc.

2.1.3.1.2. Cablofil Inc.

2.1.3.1.3. Cooper B-Line, Inc.

2.1.3.2. Cable Tray Material: Metal, suitable for indoors, and protected against corrosion by [electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inches (0.012 mm) thick.

2.1.3.2.1. Basket Cable Trays: 6 inches wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).

2.1.3.2.2. Trough Cable Trays: Nominally 6 inches wide.

2.1.3.2.3. Ladder Cable Trays: Nominally 18 inches wide, and a rung spacing of 12 inches.

2.1.3.2.4. Channel Cable Trays: One-piece construction, nominally 4 inches wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.

2.1.3.2.5. Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches wide. Provide with solid covers.

2.1.4. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems."

2.1.4.1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.2. BACKBOARDS

- 2.2.1.** Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.

2.3. UTP CABLE

- 2.3.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 2.3.1.1.** Belden CDT Inc.; Electronics Division.
- 2.3.1.2.** Berk-Tek; a Nexans company.
- 2.3.1.3.** CommScope, Inc.
- 2.3.1.4.** Genesis Cable Products; Honeywell International, Inc.
- 2.3.1.5.** Mohawk; a division of Belden CDT.
- 2.3.1.6.** Nordex/CDT; a subsidiary of Cable Design Technologies.
- 2.3.1.7.** Superior Essex Inc.
- 2.3.1.8.** 3M.

- 2.3.2.** Description: 100-ohm, 100-pair UTP, formed into 25-pair binder groups covered with a gray thermoplastic jacket and overall metallic shield.

- 2.3.2.1.** Comply with ICEA S-90-661 for mechanical properties.
- 2.3.2.2.** Comply with TIA/EIA-568-B.1 for performance specifications.
- 2.3.2.3.** Comply with TIA/EIA-568-B.2, Category 5e.
- 2.3.2.4.** Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - 2.3.2.4.1.** Communications, General Purpose: Type CM or CMG.
 - 2.3.2.4.2.** Communications, Plenum Rated: Type CMP, complying with NFPA 262.
 - 2.3.2.4.3.** Communications, Riser Rated: Type CMR, complying with UL 1666.

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- 2.3.2.4.4.** Communications, Limited Purpose: Type CMX.
- 2.3.2.4.5.** Multipurpose: Type MP or MPG.
- 2.3.2.4.6.** Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
- 2.3.2.4.7.** Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

2.4. UTP CABLE HARDWARE

- 2.4.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.4.1.1.** American Technology Systems Industries, Inc.
 - 2.4.1.2.** Dynacom Corporation.
 - 2.4.1.3.** Hubbell Premise Wiring.
 - 2.4.1.4.** Leviton Voice & Data Division.
 - 2.4.1.5.** Molex Premise Networks; a division of Molex, Inc.
 - 2.4.1.6.** Panduit Corp.
 - 2.4.1.7.** Siemon Co. (The).
- 2.4.2.** General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- 2.4.3.** Connecting Blocks: 110-style IDC for Category 5e. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
- 2.4.4.** Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 - 2.4.4.1.** Number of Terminals per Field: One for each conductor in assigned cables.
- 2.4.5.** Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

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- 2.4.5.1.** Number of Jacks per Field: One for each four-pair UTP cable indicated.

- 2.4.6.** Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

- 2.4.7.** Patch Cords: Factory-made, 4-pair cables in 36-inch lengths; terminated with 8-position modular plug at each end.

2.5. OPTICAL FIBER CABLE

- 2.5.1. Manufacturers:** Subject to compliance with requirements, provide products by one of the following:

- 2.5.1.1. Berk-Tek; a Nexans company.**

- #### 2.5.1.2. CommScope, Inc.

- ### 2.5.1.3. Corning Cable Systems.

- #### 2.5.1.4. General Cable Technologies Corporation.

- 2.5.1.5. Optical Connectivity Solutions Division; Emerson Network Power.**

- 2.5.1.6. Superior Essex Inc.**

- 2.5.1.7. SYSTIMAX Solutions; a CommScope Inc. brand.**

- 2.5.1.8. 3M.**

- 2.5.2.** Description: Multimode, 62.5/125-micrometer, 24-fiber, tight buffer, optical fiber cable.

- 2.5.2.1.** Comply with ICEA S-83-596 for mechanical properties.

- 2.5.2.2.** Comply with TIA/EIA-568-B.3 for performance specifications.

- 2.5.2.3.** Comply with TIA/EIA-492AAAA-B for detailed specifications.

- 2.5.2.4.** Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

- 2.5.2.4.1.** General Purpose, Nonconductive:
Type OFN or OFNG.

- 2.5.2.4.2.** Plenum Rated, Nonconductive:
Type OFNP, complying with NFPA 262.

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- 2.5.2.4.3.** Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
 - 2.5.2.4.4.** General Purpose, Conductive: Type OFC or OFCG.
 - 2.5.2.4.5.** Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
 - 2.5.2.4.6.** Riser Rated, Conductive: Type OFCR, complying with UL 1666.
- 2.5.2.5.** Conductive cable shall be steel armored type.
- 2.5.2.6.** Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
- 2.5.2.7.** Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
- 2.5.3.** Jacket:
 - 2.5.3.1.** Jacket Color. Orange for 62.5/125-micrometer cable.
 - 2.5.3.2.** Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
 - 2.5.3.3.** Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

2.6. OPTICAL FIBER CABLE HARDWARE

- 2.6.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.6.1.1.** American Technology Systems Industries, Inc.
 - 2.6.1.2.** Berk-Tek; a Nexans company.
 - 2.6.1.3.** Corning Cable Systems.
 - 2.6.1.4.** Hubbell Premise Wiring.
 - 2.6.1.5.** Optical Connectivity Solutions Division; Emerson Network Power.
- 2.6.2.** Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

- 2.6.2.1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
 - 2.6.3. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.
 - 2.6.4. Cable Connecting Hardware:
 - 2.6.4.1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
 - 2.6.4.2. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.
 - 2.6.4.3. Type SFF connectors may be used in termination racks, panels, and equipment packages.
- 2.7. COAXIAL CABLE
 - 2.7.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.7.1.1. Alpha Wire Company.
 - 2.7.1.2. Belden CDT Inc.; Electronics Division.
 - 2.7.1.3. Coleman Cable, Inc..
 - 2.7.1.4. CommScope, Inc.
 - 2.7.1.5. Draka USA.
 - 2.7.2. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
 - 2.7.3. RG-11/U; NFPA 70, Type CATV.
 - 2.7.3.1. No. 14 AWG, solid, copper-covered steel conductor.
 - 2.7.3.2. Gas-injected, foam-PE insulation.
 - 2.7.3.3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
 - 2.7.3.4. Jacketed with sunlight-resistant, black PVC or PE.

- 2.7.3.5.** Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.

2.7.4. RG59/U: NFPA 70, Type CATVR.

- 2.7.4.1.** No. 20 AWG, solid, silver-plated, copper-covered steel conductor.

- #### 2.7.4.2. Gas-injected, foam-PE insulation.

- 2.7.4.3.** Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.

- 2.7.4.4. Color-coded PVC jacket.**

2.7.5. RG-6/U: NFPA 70, Type CATV or CM.

- 2.7.5.1.** No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.

- 2.7.5.2.** Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.

- 2.7.5.3.** Jacketed with black PVC or PE.

- 2.7.5.4.** Suitable for indoor installations.

2.7.6. RG59/U: NFPA 70, Type CATV.

- 2.7.6.1.** No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.

- 2.7.6.2.** Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.

- #### 2.7.6.3. PVC jacket.

2.7.7. RG59/U (Plenum Rated): NFPA 70, Type CMP.

- 2.7.7.1.** No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.

- 2.7.7.2.** Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.

- ### 2.7.7.3. Copolymer jacket.

2.7.8. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:

2.7.8.1. CATV Cable: Type CATV.

2.7.8.2. CATV Plenum Rated: Type CATVP, complying with NFPA 262.

2.7.8.3. CATV Riser Rated: Type CATVR, complying with UL 1666.

2.7.8.4. CATV Limited Rating: Type CATVX.

2.8. COAXIAL CABLE HARDWARE

2.8.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.8.1.1. Aim Electronics; a brand of Emerson Electric Co.

2.8.1.2. Leviton Voice & Data Division.

2.8.1.3. Siemon Co. (The).

2.8.2. Coaxial-Cable Connectors: Type BNC, 75 ohms.

2.9. GROUNDING

2.9.1. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.

2.9.2. Comply with ANSI-J-STD-607-A.

2.10. IDENTIFICATION PRODUCTS

2.10.1. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.11. SOURCE QUALITY CONTROL

2.11.1. Testing Agency: Engage a qualified testing agency to evaluate cables.

2.11.2. Factory test cables on reels according to TIA/EIA-568-B.1.

2.11.3. Factory test UTP cables according to TIA/EIA-568-B.2.

- 2.11.4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
- 2.11.5. Cable will be considered defective if it does not pass tests and inspections.
- 2.11.6. Prepare test and inspection reports.

3. PART 3 - EXECUTION

3.1. ENTRANCE FACILITIES

- 3.1.1. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2. WIRING METHODS

- 3.2.1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
 - 3.2.1.1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 3.2.1.2. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway and Boxes for Electrical Systems."
- 3.2.2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- 3.2.3. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3. INSTALLATION OF PATHWAYS

- 3.3.1. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A.
- 3.3.2. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.
- 3.3.3. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
- 3.3.4. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

3.3.5. Install manufactured conduit sweeps and long-radius elbows whenever possible.

3.3.6. Pathway Installation in Communications Equipment Rooms:

3.3.6.1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.

3.3.6.2. Install cable trays to route cables if conduits cannot be located in these positions.

3.3.6.3. Secure conduits to backboard when entering room from overhead.

3.3.6.4. Extend conduits 3 inches above finished floor.

3.3.6.5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.3.7. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.4. INSTALLATION OF CABLES

3.4.1. Comply with NECA 1.

3.4.2. General Requirements for Cabling:

3.4.2.1. Comply with TIA/EIA-568-B.1.

3.4.2.2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

3.4.2.3. Install 110-style IDC termination hardware unless otherwise indicated.

3.4.2.4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

3.4.2.5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

- 3.4.2.6.** Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
- 3.4.2.7.** Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
- 3.4.2.8.** Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
- 3.4.2.9.** Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
- 3.4.2.10.** In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
- 3.4.2.11.** Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- 3.4.3.** UTP Cable Installation:
 - 3.4.3.1.** Comply with TIA/EIA-568-B.2.
 - 3.4.3.2.** Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
- 3.4.4.** Optical Fiber Cable Installation:
 - 3.4.4.1.** Comply with TIA/EIA-568-B.3.
 - 3.4.4.2.** Cable may be terminated on connecting hardware that is rack or cabinet mounted.
- 3.4.5.** Open-Cable Installation:
 - 3.4.5.1.** Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - 3.4.5.2.** Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches apart.

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- 3.4.5.3.** Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

3.4.6. Installation of Cable Routed Exposed under Raised Floors:

- 3.4.6.1.** Install plenum-rated cable only.
- 3.4.6.2.** Install cabling after the flooring system has been installed in raised floor areas.
- 3.4.6.3.** Coil cable 6 feet long not less than 12 inches in diameter below each feed point.

3.4.7. Outdoor Coaxial Cable Installation:

- 3.4.7.1.** Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
- 3.4.7.2.** Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).

3.4.8. Group connecting hardware for cables into separate logical fields.

3.4.9. Separation from EMI Sources:

- 3.4.9.1.** Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
- 3.4.9.2.** Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 3.4.9.2.1.** Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - 3.4.9.2.2.** Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - 3.4.9.2.3.** Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

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- 3.4.9.3.** Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 3.4.9.3.1.** Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - 3.4.9.3.2.** Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - 3.4.9.3.3.** Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
- 3.4.9.4.** Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 3.4.9.4.1.** Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 3.4.9.4.2.** Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - 3.4.9.4.3.** Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
- 3.4.9.5.** Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
- 3.4.9.6.** Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.5. FIRESTOPPING

- 3.5.1.** Comply with requirements in Division 07 Section "Penetration Firestopping." Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- 3.5.2.** Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6. GROUNDING

- 3.6.1.** Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- 3.6.2.** Comply with ANSI-J-STD-607-A.

- 3.6.3.** Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No.4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- 3.6.4.** Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.7. IDENTIFICATION

- 3.7.1.** Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 - 3.7.1.1.** Administration Class: 1.
 - 3.7.1.2.** Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- 3.7.2.** Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- 3.7.3.** See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion about TIA/EIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.
- 3.7.4.** Comply with requirements in Division 27 Section "Communications Horizontal Cabling" for cable and asset management software.
- 3.7.5.** Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- 3.7.6.** Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

3.7.7. Cable and Wire Identification:

3.7.7.1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.

3.7.7.2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.

3.7.7.3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).

3.7.7.4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

3.7.7.4.1. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.

3.7.7.4.2. Label each unit and field within distribution racks and frames.

3.7.7.5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

3.7.8. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:

3.7.8.1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.8. FIELD QUALITY CONTROL

3.8.1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

3.8.2. Perform tests and inspections.

3.8.3. Tests and Inspections:

- 3.8.3.1.** Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
- 3.8.3.2.** Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
- 3.8.3.3.** Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - 3.8.3.3.1.** Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- 3.8.3.4.** Optical Fiber Cable Tests:
 - 3.8.3.4.1.** Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - 3.8.3.4.2.** Link End-to-End Attenuation Tests:
 - 3.8.3.4.2.1.** Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
 - 3.8.3.4.2.2.** Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

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- 3.8.4.** Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- 3.8.5.** Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- 3.8.6.** End-to-end cabling will be considered defective if it does not pass tests and inspections.
- 3.8.7.** Prepare test and inspection reports.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

1.2.1. Section Includes:

- 1.2.1.1.** UTP cabling.
- 1.2.1.2.** 50/125-micrometer, optical fiber cabling.
- 1.2.1.3.** Coaxial cable.
- 1.2.1.4.** Multiuser telecommunications outlet assemblies.
- 1.2.1.5.** Cable connecting hardware, patch panels, and cross-connects.
- 1.2.1.6.** Telecommunications outlet/connectors.
- 1.2.1.7.** Cabling system identification products.
- 1.2.1.8.** Cable management system.

1.2.2. Related Requirements:

- 1.2.2.1.** Division 27 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
- 1.2.2.2.** Division 28 Section "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.3. DEFINITIONS

- 1.3.1.1.** BICSI: Building Industry Consulting Service International.
- 1.3.1.2.** Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
- 1.3.1.3.** Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

- 1.3.1.4.** EMI: Electromagnetic interference.
- 1.3.1.5.** IDC: Insulation displacement connector.
- 1.3.1.6.** LAN: Local area network.
- 1.3.1.7.** MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.
- 1.3.1.8.** Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
- 1.3.1.9.** RCDD: Registered Communications Distribution Designer.
- 1.3.1.10.** UTP: Unshielded twisted pair.

1.4. ADMINISTRATIVE REQUIREMENTS

- 1.4.1.** Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.
- 1.4.2.** Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.5. ACTION SUBMITTALS

- 1.5.1.** Product Data: For each type of product.
 - 1.5.1.1.** For coaxial cable, include the following installation data for each type used:
 - 1.5.1.1.1.** Nominal OD.
 - 1.5.1.1.2.** Minimum bending radius.
 - 1.5.1.1.3.** Maximum pulling tension.
- 1.5.2.** Shop Drawings:
 - 1.5.2.1.** System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 1.5.2.2.** System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - 1.5.2.3.** Cabling administration drawings and printouts.

1.5.2.4. Wiring diagrams to show typical wiring schematics, including the following:

1.5.2.4.1. Cross-connects.

1.5.2.4.2. Patch panels.

1.5.2.4.3. Patch cords.

1.5.2.5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.5.3. Samples: For workstation outlets, jacks, jack assemblies, [in specified finish, one for each size and outlet configuration.

1.6. INFORMATIONAL SUBMITTALS

1.6.1. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

1.6.2. Source quality-control reports.

1.6.3. Field quality-control reports.

1.7. CLOSEOUT SUBMITTALS

1.7.1. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.7.2. Software and Firmware Operational Documentation:

1.7.2.1. Software operating and upgrade manuals.

1.7.2.2. Program Software Backup: On magnetic media or compact disk, complete with data files.

1.7.2.3. Device address list.

1.7.2.4. Printout of software application and graphic screens.

1.8. MAINTENANCE MATERIAL SUBMITTALS

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

1.8.1.1. Patch-Panel Units: One of each type.

1.8.1.2. Connecting Blocks: One of each type.

1.8.1.3. Device Plates: One of each type.

- 1.8.1.4. Multiuser Telecommunications Outlet Assemblies: One of each type.

1.9. QUALITY ASSURANCE

- 1.9.1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

- 1.9.1.1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.

- 1.9.1.2. Installation Supervision: Installation shall be under the direct supervision of [Registered Technician], who shall be present at all times when Work of this Section is performed at Project site.

- 1.9.1.3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

- 1.9.2. Testing Agency Qualifications: An NRTL.

- 1.9.2.1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.10. DELIVERY, STORAGE, AND HANDLING

- 1.10.1. Test cables upon receipt at Project site.

- 1.10.1.1. Test optical fiber cables to determine the continuity of the strand end to end. Use optical fiber flashlight.

- 1.10.1.2. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.

- 1.10.1.3. Test each pair of UTP cable for open and short circuits.

2. PART 2 - PRODUCTS

2.1. HORIZONTAL CABLING DESCRIPTION

- 2.1.1. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.

- 2.1.1.1.** TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
- 2.1.1.2.** Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
- 2.1.1.3.** Bridged taps and splices shall not be installed in the horizontal cabling.
- 2.1.1.4.** Splitters shall not be installed as part of the optical fiber cabling.
- 2.1.2.** A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the telecommunications outlet/connectors to the station equipment.
- 2.1.3.** The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

2.2. PERFORMANCE REQUIREMENTS

- 2.2.1.** General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1 when tested according to test procedures of this standard.
- 2.2.2.** Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 2.2.2.1.** Flame-Spread Index: 25 or less.
 - 2.2.2.2.** Smoke-Developed Index: 50 or less.
- 2.2.3.** Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2.2.4.** Grounding: Comply with J-STD-607-A.

2.3. BACKBOARDS

- 2.3.1.** Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.

2.4. UTP CABLE

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

2.4.2. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] or comparable product by one of the following:

2.4.2.1. ADC.

2.4.2.2. Belden Inc.

2.4.2.3. Berk-Tek; a Nexans company.

2.4.2.4. CommScope, Inc.

2.4.2.5. Draka Cableteq USA.

2.4.2.6. Genesis Cable Products; Honeywell International, Inc.

2.4.2.7. Mohawk; a division of Belden Networking, Inc.

2.4.2.8. Superior Essex Inc.

2.4.2.9. SYSTIMAX Solutions; a CommScope, Inc. brand.

2.4.2.10. 3M Communication Markets Division.

2.4.2.11. Tyco Electronics Corporation; AMP Products.

2.4.3. Description: 100-ohm, four-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.

2.4.3.1. Comply with ICEA S-90-661 for mechanical properties.

2.4.3.2. Comply with TIA/EIA-568-B.1 for performance specifications.

2.4.3.3. Comply with TIA/EIA-568-B.2, Category 6.

2.4.3.4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with LIL 444 and NFPA 70 for the following types:

2.4.3.4.1. Communications, General Purpose:
Type CM or CMG; .

2.4.3.4.2. Communications, Plenum Rated:
Type CMP, complying with NFPA 262.

- 2.4.3.4.3.** Communications, Riser Rated: Type CMR;, complying with UL 1666.
- 2.4.3.4.4.** Communications, Limited Purpose: Type CMX.
- 2.4.3.4.5.** Multipurpose: Type MP or MPG.
- 2.4.3.4.6.** Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
- 2.4.3.4.7.** Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

2.5. UTP CABLE HARDWARE

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

2.5.2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

- 2.5.2.1.** ADC.
- 2.5.2.2.** American Technology Systems Industries, Inc.
- 2.5.2.3.** Belden Inc.
- 2.5.2.4.** Dynacom Inc.
- 2.5.2.5.** Hubbell Premise Wiring.
- 2.5.2.6.** Leviton Commercial Networks Division.
- 2.5.2.7.** Molex Premise Networks; a division of Molex, Inc.
- 2.5.2.8.** Panduit Corp.
- 2.5.2.9.** Siemon Co. (The).
- 2.5.2.10.** Tyco Electronics Corporation; AMP Products.

2.5.3. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

- 2.5.4.** Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
- 2.5.5.** Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 - 2.5.5.1.** Number of Terminals per Field: One for each conductor in assigned cables.
- 2.5.6.** Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
 - 2.5.6.1.** Number of Jacks per Field: One for each four-pair UTP cable indicated.
- 2.5.7.** Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
- 2.5.8.** Patch Cords: Factory-made, four-pair cables in 36-inch (900 mm) lengths; terminated with eight-position modular plug at each end.
 - 2.5.8.1.** Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
 - 2.5.8.2.** Patch cords shall have color-coded boots for circuit identification.

2.6. OPTICAL FIBER CABLE

- 2.6.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.6.2.** Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2.6.2.1.** Belden Inc.
 - 2.6.2.2.** Berk-Tek; a Nexans company.
 - 2.6.2.3.** CommScope, Inc.

- 2.6.2.4.** Corning Cable Systems.
- 2.6.2.5.** CSI Technologies Inc.
- 2.6.2.6.** General Cable Technologies Corporation.
- 2.6.2.7.** Mohawk; a division of Belden Networking, Inc.
- 2.6.2.8.** Superior Essex Inc.
- 2.6.2.9.** SYSTIMAX Solutions; a CommScope, Inc. brand.
- 2.6.2.10.** 3M Communication Markets Division.
- 2.6.2.11.** Tyco Electronics Corporation; AMP Products.
- 2.6.3.** Description: Multimode, 50/125 -micrometer, 24 >-fiber, nonconductive, tight buffer, optical fiber cable.
 - 2.6.3.1.** Comply with ICEA S-83-596 for mechanical properties.
 - 2.6.3.2.** Comply with TIA/EIA-568-B.3 for performance specifications.
 - 2.6.3.3.** Comply with TIA-492AAAB for detailed specifications.
 - 2.6.3.4.** Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - 2.6.3.4.1.** General Purpose, Nonconductive: Type OFN or OFNG.
 - 2.6.3.4.2.** Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
 - 2.6.3.4.3.** Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
 - 2.6.3.4.4.** General Purpose, Conductive: Type OFC or OFCG[; .
 - 2.6.3.4.5.** Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
 - 2.6.3.4.6.** Riser Rated, Conductive: Type OFCR, complying with UL 1666.
 - 2.6.3.5.** Conductive cable shall be [steel] armored type.
 - 2.6.3.6.** Maximum Attenuation: [3.50] dB/km at 850 nm; [1.5] dB/km at 1300 nm.

2.6.3.7. Minimum Modal Bandwidth: 160 MHz-km at 850 nm;
500 MHz-km at 1300 nm.

2.6.4. Jacket:

2.6.4.1. Jacket Color: [Aqua for 50/125-micrometer cable].

2.6.4.2. Cable cordage jacket, fiber, unit, and group color shall
be according to TIA-598-C.

2.6.4.3. Imprinted with fiber count, fiber type, and aggregate
length at regular intervals not to exceed 40 inches
(1000 mm).

2.7. OPTICAL FIBER CABLE HARDWARE

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

2.7.2. Basis-of-Design Product: Subject to compliance with
requirements, provide [product indicated on Drawings] or
comparable product by one of the following:

2.7.2.1. ADC.

2.7.2.2. American Technology Systems Industries, Inc.

2.7.2.3. Belden Inc.

2.7.2.4. Berk-Tek; a Nexans company.

2.7.2.5. Corning Cable Systems.

2.7.2.6. CSI Technologies Inc.

2.7.2.7. Dynacom Inc.

2.7.2.8. Hubbell Premise Wiring.

2.7.2.9. Molex Premise Networks; a division of Molex, Inc.

2.7.2.10. Siemon Co. (The).

2.7.3. Cross-Connects and Patch Panels: Modular panels housing
multiple-numbered, duplex cable connectors.

2.7.3.1. Number of Connectors per Field: for each fiber of
cable or cables assigned to field, plus spares and blank
positions adequate to suit specified expansion criteria.

2.7.4. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.

2.7.5. Cable Connecting Hardware:

2.7.5.1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.

2.7.5.2. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.

2.7.5.3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.8. COAXIAL CABLE

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

2.8.2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

2.8.2.1. Alpha Wire Company.

2.8.2.2. Belden Inc.

2.8.2.3. Coleman Cable, Inc.

2.8.2.4. CommScope, Inc.

2.8.2.5. Draka Cableteq USA.

2.8.3. Cable Characteristics: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

2.8.4. RG-11/U: NFPA 70, Type CATV.

2.8.4.1. [No. 14] AWG, solid, copper-covered steel conductor.

2.8.4.2. Gas-injected, foam-PE insulation.

2.8.4.3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.

2.8.4.4. Jacketed with sunlight-resistant, black PVC or PE.

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- 2.8.4.5.** Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.

2.8.5. RG59/U: NFPA 70, Type CATVR.

- 2.8.5.1.** [No. 20] AWG, solid, silver-plated, copper-covered steel conductor.

2.8.5.2. Gas-injected, foam-PE insulation.

- 2.8.5.3.** Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.

2.8.5.4. Color-coded PVC jacket.

2.8.6. RG-6/U: NFPA 70, Type CATV or CM.

- 2.8.6.1.** [No. 16] AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.

2.8.6.2. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.

2.8.6.3. Jacketed with black PVC or PE.

2.8.6.4. Suitable for indoor installations.

2.8.7. RG59/U: NFPA 70, Type CATV.

- 2.8.7.1.** [No. 20] AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.

2.8.7.2. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.

2.8.7.3. PVC jacket.

2.8.8. RG59/U (Plenum Rated): NFPA 70, Type CMP.

- 2.8.8.1.** [No. 20] AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.

2.8.8.2. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.

2.8.8.3. Copolymer jacket.

2.8.9. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:

2.8.9.1. CATV Cable: Type CATV.

2.8.9.2. CATV Plenum Rated: Type CATVP, complying with NFPA 262.

2.8.9.3. CATV Riser Rated: Type CATVR, complying with UL 1666.

2.8.9.4. CATV Limited Rating: Type CATVX.

2.9. COAXIAL CABLE HARDWARE

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

2.9.2. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] or comparable product by one of the following:

2.9.2.1. Emerson Network Power Connectivity Solutions.

2.9.2.2. Leviton Commercial Networks Division.

2.9.2.3. Siemon Co. [The].

2.9.3. Coaxial-Cable Connectors: Type BNC, 75 ohms.

2.10. CONSOLIDATION POINTS

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

2.10.2. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] or comparable product by one of the following:

2.10.2.1. American Technology Systems Industries, Inc.

2.10.2.2. Belden Inc.

2.10.2.3. Chatsworth Products, Inc.

- 2.10.2.4.** Dynacom Inc.
- 2.10.2.5.** Hubbell Premise Wiring.
- 2.10.2.6.** Molex Premise Networks; a division of Molex, Inc.
- 2.10.2.7.** Ortronics, Inc.; a subsidiary of Legrand Group.
- 2.10.2.8.** Panduit Corp.
- 2.10.2.9.** Siemon Co. (The).
- 2.10.3.** Description: Consolidation points shall comply with requirements for cable connecting hardware.
 - 2.10.3.1.** Number of Terminals per Field: [One] for each conductor in assigned cables.
 - 2.10.3.2.** Number of Connectors per Field:
 - 2.10.3.2.1.** [One] for each four-pair UTP cable indicated.
 - 2.10.3.2.2.** [One] for each four-pair conductor group of indicated cables, plus [25] percent spare positions.
 - 2.10.3.3.** Mounting: [Recessed in ceiling] [Wall] [Desk].
 - 2.10.3.4.** NRTL listed as complying with UL 50 and UL 1863.
 - 2.10.3.5.** When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.
- 2.11. MULTIUSER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)**
 - 2.11.1.** Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 2.11.2.** Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] or comparable product by one of the following:
 - 2.11.2.1.** Belden Inc.
 - 2.11.2.2.** Chatsworth Products, Inc.
 - 2.11.2.3.** Hubbell Premise Wiring.
 - 2.11.2.4.** Molex Premise Networks; a division of Molex, Inc.

- 2.11.2.5.** Ortronics, Inc.; a subsidiary of Legrand Group.
- 2.11.2.6.** Panduit Corp.
- 2.11.2.7.** Siemon Co. (The).
- 2.11.3.** Description: MUTOAs shall meet the requirements for cable connecting hardware.
 - 2.11.3.1.** Number of Terminals per Field: [One] for each conductor in assigned cables.
 - 2.11.3.2.** Number of Connectors per Field:
 - 2.11.3.2.1.** [One] for each four-pair UTP cable indicated.
 - 2.11.3.2.2.** [One] for each four-pair conductor group of indicated cables, plus [25] percent spare positions.
 - 2.11.3.3.** Mounting: [Recessed in ceiling] [Wall] [Desk].
 - 2.11.3.4.** NRTL listed as complying with UL 50 and UL 1863.
 - 2.11.3.5.** Label shall include maximum length of work area cords, based on TIA/EIA-568-B.1.
 - 2.11.3.6.** When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

2.12. TELECOMMUNICATIONS OUTLET/CONNECTORS

- 2.12.1.** Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.
- 2.12.2.** Workstation Outlets: [Two][-port-connector assemblies mounted in [single] faceplate.
 - 2.12.2.1.** Plastic Faceplate: High-impact plastic. Coordinate color with Division 26 Section "Wiring Devices."
 - 2.12.2.2.** Metal Faceplate: [Stainless steel], complying with requirements in Division 26 Section "Wiring Devices."
 - 2.12.2.3.** For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
 - 2.12.2.3.1.** Flush mounting jacks, positioning the cord at a 45-degree angle.

2.12.2.4. Legend: Factory labeled by silk-screening or engraving [for] [stainless steel].

2.12.2.5. Legend: Machine printed, in the field, using adhesive-tape label.

2.12.2.6. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

2.13. GROUNDING

2.13.1. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.

2.13.2. Comply with J-STD-607-A.

2.14. IDENTIFICATION PRODUCTS

2.14.1. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.14.2. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.15. CABLE MANAGEMENT SYSTEM

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

2.15.2. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] or comparable product by one of the following:

2.15.2.1. iTRACS Corporation, Inc.

2.15.2.2. TelSoft Solutions.

2.15.3. Description: Computer-based cable management system, with integrated database[and graphic] capabilities.

2.15.4. Document physical characteristics by recording the network, TIA/EIA details, and connections between equipment and cable.

2.15.5. Information shall be presented in database view.

2.15.5.1. [AutoCAD] drawing software shall be used as drawing and schematic plans software.

2.15.6. System shall interface with the following testing and recording devices:

2.15.6.1. Direct upload tests from circuit testing instrument into the personal computer.

2.15.6.2. Direct download circuit labeling into labeling printer.

2.16. SOURCE QUALITY CONTROL

2.16.1. Testing Agency: [Engage] a qualified testing agency to evaluate cables.

2.16.2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.

2.16.3. Factory test UTP cables according to TIA/EIA-568-B.2.

2.16.4. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA/EIA-568-B.3.

2.16.5. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

2.16.6. Cable will be considered defective if it does not pass tests and inspections.

2.16.7. Prepare test and inspection reports.

3. PART 3 - EXECUTION

3.1. ENTRANCE FACILITIES

3.1.1. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2. WIRING METHODS

3.2.1. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters[and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used]. Conceal pathways and cables except in unfinished spaces.

3.2.1.1. Install plenum cable in environmental air spaces, including plenum ceilings.

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- 3.2.1.2. Comply with requirements in Division 27 Section "Pathways for Communications Systems."
 - 3.2.1.3. Comply with requirements in Division 27 Section "Cable Trays for Communications Systems."
 - 3.2.2. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - 3.2.3. Wiring within Enclosures:
 - 3.2.3.1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
 - 3.2.3.2. Install lacing bars and distribution spools.
 - 3.2.3.3. Install conductors parallel with or at right angles to sides and back of enclosure.
- 3.3. INSTALLATION OF CABLES
 - 3.3.1. Comply with NECA 1.
 - 3.3.2. General Requirements for Cabling:
 - 3.3.2.1. Comply with TIA/EIA-568-B.1.
 - 3.3.2.2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - 3.3.2.3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 3.3.2.4. MUTOA shall not be used as a cross-connect point.
 - 3.3.2.5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
 - 3.3.2.5.1. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - 3.3.2.5.2. Locate consolidation points for UTP at least 49 feet (15 m) from communications equipment room.

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- 3.3.2.6.** Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
- 3.3.2.7.** Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- 3.3.2.8.** Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
- 3.3.2.9.** Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
- 3.3.2.10.** Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
- 3.3.2.11.** Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
- 3.3.2.12.** In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
- 3.3.2.13.** Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- 3.3.3.** UTP Cable Installation:
 - 3.3.3.1.** Comply with TIA/EIA-568-B.2.
 - 3.3.3.2.** Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
- 3.3.4.** Optical Fiber Cable Installation:
 - 3.3.4.1.** Comply with TIA/EIA-568-B.3.
 - 3.3.4.2.** Cable may be terminated on connecting hardware that is rack or cabinet mounted.
- 3.3.5.** Open-Cable Installation:

- 3.3.5.1.** Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
- 3.3.5.2.** Suspend UTP cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than [60 inches (1524 mm)] apart.
- 3.3.5.3.** Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- 3.3.6.** Installation of Cable Routed Exposed under Raised Floors:
 - 3.3.6.1.** Install plenum-rated cable only.
 - 3.3.6.2.** Install cabling after the flooring system has been installed in raised floor areas.
 - 3.3.6.3.** Coil cable [6 feet (1800 mm)] long not less than [12 inches (300 mm)] in diameter below each feed point.
- 3.3.7.** Outdoor Coaxial Cable Installation:
 - 3.3.7.1.** Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
 - 3.3.7.2.** Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
- 3.3.8.** Group connecting hardware for cables into separate logical fields.
- 3.3.9.** Separation from EMI Sources:
 - 3.3.9.1.** Comply with BICSI TDMM and TIA-569-B for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - 3.3.9.2.** Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 3.3.9.2.1.** Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).

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- 3.3.9.2.2.** Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
- 3.3.9.2.3.** Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
- 3.3.9.3.** Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 3.3.9.3.1.** Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - 3.3.9.3.2.** Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - 3.3.9.3.3.** Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
- 3.3.9.4.** Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 3.3.9.4.1.** Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 3.3.9.4.2.** Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - 3.3.9.4.3.** Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
- 3.3.9.5.** Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
- 3.3.9.6.** Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.4. FIRESTOPPING

- 3.4.1.** Comply with requirements in Division 07 Section "Penetration Firestopping."
- 3.4.2.** Comply with TIA-569-B, Annex A, "Firestopping."
- 3.4.3.** Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5. GROUNDING

- 3.5.1.** Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- 3.5.2.** Comply with J-STD-607-A.
- 3.5.3.** Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- 3.5.4.** Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.6. IDENTIFICATION

- 3.6.1.** Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 - 3.6.1.1.** Administration Class: [1].
 - 3.6.1.2.** Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
- 3.6.2.** Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
- 3.6.3.** Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- 3.6.4.** Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for [Class 2] level of administration[, including optional identification requirements of this standard].
- 3.6.5.** Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

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- 3.6.6.** Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, [backbone pathways and cables,] terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
- 3.6.7.** Cable and Wire Identification:
- 3.6.7.1.** Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 3.6.7.2.** Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3.6.7.3.** Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
 - 3.6.7.4.** Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - 3.6.7.4.1.** Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
 - 3.6.7.4.2.** Label each unit and field within distribution racks and frames.
 - 3.6.7.5.** Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
 - 3.6.7.6.** Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

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3.6.8. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.

3.6.8.1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.7. FIELD QUALITY CONTROL

3.7.1. Testing Agency: [Engage] a qualified testing agency to perform tests and inspections.

3.7.2. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

3.7.3. Perform the following tests and inspections[with the assistance of a factory-authorized service representative]:

3.7.3.1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.

3.7.3.2. Visually confirm [Category 6,] marking of outlets, cover plates, outlet/connectors, and patch panels.

3.7.3.3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

3.7.3.4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

3.7.3.4.1. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

3.7.3.5. Optical Fiber Cable Tests:

- 3.7.3.5.1.** Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- 3.7.3.5.2.** Link End-to-End Attenuation Tests:
- 3.7.3.5.3.** Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA-526-14-A, Method B, One Reference Jumper.
 - 3.7.3.5.3.1.** Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
- 3.7.3.6.** UTP Performance Tests:
 - 3.7.3.6.1.** Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:
 - 3.7.3.6.1.1.** Wire map.
 - 3.7.3.6.1.2.** Length (physical vs. electrical, and length requirements).
 - 3.7.3.6.1.3.** Insertion loss.
 - 3.7.3.6.1.4.** Near-end crosstalk (NEXT) loss.
 - 3.7.3.6.1.5.** Power sum near-end crosstalk (PSNEXT) loss.
 - 3.7.3.6.1.6.** Equal-level far-end crosstalk (ELFEXT).
 - 3.7.3.6.1.7.** Power sum equal-level far-end crosstalk (PSELFEXT).
 - 3.7.3.6.1.8.** Return loss.
 - 3.7.3.6.1.9.** Propagation delay.
 - 3.7.3.6.1.10.** Delay skew.

- 3.7.3.7.** Optical Fiber Cable Performance Tests: Perform optical fiber end-to-end link tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.3.
- 3.7.3.8.** Coaxial Cable Tests: Conduct tests according to Division 27 Section "Master Antenna Television System."
- 3.7.3.9.** Final Verification Tests: Perform verification tests for UTP[and optical fiber] systems after the complete communications cabling and workstation outlet/connectors are installed.
 - 3.7.3.9.1.** Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
 - 3.7.3.9.2.** Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
- 3.7.4.** Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- 3.7.5.** End-to-end cabling will be considered defective if it does not pass tests and inspections.
- 3.7.6.** Prepare test and inspection reports.
- 3.8. SOFTWARE SERVICE AGREEMENT**
 - 3.8.1.** Technical Support: Beginning with Substantial Completion, provide software support for [two] years.
 - 3.8.2.** Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within [two] years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

- 3.8.2.1.** Provide [30] days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

3.9. DEMONSTRATION

- 3.9.1.** [Engage a factory-authorized service representative to train] Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.[Include training in cabling administration software.]

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

1.2.1. Section Includes:

- 1.2.1.1. Preamplifiers.
- 1.2.1.2. Power amplifiers.
- 1.2.1.3. Transfer to standby amplifier.
- 1.2.1.4. Microphones.
- 1.2.1.5. Volume limiter/compressors.
- 1.2.1.6. Control console.
- 1.2.1.7. Equipment cabinet.
- 1.2.1.8. Equipment rack.
- 1.2.1.9. Telephone paging adapters.
- 1.2.1.10. Tone generator.
- 1.2.1.11. Monitor panel.
- 1.2.1.12. Loudspeakers.
- 1.2.1.13. Noise-operated gain controllers.
- 1.2.1.14. Microphone and headphone outlets.
- 1.2.1.15. Battery backup power unit.
- 1.2.1.16. Conductors and cables.
- 1.2.1.17. Raceways.

1.3. DEFINITIONS

- 1.3.1. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.

- 1.3.2. VU: Volume unit.
- 1.3.3. Zone: Separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

1.4. PERFORMANCE REQUIREMENTS

- 1.4.1. Delegated Design: Design supports and seismic restraints for control consoles, equipment cabinets and racks, and components, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- 1.4.2. Seismic Performance: Supports and seismic restraints for control consoles, equipment cabinets and racks, and components shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - 1.4.2.1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.5. ACTION SUBMITTALS

- 1.5.1. Product Data: For each type of product indicated.
- 1.5.2. Shop Drawings: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components. Include plans, elevations, sections, details, and attachments to other work.
 - 1.5.2.1. Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1.5.2.2. Console layouts.
 - 1.5.2.3. Control panels.
 - 1.5.2.4. Rack arrangements.
 - 1.5.2.5. Calculations: For sizing backup battery.
 - 1.5.2.6. Wiring Diagrams: For power, signal, and control wiring.
 - 1.5.2.6.1. Identify terminals to facilitate installation, operation, and maintenance.
 - 1.5.2.6.2. Single-line diagram showing interconnection of components.

1.5.2.6.3. Cabling diagram showing cable routing.

1.5.3. Delegated-Design Submittal: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5.3.1. Detail fabrication and assembly of supports and seismic restraints for control consoles, equipment cabinets and racks, and components.

1.6. INFORMATIONAL SUBMITTALS

1.6.1. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.

1.6.2. Qualification Data: For qualified Installer.

1.6.3. Seismic Qualification Certificates: For control consoles, equipment cabinets and racks, accessories, and components, from manufacturer.

1.6.3.1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

1.6.3.2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

1.6.3.3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6.4. Field quality-control reports.

1.7. CLOSEOUT SUBMITTALS

1.7.1. Operation and Maintenance Data: For public address and mass notification systems to include in emergency, operation, and maintenance manuals.

1.8. MAINTENANCE MATERIAL SUBMITTALS

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

1.8.1.1. Microphone: One.

1.8.1.2. Desk Stand(s): One.

1.9. QUALITY ASSURANCE

1.9.1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1.9.1.1. Personnel certified by NICET as Audio Systems Level II Technician.

1.9.1.2. If an independent testing agency is required, see Division 01 Section "Quality Requirements" for general testing and inspecting agency qualification requirements.

1.9.2. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.

1.9.2.1. Testing Agency's Field Supervisor: Currently certified by NICET at Level III to supervise on-site testing.

1.9.3. Source Limitations: Obtain public address and mass notification systems from single source from single manufacturer.

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

1.9.5. Comply with NFPA 70.

1.10. COORDINATION

1.10.1. Coordinate layout and installation of system components and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

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

2.1.1.1. Telecore Communications.

2.1.1.2. Rauland-Borg Corporation.

- 2.1.1.3. Bogen Communications, Inc.
- 2.1.1.4. Electro-Voice; Telex Communications, Inc.
- 2.1.1.5. Federal Signal Corporation; Electrical Products Division.
- 2.1.1.6. Peavey Electronics.
- 2.1.1.7. Whelen Engineering Company, Inc.

2.2. FUNCTIONAL DESCRIPTION OF SYSTEM

2.2.1. System Functions:

- 2.2.1.1. Selectively connect any zone to any available signal channel.
- 2.2.1.2. Selectively control sound from microphone outlets and other inputs.
- 2.2.1.3. "All-call" feature shall connect the all-call sound signal simultaneously to all zones regardless of zone or channel switch settings.
- 2.2.1.4. Telephone paging adapter shall allow paging by dialing an extension from any local telephone instrument and speaking into the telephone.
- 2.2.1.5. Produce a program-signal tone that is amplified and sounded over all speakers, overriding signals currently being distributed.
- 2.2.1.6. Reproduce high-quality sound that is free of noise and distortion at all loudspeakers at all times during equipment operation including standby mode with inputs off; output free of non-uniform coverage of amplified sound.

2.3. GENERAL EQUIPMENT AND MATERIAL REQUIREMENTS

- 2.3.1. Compatibility of Components: Coordinate component features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
- 2.3.2. Equipment: Comply with UL 813. Equipment shall be modular, using solid-state components, and fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.

2.3.3. Equipment Mounting: Where rack, cabinet, or console mounting is indicated, equipment shall be designed to mount in a 19-inch (483-mm) housing complying with TIA/EIA-310-D.

2.3.4. Weather-Resistant Equipment: Listed and labeled by a qualified testing agency for duty outdoors or in damp locations.

2.4. PREAMPLIFIERS

2.4.1. Preamplifier: Separately mounted.

2.4.2. Preamplifier: Integral to power amplifier.

2.4.3. Output Power: Plus 4 dB above 1 mW at matched power-amplifier load.

2.4.4. Total Harmonic Distortion: Less than 1 percent.

2.4.5. Frequency Response: Within plus or minus 2 dB from 20 to 20,000 Hz.

2.4.6. Input Jacks: Minimum of two. One matched for low-impedance microphone; the other matchable to cassette deck, CD player, or radio tuner signals without external adapters.

2.4.7. Minimum Noise Level: Minus 55 dB below rated output.

2.4.8. Controls: On-off, input levels, and master gain.

2.5. POWER AMPLIFIERS

2.5.1. Mounting: Rack.

2.5.2. Output Power: 70-V balanced line, for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.

2.5.3. Total Harmonic Distortion: Less than 3 percent at rated power output from 50 to 12,000 Hz.

2.5.4. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.

2.5.5. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.

2.5.6. Output Regulation: Less than 2 dB from full to no load.

2.5.7. Controls: On-off, input levels, and low-cut filter.

2.5.8. Input Sensitivity: Matched to preamplifier and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphone or handset transmitter.

2.6. TRANSFER TO STANDBY AMPLIFIER

- 2.6.1.** Monitoring Circuit and Sensing Relay: Detect reduction in output of power amplifier of 40 percent or more and, in such event, transfer load and signal automatically to standby amplifier.

2.7. MICROPHONES

2.7.1. Paging Microphone:

- 2.7.1.1.** Type: Dynamic, with cardioid polar characteristic.
- 2.7.1.2.** Impedance: 150 ohms.
- 2.7.1.3.** Frequency Response: Uniform, 50 to 14,000 Hz.
- 2.7.1.4.** Output Level: Minus 58 dB, minimum.
- 2.7.1.5.** Finish: Satin chrome.
- 2.7.1.6.** Cable: C25J.
- 2.7.1.7.** Mounting: Desk stand with integral-locking, press-to-talk switch.

2.8. VOLUME LIMITER/COMPRESSOR

2.8.1. Minimum Performance Requirements:

- 2.8.1.1.** Frequency Response: 45 to 15,000 Hz, plus or minus 1 dB minimum.
- 2.8.1.2.** Signal Reduction Ratio: At least a 10:1 and 5:1 selectable capability.
- 2.8.1.3.** Distortion: 1 percent, maximum.
- 2.8.1.4.** Rated Output: Minimum of plus 14 dB.
- 2.8.1.5.** Inputs: Minimum of two inputs with variable front-panel gain controls and VU or decibel meter for input adjustment.
- 2.8.1.6.** Rack mounting.

2.9. CONTROL CONSOLE

- 2.9.1.** Cabinet: Modular, desktop; complying with TIA/EIA-310-D.
- 2.9.2.** Housing: Steel, 0.0478 inch (1.2 mm) minimum, with removable front and rear panels. Side panels are removable for interconnecting side-by-side mounting.

- 2.9.3.** Panel for Equipment and Controls: Rack mounted.
- 2.9.4.** Controls:
 - 2.9.4.1.** Switching devices to select signal sources for distribution channels.
 - 2.9.4.2.** Program selector switch to select source for each program channel.
 - 2.9.4.3.** Switching devices to select zones for paging.
 - 2.9.4.4.** All-call selector switch.
- 2.9.5.** Indicators: A visual annunciation for each distribution channel to indicate source being used.
- 2.9.6.** Self-Contained Power and Control Unit: A single assembly of basic control, electronics, and power supply necessary to accomplish specified functions.
- 2.9.7.** Spare Positions: 20 percent spare zone control and annunciation positions on console.
- 2.9.8.** Microphone jack.

2.10. EQUIPMENT CABINET

- 2.10.1.** Comply with TIA/EIA-310-D.
- 2.10.2.** House amplifiers and auxiliary equipment at each location.
- 2.10.3.** Cabinet Housing:
 - 2.10.3.1.** Constructed of 0.0478-inch (1.2-mm) steel, minimum, with front- and rear-locking doors and standard TIA/EIA-310-D-compliant, 19-inch (483-mm) racks.
 - 2.10.3.2.** Arranged for floor or wall mounting as indicated.
 - 2.10.3.3.** Sized to house all equipment indicated, plus spare capacity.
 - 2.10.3.4.** Include 20 percent minimum spare capacity for future equipment in addition to space required for future cassette deck and CD player.
- 2.10.4.** Power Provisions: A single switch in cabinet shall disconnect cabinet power distribution system and electrical outlets, which shall be uniformly spaced to accommodate ac-power cords for each item of equipment.

- 2.10.5.** Ventilation: A low-noise fan for forced-air cabinet ventilation. Fan shall be equipped with a filtered input vent and shall be connected to operate from 105- to 130-V ac, 60 Hz; separately fused and switched; arranged to be powered when main cabinet power switch is on.

2.11. EQUIPMENT RACK

- 2.11.1.** Racks: 19 inches (483 mm) standard, complying with TIA/EIA-310-D.
- 2.11.2.** Power-Supply Connections: Compatible plugs and receptacles.
- 2.11.3.** Enclosure Panels: Ventilated rear and sides and solid top. Use louvers in panels to ensure adequate ventilation.
- 2.11.4.** Finish: Uniform, baked-enamel factory finish over rust-inhibiting primer.
- 2.11.5.** Power-Control Panel: On front of equipment housing, with master power on-off switch and pilot light; and with socket for 5-A cartridge fuse for rack equipment power.
- 2.11.6.** Service Light: At top rear of rack with an adjacent control switch.
- 2.11.7.** Vertical Plug Strip: Grounded receptacles, 12 inches (300 mm) o.c.; the full height of rack.
- 2.11.8.** Maintenance Receptacles: Duplex convenience outlets supplied independent of vertical plug strip and located in front and bottom rear of rack.
- 2.11.9.** Spare Capacity: 20 percent in rack for future equipment.

2.12. TELEPHONE PAGING ADAPTER

- 2.12.1.** Adapters shall accept voice signals from telephone extension dialing access and automatically provide amplifier input and program override for preselected zones.
 - 2.12.1.1.** Minimum Frequency Response: Flat, 200 to 2500 Hz.
 - 2.12.1.2.** Impedance Matching: Adapter matches telephone line to public address equipment input.
 - 2.12.1.3.** Rack mounting.

2.13. TONE GENERATOR

- 2.13.1.** Generator shall provide clock and program interface with public address and mass notification system.

- 2.13.2.** Signals: Minimum of seven distinct, audible signal types including wail, warble, high/low, alarm, repeating and single-stroke chimes, and tone.
- 2.13.3.** Pitch Control: Chimes and tone.
- 2.13.4.** Volume Control: All outputs.
- 2.13.5.** Activation-Switch Network: Establishes priority and hierarchy of output signals produced by different activation setups.
- 2.13.6.** Mounting: Rack.

2.14. MONITOR PANEL

- 2.14.1.** Monitor power amplifiers.
- 2.14.2.** Components: VU or dB meter, speaker with volume control, and multiple-position rotary selector switch.
- 2.14.3.** Selector Switch and Volume Control: Selective monitoring of output of each separate power amplifier via VU or dB meter and speaker.
- 2.14.4.** Mounting: Rack.

2.15. LOUDSPEAKERS

- 2.15.1.** Cone-Type Loudspeakers:
 - 2.15.1.1.** Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
 - 2.15.1.2.** Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
 - 2.15.1.3.** Size: 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet.
 - 2.15.1.4.** Minimum Dispersion Angle: 100 degrees.
 - 2.15.1.5.** Rated Output Level: 10 W.
 - 2.15.1.6.** Matching Transformer: Full-power rated with four taps. Maximum insertion loss of 0.5 dB.
 - 2.15.1.7.** Surface-Mounting Units: Ceiling, wall, or pendant mounting, as indicated, in steel back boxes, acoustically dampened. Front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and shop primed for field painting.

2.15.1.8. Flush-Ceiling-Mounting Units: In steel back boxes, acoustically dampened. Metal ceiling grille with white baked enamel.

2.15.2. Horn-Type Loudspeakers:

2.15.2.1. Type: Single-horn units, double-reentrant design, with minimum full-range power rating of 15 W.

2.15.2.2. Matching Transformer: Full-power rated with four standard taps. Maximum insertion loss of 0.5 dB.

2.15.2.3. Frequency Response: Within plus or minus 3 dB from 250 to 12,000 Hz.

2.15.2.4. Dispersion Angle: 130 by 110 degrees.

2.15.2.5. Mounting: Integral bracket.

2.15.2.6. Units in Hazardous (Classified) Locations: Listed and labeled for environment in which they are located.

2.16. NOISE-OPERATED GAIN CONTROLLER

2.16.1. Gain controller shall be designed to continuously sense space noise level and automatically adjust signal level to local speakers.

2.16.2. Frequency Response: 20 to 20,000 Hz, plus or minus 1 dB.

2.16.3. Level Adjustment Range: 20 dB minimum.

2.16.4. Maximum Distortion: 1 percent.

2.16.5. Control: Permits adjustment of sensing level of device.

2.17. OUTLETS

2.17.1. Volume Attenuator Station: Wall-plate-mounted autotransformer type with paging priority feature.

2.17.1.1. Wattage Rating: 10 W unless otherwise indicated.

2.17.1.2. Attenuation per Step: 3 dB, with positive off position.

2.17.1.3. Insertion Loss: 0.4 dB maximum.

2.17.1.4. Attenuation Bypass Relay: Single pole, double throw. Connected to operate and bypass attenuation when all-call, paging, program signal, or prerecorded message features are used. Relay returns to normal position at end of priority transmission.

2.17.1.5. Label: "PA Volume."

2.17.2. Microphone Outlet: Three-pole, polarized, locking-type, microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed outlet covers.

2.17.3. Headphone Outlet (for the Hearing Impaired): Microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed-outlet covers.

2.18. BATTERY BACKUP POWER UNIT

2.18.1. Unit shall be rack mounted, consisting of time-delay relay, sealed lead-calcium battery, battery charger, on-off switch, "normal" and "emergency" indicating lights, and adequate capacity to supply maximum equipment power requirements for one hour of continuous full operation.

2.18.2. Unit shall supply public address equipment with 12- to 15-V dc power automatically during an outage of normal 120-V ac power.

2.18.3. Battery shall be on float charge when not supplying system and to transfer automatically to supply system after three to five seconds of continuous outage of normal power, as sensed by time-delay relay.

2.18.4. Unit shall automatically retransfer system to normal supply when normal power has been reestablished for three to five seconds continuously.

2.19. CONDUCTORS AND CABLES

2.19.1. Jacketed, twisted pair and twisted multipair, untinned solid copper.

2.19.1.1. Insulation for Wire in Conduit: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.

2.19.1.2. Microphone Cables: Neoprene jacketed, not less than 2/64 inch (0.8 mm) thick, over shield with filled interstices. Shield No. 34 AWG, tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.

2.19.1.3. Plenum Cable: Listed and labeled for plenum installation.

2.20. RACEWAYS

2.20.1. Conduit and Boxes: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems."

2.20.1.1. Outlet boxes shall be not less than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

3. PART 3- EXECUTION

3.1. WIRING METHODS

3.1.1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

3.1.1.1. Install plenum cable in environmental air spaces, including plenum ceilings.

3.1.1.2. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway and Boxes for Electrical Systems."

3.1.2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.1.3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2. INSTALLATION OF RACEWAYS

3.2.1. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

3.2.2. Install manufactured conduit sweeps and long-radius elbows whenever possible.

3.3. INSTALLATION OF CABLES

3.3.1. Comply with NECA 1.

3.3.2. General Cable Installation Requirements:

3.3.2.1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.

- 3.3.2.2.** Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
- 3.3.2.3.** Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- 3.3.2.4.** Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- 3.3.2.5.** Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
- 3.3.2.6.** Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used.
- 3.3.3.** Open-Cable Installation:
 - 3.3.3.1.** Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - 3.3.3.2.** Suspend speaker cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
 - 3.3.3.3.** Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.
- 3.3.4.** Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

3.4. INSTALLATION

- 3.4.1.** Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

3.4.2. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.

3.4.3. Equipment Cabinets and Racks:

3.4.3.1. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.

3.4.3.2. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.

3.4.3.3. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.

3.4.4. Volume Limiter/Compressor: Equip each zone with a volume limiter/compressor. Install in central equipment cabinet. Arrange to provide a constant input to power amplifiers.

3.4.5. Wall-Mounted Outlets: Flush mounted.

3.4.6. Floor-Mounted Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.

3.4.7. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.

3.4.8. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

3.4.9. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.

3.4.10. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5. GROUNDING

3.5.1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

3.5.2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

- 3.5.3.** Install grounding electrodes as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.6. FIELD QUALITY CONTROL

- 3.6.1.** Testing Agency: Engage a qualified testing agency to perform tests and inspections.

- 3.6.2.** Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

- 3.6.3.** Perform tests and inspections.

- 3.6.3.1.** Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

- 3.6.4.** Tests and Inspections:

- 3.6.4.1.** Schedule tests with at least seven days' advance notice of test performance.

- 3.6.4.2.** After installing public address and mass notification systems and after electrical circuitry has been energized, test for compliance with requirements.

- 3.6.4.3.** Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.

- 3.6.4.4.** Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

- 3.6.4.4.1.** Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.

- 3.6.4.4.2.** Repeat test for each separately controlled zone of loudspeakers.

- 3.6.4.4.3.** Minimum acceptance ratio is 50 dB.

- 3.6.4.5.** Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
- 3.6.4.6.** Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
- 3.6.4.7.** Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
- 3.6.4.8.** Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Comply with testing requirements specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
- 3.6.5.** Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.
- 3.6.6.** Public address and mass notification systems will be considered defective if they do not pass tests and inspections.
- 3.6.7.** Prepare test and inspection reports.
 - 3.6.7.1.** Include a record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

3.7. STARTUP SERVICE

- 3.7.1.** Engage a factory-authorized service representative to perform startup service.
 - 3.7.1.1.** Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.

- 3.7.1.2. Complete installation and startup checks according to manufacturer's written instructions.

3.8. ADJUSTING

- 3.8.1. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
- 3.8.2. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two] visits to Project during other-than-normal occupancy hours for this purpose.

3.9. DEMONSTRATION

- 3.9.1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the public address and mass notification systems and equipment.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section specifies a master clock and program control system including the following components:
 - 1.2.1.1.** Master clock and program control unit.
 - 1.2.1.2.** Secondary indicating clocks.
 - 1.2.1.3.** Program signal devices.
 - 1.2.1.4.** Clock circuit power boosters.
 - 1.2.1.5.** Interface with public-address system.
 - 1.2.1.6.** System wire and cable.

1.3. DEFINITIONS

- 1.3.1.** GPS: Global Positioning System .
- 1.3.2.** NIST: National Institute of Science and Technology.
- 1.3.3.** PC: Personal computer.
- 1.3.4.** UTC: Universal time coordinated. The precisely measured time at zero degrees longitude; used as a worldwide standard for time synchronization.

1.4. SYSTEM DESCRIPTION

- 1.4.1.** System shall perform the following functions:
 - 1.4.1.1.** Supply power to remote indicating clocks.
 - 1.4.1.2.** Maintain correct synchronized time and transmit time-correction signals over dedicated system wiring from a master clock to any one type(s) of secondary indicating clocks, including the following:

- 1.4.1.2.1. Analog Synchronous Clocks: Correct for minute- and second-hand synchronization at least once each hour and for hour-hand synchronization at least once each day.
- 1.4.1.2.2. Access to review existing programs only.
- 1.4.1.2.3. Access to normal system operating controls.
- 1.4.1.2.4. Access to all user-programming and control functions.
- 1.4.1.3. Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator.
- 1.4.1.4. Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator, and automated periodic reference to NIST or UTC time signals via internal modem and network or microcomputer internet access. Reference time signals shall be automatically accessed at programmable intervals.
- 1.4.1.5. System shall be capable of programming multiple independent event schedules into memory and running them simultaneously for different output circuits.
 - 1.4.1.5.1. Quantity of Programmable Schedules: Four minimum.
 - 1.4.1.5.2. Number of Weekly Events That Can Be Programmed for Each Schedule: 128 minimum.
 - 1.4.1.5.3. Simultaneous operation of independent schedules shall be limited only by the number of signal-device and equipment-switching output circuits.
 - 1.4.1.5.4. Advance Programming for Automatic Holiday Schedule Changes: Number of schedule changes that can be programmed to suit holidays and vacations shall be 16, and each change may be programmed up to a year in advance to occur on any day of the calendar year.

- 1.4.1.6. System and Equipment Diagnostics: An integral program shall automatically check functioning of LEDs, switches, input keys, central processor, read-only memory, random access memory, and output circuits. A display on the control panel shall indicate failure by identifying faulty component or circuit and shall recommend corrective action.
- 1.4.1.7. Daylight Savings Time Correction: Manually initiated.
- 1.4.1.8. Adjustments to Master Clock Output Signals: Duration of momentary signal shall be individually programmable for each signal and equipment-control output circuit from 1 to 99 seconds. Signals shall be programmable for either on or off switching to suit equipment-operation scheduling.

1.5. SUBMITTALS

- 1.5.1. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes (including available colors) for each product indicated and describe features and operating sequences, both automatic and manual, for the following:
 - 1.5.1.1. Master unit.
 - 1.5.1.2. Indicating clocks.
 - 1.5.1.3. Signal equipment.
 - 1.5.1.4. Equipment enclosures and back boxes.
 - 1.5.1.5. Accessory components.
- 1.5.2. Shop Drawings:
 - 1.5.2.1. Wiring diagrams to detail power, signal, control, and correction circuits. Identify terminals and wiring color-codes to facilitate installation, operation, and maintenance. Indicate recommended wire types and sizes, and circuiting arrangements for field-installed system wiring. Show protection from over current, static discharge, and voltage surge.
 - 1.5.2.2. Details of seismic restraints including mounting, anchoring, and fastening devices for the following system components:
 - 1.5.2.2.1. Surface-mounted and semi-recessed secondary indicating clocks.

- 1.5.2.2.2. Master clock enclosures.
 - 1.5.2.2.3. Clock circuit power boosters.
 - 1.5.2.3. Details of seismic strengthening of master clock enclosures.
 - 1.5.2.4. Dimensioned Outline Drawings of Mounting Rack for Master Clock: Show internal seismic bracing, and locate center of gravity of fully equipped and assembled unit. Locate and describe mounting and anchorage provisions.
 - 1.5.3. Samples for Initial Selection: Include the following:
 - 1.5.3.1. Manufacturer's color photographs or color chips showing the full range of colors available for clocks, signal equipment, and control panels.
 - 1.5.3.2. Representative operating models of clock type
 - 1.5.4. Manufacturer Seismic Qualification Certification: Submit certification that master clock system components and their mounting and anchorage provisions are designed to remain in place without separation of any parts when subjected to the seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:
 - 1.5.4.1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.
 - 1.5.4.2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - 1.5.5. Qualification Data: For Installer and manufacturer.
 - 1.5.6. Field quality-control test reports.
 - 1.5.7. Operation and Maintenance Data: For clock and program control to include in emergency, operation, and maintenance manuals.
 - 1.6. QUALITY ASSURANCE
 - 1.6.1. Installer Qualifications: Master clock manufacturer's authorized representative who is trained and approved for installation and maintenance of units required for this Project.

- 1.6.2.** Manufacturer Qualifications: A qualified manufacturer. Maintain, within 2 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- 1.6.3.** Source Limitations: Obtain master and secondary clocks and signal-device-control components through one source from a single manufacturer.
- 1.6.4.** Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- 1.6.5.** Comply with NFPA 70 for components and installation.

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

- 2.1.1.** Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2.1.2.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.1.2.1.** Rauland-Borg Corporation.
 - 2.1.2.2.** Or approved equal by School District.

2.2. MASTER CLOCK

- 2.2.1.** Description: Microprocessor-based, software-controlled unit complying with Class A device requirements in 47 CFR 15, and having the following components and features:
 - 2.2.1.1.** Programming and control switches.
 - 2.2.1.2.** Informational Display: LED or backlit LCD type.
 - 2.2.1.2.1.** Normally shows current time, date, and day of week display.
 - 2.2.1.2.2.** Provides programming cues when system is being programmed.
 - 2.2.1.3.** Output Circuits for Power and Correction of Secondary Indicating Clocks:

- 2.2.1.3.1. Wired Synchronous Clock Power and Correction Circuits: For analog clocks; minimum of one required. Relay controlled.
 - 2.2.1.3.2. Wired Synchronous Digital Clock Power and Correction Circuits: One required.
 - 2.2.1.4. Data Output Port for Digital Secondary Clock Correction Circuit: RS485 or similar circuit for scheduled periodic correction signals.
 - 2.2.1.5. Modem and PC interface software suitable for automatic NIST or UTC synchronization.
 - 2.2.1.6. RS232 data communications port.
 - 2.2.1.7. Circuits for audible and Visual signal devices: Relay controlled, manually switchable, using controls on master clock. Rated 120-V ac, 5A minimum. A minimum of four circuits.
 - 2.2.1.8. Circuits for Programmable Switching of Remote Equipment and Circuits: Relay controlled, manually switchable, using controls on master clock. Rated 120-V ac, 5A minimum. A minimum of four circuits.
 - 2.2.1.9. Power Supplies: Capacity for internal loads and power and correction circuits of connected clocks.
 - 2.2.1.10. Enclosure: Metal cabinet with locking front panel. When cabinet is locked, display indication shall be visible on or through front panel face. Arrange cabinet for surface, semi-recessed, or flush mounting as indicated.
 - 2.2.1.11. Housing: Rack-mounting metal enclosure with display indication visible on front panel face.
 - 2.2.1.11.1. Reinforce mounting and attachment capable of resisting seismic forces described in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
 - 2.2.1.12. Battery Backup for Time Base: Lithium battery to maintain the timekeeping function and retain the programs in memory during outage of normal ac power supply for up to 10 years.

- 2.2.1.13.** Electrostatic Discharge Resistance: Master clock shall be tested and certified according to IEC 61000-4-2 in both human discharge and direct injection modes.

2.3. SECONDARY INDICATING CLOCKS, GENERAL

- 2.3.1.** Analog Clock: Equipped with a sweep second hand. Movement shall be driven by self-starting, permanently lubricated, sealed synchronous motor equipped with a correcting solenoid actuator, or be a microprocessor-based, second impulse unit, compatible with the master clock.
- 2.3.2.** Digital Clock: Microprocessor-controlled unit complying with Class A device requirements in 47 CFR 15, with red LED digital time display of hours, minutes and seconds.
- 2.3.2.1.** Display Height: 2.5-Inch (64-mm) Clock: Hour and minute numerals readable at 50 feet (15 m).
- 2.3.2.2.** Display Height: 4-Inch (102-mm) Clock: Hour and minute numerals readable at 100 feet (30 m).
- 2.3.2.3.** Display Format: Selectable between 12-hour with "PM" LED display and 24-hour formats.
- 2.3.2.4.** Connections for Power and Correction:
- 2.3.2.4.1.** Wired synchronous connection to master clock for both operating power and correction.
- 2.3.2.4.1.1.** Time-Base Backup: Internal alkaline battery shall back up internal time base to maintain timekeeping during outages of up to six days' duration.
- 2.3.2.4.1.2.** Time-Base Backup: Internal capacitor shall back up internal time base to maintain timekeeping during outages of up to 12 hours' duration.
- 2.3.2.4.2.** Correction by RS485 or similar data line, with operating power supplied over a separate connection.
- 2.3.3.** Connection Provision for Secondary Indicating Clocks: Plug connector.

- 2.3.4.** Provision for Modular Panel Installation: Equip designated clock for panel mounting. Mount flush or semi-recessed with arrangement and trim as indicated. Coordinate wiring with other modular panel components, including room lighting switches, intercom devices, convenience outlets, speaker and other similar devices.
- 2.3.5.** Provision for Time-Tone-Unit Installation: Equip indicated clocks for housing or mounting in an acoustically treated and baffled speaker compartment specified in Division 27 Section "Public Address and Mass Notification Systems."

2.4. DETAILED REQUIREMENTS FOR SECONDARY INDICATING CLOCKS

2.4.1. Clock Type: Analog.

- 2.4.1.1. Products:**
- 2.4.1.2. Face Configuration: Single face.**
- 2.4.1.3. Mounting: Recessed.**
- 2.4.1.4. Nominal Dimensions: 12" diameter.**
- 2.4.1.5. External Finish: Per Architect.**
- 2.4.1.6. Trim and Hardware: Per Architect.**
- 2.4.1.7. Crystal: Clear glass.**

2.4.2. Interval-Timer Clock: Digital microprocessor-controlled, 4-inch (102-mm) unit with 2.5-inch (64-mm), red LED digital display for hours and minutes and 1.3-inch (33-mm) display for seconds; a separately mounted, mode-control switch; and the following features:

- 2.4.2.1. Display Visibility: Hour and minute numerals readable at 30 feet in normal ambient light.**
- 2.4.2.2. Operating Modes:**
 - 2.4.2.2.1. Normal: Clock operates as a regular secondary system clock, displaying corrected time in normal display configuration, selectable between 12- and 24-hour formats, with "PM" LED display for 12-hour format.**

- 2.4.2.2.2.** Count-Down or Count-Up Timer: Selected by mode control switch count-up and count-down positions, and capable of being preset at the mode control station.
- 2.4.2.2.3.** Code Blue: Automatically selected by a signal through a wiring connection from the code-blue system. This signal captures control of the clock regardless of current mode or correction status and instantly initiates count-up operation, starting at time 00:00:00. While in this mode, other clock functions, including correction, shall run in the background. The clock shall revert to normal operating mode when the initiating signal system is reset.
- 2.4.2.3.** Mode Selector Switch: Pushbutton or rotary, multi-position type, flush mounted; with start, stop, and reset capability in both count-up and count-down modes.
- 2.4.2.4.** Audible tone signal: Housed in clock or mode-selector-switch box. Sounds at end of preset up or down count.

2.5. PROGRAM SIGNAL DEVICES

- 2.5.1.** Bells: Heavy-duty, modular, vibrating type with the following sound output ratings measured at 10 feet (3 m):
 - 2.5.1.1.** 4-Inch (100-mm) Bell: 90 dB.
 - 2.5.1.2.** 6-Inch (150-mm) Bell: 95 dB.
 - 2.5.1.3.** 10-Inch (250-mm) Bell: 104 dB.
- 2.5.2.** Chimes: Heavy-duty, modular, vibrating chimes with polished-chrome tone bar and enamel-finished housing. Minimum sound output rating measured at 10 feet (3 m) shall be 75 dB.
- 2.5.3.** Clock Buzzers: Adjustable output signal device designed for mounting within clock housing or outlet box.
 - 2.5.3.1.** Sound Output Rating Measured at 3 Feet (1 m): 75 dB.
 - 2.5.3.2.** Audible Tone Frequency: Manufacturer's standard between 120 Hz and 2 kHz.
- 2.5.4.** Horns: Modular, adjustable-output, vibrating type with minimum full-intensity-rated sound output of 103 dB measured at 10 feet (3 m).

- 2.5.5.** Projector Horns: Adjustable-output, vibrating-type units with single projector arranged to channel the sound in the direction of the projector axis, and with minimum full-intensity-rated sound output of 104 dB measured at 10 feet (3 m).
- 2.5.6.** Loudspeakers for Audible Tones: Refer to Division 27 Section "Public Address and Mass Notification Systems."
- 2.5.7.** Visible Signal Devices: Strobe lights with blue polycarbonate lens and xenon flash tube with lens mounted on an aluminum faceplate and the word "Program" engraved in letters at least 1 inch (25 mm) high on lens. Lamp unit shall have a minimum rated light output of 75 candela.
- 2.5.8.** Combination Audible and Visible Signal Devices: Factory-integrated horn and strobe light in a single mounting assembly.
- 2.5.9.** Outdoor Signal Equipment: Weatherproof models listed for outdoor use.
- 2.5.10.** Mounting Arrangement for Signal Devices: Designed for attachment with screws on the mounting plate of a flush-mounted back box, unless otherwise indicated.
- 2.5.11.** Enclosures for Flush-Mounting Bells and Horns: Enclosure, mounting plate, and grille assembly shall be furnished by device manufacturer to match features of the device to be mounted. Enclosure shall be recessed in wall, completely enclosing the device, with the grille mounting over the open side of the enclosure and flush with the wall.
- 2.5.12.** Connection Provision for Signal Indicating Devices: Plug connector.
- 2.6.** CLOCK CIRCUIT POWER BOOSTER

 - 2.6.1.** Description: Transformer power supply, mounted in steel cabinet with hinged door, and having fuse-protected input and output circuits.
- 2.7.** BACK BOXES FOR SECONDARY INDICATING CLOCKS AND PROGRAM DEVICES

 - 2.7.1.** Description: Box and coverplate assembly shall be furnished by device manufacturer and be suitable for device to be mounted. Back boxes shall be equipped with knockouts and hanger straps or mounting adapters arranged for flush mounting device, unless otherwise indicated.

2.8. GUARDS

- 2.8.1.** Description: Formed-steel wire, shaped to fit around guarded device, with 1-inch (25-mm) maximum clearance.
 - 2.8.1.1.** Mounting Provisions: Fixed tabs, welded to guard and arranged for screw attachment to mounting surface.
 - 2.8.1.2.** Finish for Indoor Devices: Clear epoxy lacquer over zinc plating.
 - 2.8.1.3.** Finish for Outdoor Devices: Black powder coat over zinc plating and primer.

2.9. RACK-MOUNTING PROVISION FOR MASTER CLOCK

- 2.9.1.** Equipment Cabinet: Rack type, floor mounting. Comply with EIA-310-D and the following:
 - 2.9.1.1.** Cabinet Housing: Construct of 0.0478-inch (1.2-mm) steel, minimum, with front doors with manufacturer's standard tumbler locks, keyed alike.
 - 2.9.1.1.1.** Front door shall have a clear panel in front of the master clock display.
 - 2.9.1.1.2.** Housing shall enclose master clock and auxiliary clock system components, plus a minimum of 20 percent spare capacity for future equipment.
 - 2.9.1.2.** Forced Ventilation: Internal low-noise fan with a filtered intake vent. Connect fan to operate from 105- to 130-V ac, 60 Hz; separately fused and switchable and arranged to be powered when main cabinet power switch is on.
 - 2.9.1.3.** Natural Ventilation: Ventilated rear and sides with louvers and solid top.
 - 2.9.1.4.** Arrange inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
 - 2.9.1.5.** Service Light: At top rear of rack and controlled by an adjacent switch.
 - 2.9.1.6.** Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by equipment or panels.

- 2.9.1.7.** Finish: Uniform, baked-enamel, manufacturer's standard color finish over rust-inhibiting primer.
- 2.9.1.8.** Power-Control Panel: On front of equipment housing; with master power on-off switch and pilot light, and socket for a 5-A, indicating, cartridge fuse for rack equipment power.
- 2.9.1.9.** Vertical Plug Strip: Grounded receptacles, 12 inches (300 mm) o.c. the full height of rack, to supply rack-mounting equipment.
- 2.9.1.10.** Maintenance Receptacles: Duplex convenience outlet with supply terminals separate from equipment plug strip and located in front of rack.

2.10. WIRE AND CABLE

- 2.10.1.** Conductors: Insulated copper, with minimum sizes as recommended by the connected device manufacturer. Voltage drop for signal, control, and clock correction circuits shall not exceed 10 percent under peak load conditions.
- 2.10.2.** 120-V ac and Class 1 Signal and Control Circuits: Stranded single conductors of size recommended by system manufacturer. Materials and installation requirements are specified in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- 2.10.3.** Classes 2 and 3 Signal and Control Circuits: Single conductor or twisted-pair cable, unshielded, unless manufacturer recommends shielded cable.
- 2.10.4.** Data Circuits: Category 3 minimum, unshielded, twisted-pair cable, unless manufacturer recommends shielded cable.
- 2.10.5.** Plenum Cable: Listed and labeled for use in air-handling spaces, plenums, and plenum ceilings.
- 2.10.6.** Conductor Color-Coding: Uniformly identified and coordinated with wiring diagrams.

3. PART 3 - EXECUTION

3.1. INSTALLATION

- 3.1.1.** Mount system components with fastening methods and devices designed to resist the seismic forces indicated in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

- 3.1.2.** Wiring: Install 60-Hz wiring according to NFPA 70. Install data cable complying with TIA/EIA-568-A. Install number of conductors recommended by system manufacturer for functions indicated, and as follows:
 - 3.1.2.1.** Conceal wiring except in unfinished spaces.
 - 3.1.2.2.** Wiring Method: Install wiring in raceways.
 - 3.1.2.3.** Wiring Method: Install wiring in raceways except for Classes 2 and 3 remote-control and signaling circuits, as defined in NFPA 70, if installed in accessible ceiling spaces and hollow gypsum-board partitions, where unenclosed wiring method may be used. Install listed plenum cable for Classes 2 and 3 wiring in environmental air spaces, including plenum ceilings.
 - 3.1.2.4.** Wiring Method: Install metal-clad cable except for Classes 2 and 3 remote-control and signaling circuits, as defined in NFPA 70, if installed in accessible ceiling spaces and hollow gypsum-board partitions, where unenclosed wiring method may be used. Install listed plenum cable for Classes 2 and 3 wiring in environmental air spaces, including plenum ceilings.
- 3.1.3.** Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess; use lacing bars and distribution spools.

3.2. ELECTRICAL CONNECTIONS

- 3.2.1.** Make splices, taps, and terminations on numbered terminal strips in junction, pull and outlet boxes, terminal cabinets, and equipment enclosures.
- 3.2.2.** Use plug connectors for connections to clocks and signal devices.
- 3.2.3.** Ground clocks, programming equipment, and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

3.3. IDENTIFICATION

- 3.3.1.** Comply with Division 26 Section "Identification for Electrical Systems."
- 3.3.2.** Color-code wire and apply wire and cable marking tape to designate wires and cables so they are uniformly identified and coordinated with wiring diagrams throughout the system.

3.4. FIELD QUALITY CONTROL

- 3.4.1.** Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections and to assist in programming. Report results in writing.
- 3.4.2.** Perform the following field adjustments, tests, and inspections and prepare test reports:
 - 3.4.2.1.** Perform operational-system tests to verify compliance with the Specifications and make adjustments to bring system into compliance. Include operation of all modes of clock correction and all programming and manually programmed signal and relay operating functions.
 - 3.4.2.2.** Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
- 3.4.3.** Remove and replace malfunctioning units and retest as specified above.

3.5. PROGRAMMING AND ADJUSTMENTS

- 3.5.1.** Program system according to Owner's requirements. Set system so signal devices operate on Owner-required schedules and are activated for durations selected by Owner. Program equipment-control output circuits to suit Owner's operating schedule for equipment controlled.
- 3.5.2.** Adjust sound-output level of adjustable signal devices to suit Owner's requirements.
- 3.5.3.** Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance for adjusting and reprogramming system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

3.6. DEMONSTRATION

- 3.6.1.** Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain clock-and-program-control system components. Refer to Division 01 Section "Demonstration and Training"

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

1.2.1. Section Includes:

- 1.2.1.1. UTP cabling.
- 1.2.1.2. 62.5/125-micrometer, multimode optical fiber cabling.
- 1.2.1.3. Coaxial cabling.
- 1.2.1.4. RS-232 cabling.
- 1.2.1.5. RS-485 cabling.
- 1.2.1.6. Low-voltage control cabling.
- 1.2.1.7. Control-circuit conductors.
- 1.2.1.8. Fire alarm wire and cable.
- 1.2.1.9. Identification products.

1.3. DEFINITIONS

- 1.3.1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
- 1.3.2. BICSI: Building Industry Consulting Service International.
- 1.3.3. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel section.
- 1.3.4. EMI: Electromagnetic interference.
- 1.3.5. IDC: Insulation displacement connector.
- 1.3.6. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
- 1.3.7. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

- 1.3.8.** Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- 1.3.9.** RCDD: Registered Communications Distribution Designer.
- 1.3.10.** Solid-Bottom or Non-ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal side rails, and a bottom without ventilation openings.
- 1.3.11.** Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.
- 1.3.12.** UTP: Unshielded twisted pair.

1.4. SUBMITTALS

- 1.4.1.** Product Data: For each type of product indicated.
 - 1.4.1.1.** For coaxial cable, include the following installation data for each type used:
 - 1.4.1.1.1.** Nominal OD.
 - 1.4.1.1.2.** Minimum bending radius.
 - 1.4.1.1.3.** Maximum pulling tension.
- 1.4.2.** Shop Drawings: Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - 1.4.2.1.** Vertical and horizontal offsets and transitions.
 - 1.4.2.2.** Clearances for access above and to side of cable trays.
 - 1.4.2.3.** Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - 1.4.2.4.** Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.
- 1.4.3.** Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- 1.4.4.** Source quality-control reports.

1.4.5. Field quality-control reports.

1.4.6. Maintenance Data: For wire and cable to include in maintenance manuals.

1.5. QUALITY ASSURANCE

1.5.1. Testing Agency Qualifications: An NRTL.

1.5.1.1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.5.2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1.5.2.1. Flame-Spread Index: 25 or less.

1.5.2.2. Smoke-Developed Index: 50 or less.

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

1.6. DELIVERY, STORAGE, AND HANDLING

1.6.1. Test cables upon receipt at Project site.

1.6.1.1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical-fiber flashlight.

1.6.1.2. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.

1.6.1.3. Test each pair of UTP cable for open and short circuits.

1.7. PROJECT CONDITIONS

1.7.1. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. PART 2 - PRODUCTS

2.1. PATHWAYS

2.1.1. Support of Open Cabling: NRTL labeled for support of Category 5e cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

2.1.1.1. Support brackets with cable tie slots for fastening cable ties to brackets.

2.1.1.2. Lacing bars, spools, J-hooks, and D-rings.

2.1.1.3. Straps and other devices.

2.1.2. Cable Trays:

2.1.2.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.1.2.1.1. Cable Management Solutions, Inc.

2.1.2.1.2. Cablofil Inc.

2.1.2.1.3. Cooper B-Line, Inc.

2.1.2.2. Cable Tray Materials: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick.

2.1.2.2.1. Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).

2.1.2.2.2. Trough Cable Trays: Nominally 6 inches (150 mm) wide.

2.1.2.2.3. Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).

2.1.2.2.4. Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.

2.1.2.2.5. Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with solid covers.

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2.1.3. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems."

2.1.3.1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.2. BACKBOARDS

2.2.1. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry".

2.3. UTP CABLE

2.3.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.3.1.1. Belden CDT Inc.; Electronics Division.

2.3.1.2. Berk-Tek; a Nexans company.

2.3.1.3. CommScope, Inc.

2.3.1.4. Nordex/CDT; a subsidiary of Cable Design Technologies.

2.3.1.5. Superior Essex Inc.

2.3.1.6. 3M.

2.3.2. Description: 100-ohm, 4-pair UTP, formed into 25-pair binder groups covered with a blue thermoplastic jacket.

2.3.2.1. Comply with ICEA S-90-661 for mechanical properties.

2.3.2.2. Comply with TIA/EIA-568-B.1 for performance specifications.

2.3.2.3. Comply with TIA/EIA-568-B.2, Category 5e.

2.3.2.4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

2.3.2.4.1. Communications, General Purpose: Type CM or CMG.

2.3.2.4.2. Communications, Plenum Rated: Type CMP, complying with NFPA 262.

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- 2.3.2.4.3.** Communications, Riser Rated: Type CMR, complying with UL 1666.
- 2.3.2.4.4.** Communications, Limited Purpose: Type CMX.
- 2.3.2.4.5.** Multipurpose: Type MP or MPG.
- 2.3.2.4.6.** Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
- 2.3.2.4.7.** Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

2.4. UTP CABLE HARDWARE

- 2.4.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.4.1.1.** American Technology Systems Industries, Inc.
 - 2.4.1.2.** Dynacom Corporation.
 - 2.4.1.3.** Hubbell Premise Wiring.
 - 2.4.1.4.** Nordex/CDT; a subsidiary of Cable Design Technologies.
 - 2.4.1.5.** Panduit Corp.
- 2.4.2.** UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
- 2.4.3.** Connecting Blocks: 110-style for Category 5e. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

2.5. OPTICAL FIBER CABLE

- 2.5.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.5.1.1.** Berk-Tek; a Nexans company.
 - 2.5.1.2.** CommScope, Inc.
 - 2.5.1.3.** General Cable Technologies Corporation.

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- #### 2.5.1.4. Superior Essex Inc.

- 2.5.1.5. 3M.**

- 2.5.2.** Description: Multimode, 62.5/125-micrometer, 12-fiber, tight buffer, optical fiber cable.

- 2.5.2.1.** Comply with ICEA S-83-596 for mechanical properties.

- 2.5.2.2.** Comply with TIA/EIA-568-B.3 for performance specifications.

- 2.5.2.3.** Comply with TIA/EIA-492AAAA-B for detailed specifications.

- 2.5.2.4.** Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

- 2.5.2.4.1.** General Purpose, Nonconductive: Type OFN or OFNG.

- 2.5.2.4.2.** Plenum Rated, Nonconductive: Type
OFNP, complying with NFPA 262.

- 2.5.2.4.3.** Riser Rated, Nonconductive: Type OFNR, complying with LIL 1666.

- 2.5.2.4.4.** General Purpose, Conductive: Type OFC or OFCG.

- 2.5.2.4.5.** Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.

- 2.5.2.4.6.** Riser Rated, Conductive: Type OFCR, complying with UL 1666.

- 2.5.2.5.** Conductive cable shall be steel armored type.

- 2.5.2.6. Maximum Attenuation:** 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

- 2.5.2.7. Minimum Modal Bandwidth:** 160 MHz-km at 850 nm;
500 MHz-km at 1300 nm.

- ### 2.5.3. Jacket:

- 2.5.3.1. Jacket Color:** Orange for 62.5/125-micrometer cable.

- 2.5.3.2.** Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.

- 2.5.3.3.** Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

2.6. OPTICAL FIBER CABLE HARDWARE

- 2.6.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 2.6.1.1.** American Technology Systems Industries, Inc.

- 2.6.1.2.** Berk-Tek; a Nexans company.

- 2.6.1.3.** Corning Cable Systems.

- 2.6.1.4.** Dynacom Corporation.

- 2.6.2.** Cable Connecting Hardware: Meet the Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.

- 2.6.2.1.** Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.

- 2.6.2.2.** Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.7. COAXIAL CABLE

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

- 2.7.1.1.** Alpha Wire Company.

- 2.7.1.2.** Belden CDT Inc.; Electronics Division.

- 2.7.1.3.** Coleman Cable, Inc.

- 2.7.1.4.** CommScope, Inc.

- 2.7.1.5.** Draka USA.

- 2.7.2.** General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

- 2.7.3.** RG-11/U: NFPA 70, Type CATV.
 - 2.7.3.1.** No. 14 AWG, solid, copper-covered steel conductor.
 - 2.7.3.2.** Gas-injected, foam-PE insulation.
 - 2.7.3.3.** Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
 - 2.7.3.4.** Jacketed with sunlight-resistant, black PVC or PE.
 - 2.7.3.5.** Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
- 2.7.4.** RG59/U: NFPA 70, Type CATVR.
 - 2.7.4.1.** No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
 - 2.7.4.2.** Gas-injected, foam-PE insulation.
 - 2.7.4.3.** Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
 - 2.7.4.4.** Color-coded PVC jacket.
- 2.7.5.** RG-6/U: NFPA 70, Type CATV or CM.
 - 2.7.5.1.** No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
 - 2.7.5.2.** Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
 - 2.7.5.3.** Jacketed with black PVC or PE.
 - 2.7.5.4.** Suitable for indoor installations.
- 2.7.6.** RG59/U: NFPA 70, Type CATV.
 - 2.7.6.1.** No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
 - 2.7.6.2.** Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
 - 2.7.6.3.** PVC jacket.
- 2.7.7.** RG59/U (Plenum Rated): NFPA 70, Type CMP.

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2.9.1.5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

2.9.1.6. Flame Resistance: Comply with UL 1581.

2.9.2. Plenum-Rated Cable: NFPA 70, Type CMP.

2.9.2.1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.

2.9.2.2. Plastic insulation.

2.9.2.3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.

2.9.2.4. Plastic jacket.

2.9.2.5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

2.9.2.6. Flame Resistance: Comply with NFPA 262.

2.10. RS-485 CABLE

2.10.1. Standard Cable: NFPA 70, Type CM.

2.10.1.1. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.

2.10.1.2. PVC insulation.

2.10.1.3. Unshielded.

2.10.1.4. PVC jacket.

2.10.1.5. Flame Resistance: Comply with UL 1581.

2.10.2. Plenum-Rated Cable: NFPA 70, Type CMP.

2.10.2.1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.

2.10.2.2. Fluorinated ethylene propylene insulation.

2.10.2.3. Unshielded.

2.10.2.4. Fluorinated ethylene propylene jacket.

2.10.2.5. Flame Resistance: NFPA 262, Flame Test.

2.11. LOW-VOLTAGE CONTROL CABLE

2.11.1. Paired Lock Cable: NFPA 70, Type CMG.

2.11.1.1. 1 pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors.

2.11.1.2. PVC insulation.

2.11.1.3. Unshielded.

2.11.1.4. PVC jacket.

2.11.1.5. Flame Resistance: Comply with UL 1581.

2.11.2. Plenum-Rated, Paired Lock Cable: NFPA 70, Type CMP.

2.11.2.1. 1 pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors.

2.11.2.2. PVC insulation.

2.11.2.3. Unshielded.

2.11.2.4. PVC jacket.

2.11.2.5. Flame Resistance: Comply with NFPA 262.

2.11.3. Paired Lock Cable: NFPA 70, Type CMG.

2.11.3.1. 1 pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors.

2.11.3.2. PVC insulation.

2.11.3.3. Unshielded.

2.11.3.4. PVC jacket.

2.11.3.5. Flame Resistance: Comply with UL 1581.

2.11.4. Plenum-Rated, Paired Lock Cable: NFPA 70, Type CMP.

2.11.4.1. 1 pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors.

2.11.4.2. Fluorinated ethylene propylene insulation.

2.11.4.3. Unshielded.

2.11.4.4. Plastic jacket.

2.11.4.5. Flame Resistance: NFPA 262, Flame Test.

2.12. CONTROL-CIRCUIT CONDUCTORS

- 2.12.1.** Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway complying with UL 83.
- 2.12.2.** Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway complying with UL 83.
- 2.12.3.** Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF, complying with UL 83.

2.13. FIRE ALARM WIRE AND CABLE

- 2.13.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2.13.1.1.** Comtran Corp.
 - 2.13.1.2.** Draka USA.
 - 2.13.1.3.** Genesis Cable Products; Honeywell International, Inc.
 - 2.13.1.4.** Rockbestos-Suprenant Cable Corporation.
 - 2.13.1.5.** West Penn Wire/CDT; a division of Cable Design Technologies.
- 2.13.2.** General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- 2.13.3.** Signaling Line Circuits: Twisted, shielded pair, No. 18 AWG or size as recommended by system manufacturer.
 - 2.13.3.1.** Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.
- 2.13.4.** Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 - 2.13.4.1.** Low-Voltage Circuits: No. 16 AWG, minimum.
 - 2.13.4.2.** Line-Voltage Circuits: No. 12 AWG, minimum.

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2.13.4.3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

2.14. IDENTIFICATION PRODUCTS

2.14.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.14.1.1. Brady Corporation

2.14.1.2. HellermannTyton.

2.14.1.3. Kroy LLC.

2.14.1.4. Panduit Corp.

2.14.2. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.14.3. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.15. SOURCE QUALITY CONTROL

2.15.1. Testing Agency: Engage a qualified testing agency to evaluate cables.

2.15.2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.

2.15.3. Factory test UTP cables according to TIA/EIA-568-B.2.

2.15.4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.

2.15.5. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

2.15.6. Cable will be considered defective if it does not pass tests and inspections.

2.15.7. Prepare test and inspection reports.

3. PART 3 - EXECUTION

3.1. INSTALLATION OF PATHWAYS

- 3.1.1.** Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
- 3.1.2.** Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
- 3.1.3.** Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." for installation of conduits and wireways.
- 3.1.4.** Install manufactured conduit sweeps and long-radius elbows whenever possible.
- 3.1.5.** Pathway Installation in Equipment Rooms:
 - 3.1.5.1.** Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - 3.1.5.2.** Install cable trays to route cables if conduits cannot be located in these positions.
 - 3.1.5.3.** Secure conduits to backboard when entering room from overhead.
 - 3.1.5.4.** Extend conduits 3 inches (75 mm) above finished floor.
 - 3.1.5.5.** Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- 3.1.6.** Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.2. INSTALLATION OF CONDUCTORS AND CABLES

- 3.2.1.** Comply with NECA 1.
- 3.2.2.** General Requirements for Cabling:
 - 3.2.2.1.** Comply with TIA/EIA-568-B.1.
 - 3.2.2.2.** Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

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- 3.2.2.3.** Install 110-style IDC termination hardware unless otherwise indicated.
- 3.2.2.4.** Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
- 3.2.2.5.** Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- 3.2.2.6.** Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
- 3.2.2.7.** Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
- 3.2.2.8.** Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
- 3.2.2.9.** Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- 3.2.3.** UTP Cable Installation:
 - 3.2.3.1.** Comply with TIA/EIA-568-B.2.
 - 3.2.3.2.** Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
- 3.2.4.** Optical Fiber Cable Installation:
 - 3.2.4.1.** Comply with TIA/EIA-568-B.3.
 - 3.2.4.2.** Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
- 3.2.5.** Open-Cable Installation:

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- 3.2.5.1.** Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
- 3.2.5.2.** Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart.
- 3.2.5.3.** Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- 3.2.6.** Installation of Cable Routed Exposed under Raised Floors:
 - 3.2.6.1.** Install plenum-rated cable only.
 - 3.2.6.2.** Install cabling after the flooring system has been installed in raised floor areas.
 - 3.2.6.3.** Coil cable 72 inches (1830 mm) long shall be neatly coiled not less than 12 inches (300 mm) in diameter below each feed point.
- 3.2.7.** Outdoor Coaxial Cable Installation:
 - 3.2.7.1.** Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
 - 3.2.7.2.** Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
- 3.2.8.** Separation from EMI Sources:
 - 3.2.8.1.** Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - 3.2.8.2.** Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 3.2.8.2.1.** Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).

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- 3.2.8.2.2.** Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
- 3.2.8.2.3.** Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
- 3.2.8.3.** Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 3.2.8.3.1.** Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - 3.2.8.3.2.** Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - 3.2.8.3.3.** Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
- 3.2.8.4.** Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 3.2.8.4.1.** Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 3.2.8.4.2.** Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
 - 3.2.8.4.3.** Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
- 3.2.8.5.** Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
- 3.2.8.6.** Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.3. FIRE ALARM WIRING INSTALLATION

- 3.3.1.** Comply with NECA 1 and NFPA 72.
- 3.3.2.** Wiring Method: Install wiring in metal raceway according to Division 26 Section "Raceway and Boxes for Electrical Systems."

- 3.3.2.1.** Install plenum cable in environmental air spaces, including plenum ceilings.
 - 3.3.2.2.** Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
 - 3.3.3.** Wiring Method:
 - 3.3.3.1.** Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
 - 3.3.3.2.** Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is permitted.
 - 3.3.3.3.** Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.
 - 3.3.4.** Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
 - 3.3.5.** Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
 - 3.3.6.** Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
 - 3.3.7.** Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.

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- 3.3.8.** Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.4. CONTROL-CIRCUIT CONDUCTORS

3.4.1. Minimum Conductor Sizes:

- 3.4.1.1.** Class 1 remote-control and signal circuits, No. 14 AWG.
- 3.4.1.2.** Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
- 3.4.1.3.** Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.5. CONNECTIONS

- 3.5.1.** Comply with requirements in Division 28 Section "Perimeter Security Systems" for connecting, terminating, and identifying wires and cables.
- 3.5.2.** Comply with requirements in Division 28 Section "Intrusion Detection" for connecting, terminating, and identifying wires and cables.
- 3.5.3.** Comply with requirements in Division 28 Section "Access Control" for connecting, terminating, and identifying wires and cables.
- 3.5.4.** Comply with requirements in Division 28 Section "Video Surveillance" for connecting, terminating, and identifying wires and cables.
- 3.5.5.** Comply with requirements in Division 28 Section "PLC Electronic Detention Monitoring and Control Systems" for connecting, terminating, and identifying wires and cables.
- 3.5.6.** Comply with requirements in Division 28 Section "Fire Detection and Alarm" for connecting, terminating, and identifying wires and cables.
- 3.5.7.** Comply with requirements in Division 28 Section "Refrigerant Detection and Alarm" for connecting, terminating, and identifying wires and cables.

3.6. FIRESTOPPING

- 3.6.1.** Comply with requirements in Division 07 Section "Penetration Firestopping."

- 3.6.2.** Comply with TIA/EIA-569-A, "Firestopping" Annex A.
- 3.6.3.** Comply with BICSI TDMM, "Firestopping Systems" Article.

3.7. GROUNDING

- 3.7.1.** For communications wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- 3.7.2.** For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.8. IDENTIFICATION

- 3.8.1.** Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.9. FIELD QUALITY CONTROL

- 3.9.1.** Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- 3.9.2.** Perform tests and inspections.
- 3.9.3.** Tests and Inspections:
 - 3.9.3.1.** Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
 - 3.9.3.2.** Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3.9.3.3.** Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.

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3.9.3.3.1. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

3.9.3.4. Optical Fiber Cable Tests:

3.9.3.4.1. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

3.9.3.4.2. Link End-to-End Attenuation Tests:

3.9.3.4.2.1. Multimode Link Measurements:
Test at 850 or 1300 nm in
1 direction according to TIA/EIA-
526-14-A, Method B, One
Reference Jumper.

3.9.3.4.2.2. Attenuation test results for links
shall be less than 2.0 dB.
Attenuation test results shall be
less than that calculated
according to equation in TIA/EIA-
568-B.1.

3.9.3.5. Coaxial Cable Tests: Comply with requirements in Division 27 Section "Master Antenna Television System."

3.9.4. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

3.9.5. End-to-end cabling will be considered defective if it does not pass tests and inspections.

3.9.6. Prepare test and inspection reports.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

1.2.1. Section Includes:

- 1.2.1.1. Metal conduits, tubing, and fittings.
- 1.2.1.2. Nonmetallic conduits, tubing, and fittings.
- 1.2.1.3. Optical-fiber-cable pathways and fittings.
- 1.2.1.4. Metal wireways and auxiliary gutters.
- 1.2.1.5. Nonmetallic wireways and auxiliary gutters.
- 1.2.1.6. Surface pathways.
- 1.2.1.7. Boxes, enclosures, and cabinets.
- 1.2.1.8. Handholes and boxes for exterior underground cabling.

1.2.2. Related Requirements:

- 1.2.2.1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
- 1.2.2.2. Division 26 Section "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
- 1.2.2.3. Division 27 Section "Pathways for Communications Systems" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving communications systems.

1.3. DEFINITIONS

- 1.3.1. ARC: Aluminum rigid conduit.
- 1.3.2. GRC: Galvanized rigid steel conduit.
- 1.3.3. IMC: Intermediate metal conduit.

1.4. ACTION SUBMITTALS

- 1.4.1.** Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- 1.4.2.** LEED Submittals:
 - 1.4.2.1.** Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
 - 1.4.2.2.** Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- 1.4.3.** Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.
- 1.4.4.** Samples: For wireways, nonmetallic wireways and surface pathways and for each color and texture specified, 12 inches (300 mm) long.

1.5. INFORMATIONAL SUBMITTALS

- 1.5.1.** Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1.5.1.1.** Structural members in paths of pathway groups with common supports.
 - 1.5.1.2.** HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- 1.5.2.** Qualification Data: For professional engineer.
- 1.5.3.** Seismic Qualification Certificates: For pathway racks, enclosures, cabinets, and equipment racks and their mounting provisions, including those for internal components, from manufacturer.
 - 1.5.3.1.** Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 1.5.3.2.** Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

1.5.3.3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.

1.5.3.4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.

1.5.4. Source quality-control reports.

2. PART 2 - PRODUCTS

2.1. METAL CONDUITS, TUBING, AND FITTINGS

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

2.1.1.1. AFC Cable Systems, Inc.

2.1.1.2. Allied Tube & Conduit; a Tyco International Ltd. Co.

2.1.1.3. Alpha Wire Company.

2.1.1.4. Anamet Electrical, Inc.

2.1.1.5. Electri-Flex Company.

2.1.1.6. O-Z/Gedney; a brand of EGS Electrical Group.

2.1.1.7. Picoma Industries; Subsidiary of Mueller Water Products, Inc.

2.1.1.8. Republic Conduit.

2.1.1.9. Robroy Industries

2.1.1.10. Southwire Company.

2.1.1.11. Thomas & Betts Corporation.

2.1.1.12. Western Tube and Conduit Corporation.

2.1.1.13. Wheatland Tube Company; a division of John Maneely Company.

2.1.2. General Requirements for Metal Conduits and Fittings:

- 2.1.2.1.** Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- 2.1.2.2.** Comply with TIA-569-B.

- 2.1.3.** GRC: Comply with ANSI C80.1 and UL 6.

- 2.1.4.** ARC: Comply with ANSI C80.5 and UL 6A.

- 2.1.5.** IMC: Comply with ANSI C80.6 and UL 1242.

- 2.1.6.** PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

- 2.1.6.1. Comply with NEMA RN 1.**

- 2.1.6.2. Coating Thickness:** 0.040 inch (1 mm), minimum.

- 2.1.7.** EMT: Comply with ANSI C80.3 and UL 797.

- 2.1.8.** FMC: Comply with UL 1; zinc-coated steel.

- 2.1.9.** LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

- 2.1.10. Fittings for Metal Conduit:** Comply with NEMA FB 1 and UL 514B.

- 2.1.10.1. Conduit Fittings for Hazardous (Classified) Locations:**
Comply with UL 886 and NFPA 70.

- #### 2.1.10.2. Fittings for EMT:

- 2.1.10.2.1. Material: Steel.**

- 2.1.10.2.2.** Type: compression.

- 2.1.10.3.** Expansion Fittings: PVC or steel to match conduit type, complying with UL 467, rated for environmental conditions where installed, and including flexible external bonding jumper.

- 2.1.10.4. Coating for Fittings for PVC-Coated Conduit:** Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

- 2.1.11.** Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2. NONMETALLIC CONDUITS, TUBING, AND FITTINGS

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

- 2.2.1.1.** AFC Cable Systems, Inc.
- 2.2.1.2.** Allied Tube & Conduit; a Tyco International Ltd. Co.
- 2.2.1.3.** Anamet Electrical, Inc.
- 2.2.1.4.** Arnco Corporation.
- 2.2.1.5.** CANTEX Inc.
- 2.2.1.6.** CertainTeed Corp.
- 2.2.1.7.** Condux International, Inc.
- 2.2.1.8.** Electri-Flex Company.
- 2.2.1.9.** Kraloy.
- 2.2.1.10.** Lamson & Sessions; Carlon Electrical Products.
- 2.2.1.11.** Niedax-Kleinhuis USA, Inc.
- 2.2.1.12.** RACO; a Hubbell Company.
- 2.2.1.13.** Thomas & Betts Corporation.

2.2.2. General Requirements for Nonmetallic Conduits and Fittings:

2.2.2.1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2.2.2. Comply with TIA-569-B.

2.2.3. ENT: Comply with NEMA TC 13 and UL 1653.

2.2.4. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

2.2.5. LFNC: Comply with UL 1660.

2.2.6. Rigid HDPE: Comply with UL 651A.

2.2.7. Continuous HDPE: Comply with UL 651B.

- 2.2.8.** RTRC: Comply with UL 1684A and NEMA TC 14.
- 2.2.9.** Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- 2.2.10.** Fittings for LFNC: Comply with UL 514B.
- 2.2.11.** Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 2.2.12.** Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3. OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- 2.3.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.3.1.1.** Alpha Wire Company.
 - 2.3.1.2.** Arnco Corporation.
 - 2.3.1.3.** Endot Industries Inc.
 - 2.3.1.4.** IPEX.
 - 2.3.1.5.** Lamson & Sessions; Carlon Electrical Products.
- 2.3.2.** Description: Comply with UL 2024; flexible-type pathway, approved for plenum [riser] or general-use installation unless otherwise indicated.
 - 2.3.2.1.** Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2.3.2.2.** Comply with TIA-569-B.

2.4. METAL WIREWAYS AND AUXILIARY GUTTERS

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

- 2.4.1.1. Cooper B-Line, Inc.
 - 2.4.1.2. Hoffman; a Pentair company.
 - 2.4.1.3. Mono-Systems, Inc.
 - 2.4.1.4. Square D; a brand of Schneider Electric.
 - 2.4.2. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1, Type 3R unless otherwise indicated, and sized according to NFPA 70.
 - 2.4.2.1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2.4.2.2. Comply with TIA-569-B.
 - 2.4.3. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
 - 2.4.4. Wireway Covers: Hinged type unless otherwise indicated.
 - 2.4.5. Finish: Manufacturer's standard enamel finish.
 - 2.5. NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS
 - 2.5.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.5.1.1. Allied Moulded Products, Inc.
 - 2.5.1.2. Hoffman; a Pentair company.
 - 2.5.1.3. Lamson & Sessions; Carlon Electrical Products.
 - 2.5.1.4. Niedax-Kleinhuys USA, Inc.
 - 2.5.2. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:
 - 2.5.2.1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2.5.2.2. Comply with TIA-569-B.

- 2.5.3.** Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.
- 2.5.4.** Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
- 2.5.5.** Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.
- 2.5.6.** Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 2.5.7.** Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6. SURFACE PATHWAYS

- 2.6.1.** General Requirements for Surface Pathways:
 - 2.6.1.1.** Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2.6.1.2.** Comply with TIA-569-B.
- 2.6.2.** Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Prime coated, ready for field painting.
 - 2.6.2.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2.6.2.1.1.** Mono-Systems, Inc.
 - 2.6.2.1.2.** Niedax-Kleinhuis USA, Inc.
 - 2.6.2.1.3.** Panduit Corp.

2.6.2.1.4. Wiremold / Legrand.

2.6.3. Surface Nonmetallic Pathways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard custom colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

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

2.6.3.1.1. Hubbell Incorporated; Wiring Device-Kellems Division.

2.6.3.1.2. Lamson & Sessions; Carlon Electrical Products.

2.6.3.1.3. Mono-Systems, Inc.

2.6.3.1.4. Panduit Corp.

2.6.3.1.5. Wiremold / Legrand.

2.6.4. Tele-Power Poles:

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

2.6.4.1.1. Mono-Systems, Inc.

2.6.4.1.2. Panduit Corp.

2.6.4.1.3. Wiremold / Legrand.

2.6.4.2. Material: Galvanized steel with ivory baked-enamel finish.

2.6.4.3. Fittings and Accessories: Dividers, end caps, covers, cutouts, wiring harnesses, devices, mounting materials, and other fittings shall match and mate with tele-power pole as required for complete system.

2.7. BOXES, ENCLOSURES, AND CABINETS

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

2.7.1.1. Adalet.

2.7.1.2. Cooper Technologies Company; Cooper Crouse-Hinds.

2.7.1.3. EGS/Appleton Electric.

2.7.1.4. Erickson Electrical Equipment Company.

2.7.1.5. Hoffman; a Pentair company.

2.7.1.6. Hubbell Incorporated; Killark Division.

2.7.1.7. Lamson & Sessions; Carlon Electrical Products.

2.7.1.8. Milbank Manufacturing Co.

2.7.1.9. Molex, Woodhead Brand

2.7.1.10. Mono-Systems, Inc.

2.7.1.11. O-Z/Gedney; a brand of EGS Electrical Group.

2.7.1.12. RACO; a Hubbell Company.

2.7.1.13. Robroy Industries.

2.7.1.14. Spring City Electrical Manufacturing Company.

2.7.1.15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.

2.7.1.16. Thomas & Betts Corporation.

2.7.1.17. Wiremold / Legrand.

2.7.2. General Requirements for Boxes, Enclosures, and Cabinets:

2.7.2.1. Comply with TIA-569-B.

2.7.2.2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.

2.7.3. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

- 2.7.4.** Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- 2.7.5.** Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- 2.7.6.** Metal Floor Boxes:
 - 2.7.6.1.** Material: Cast metal.
 - 2.7.6.2.** Type: Fully adjustable.
 - 2.7.6.3.** Shape: Rectangular.
 - 2.7.6.4.** Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2.7.7.** Nonmetallic Floor Boxes: Nonadjustable, round.
 - 2.7.7.1.** Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2.7.8.** Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- 2.7.9.** Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- 2.7.10.** Device Box Dimensions: 4-inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).
- 2.7.11.** Gangable boxes are allowed.
- 2.7.12.** Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- 2.7.13.** Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R with continuous-hinge cover with flush latch unless otherwise indicated.
 - 2.7.13.1.** Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2.7.13.2.** Nonmetallic Enclosures:
 - 2.7.13.2.1.** Material: Plastic.

2.7.13.2.2. Finished inside with radio-frequency-resistant paint.

2.7.13.3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

2.7.14. Cabinets:

2.7.14.1. NEMA 250, Type 1, Type 3R, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.

2.7.14.2. Hinged door in front cover with flush latch and concealed hinge.

2.7.14.3. Key latch to match panelboards.

2.7.14.4. Metal barriers to separate wiring of different systems and voltage.

2.7.14.5. Accessory feet where required for freestanding equipment.

2.7.14.6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.8. HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND CABLING

2.8.1. General Requirements for Handholes and Boxes:

2.8.1.1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.

2.8.1.2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.8.1.3. Comply with TIA-569-B.

2.8.2. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass or a combination of the two.

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

- 2.8.2.2.** Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2.8.2.2.1.** Armorcast Products Company.
 - 2.8.2.2.2.** Carson Industries LLC.
 - 2.8.2.2.3.** CDR Systems Corporation; Hubbell Power Systems.
 - 2.8.2.2.4.** NewBasis.
 - 2.8.2.2.5.** Oldcastle Precast, Inc.; Christy Concrete Products.
 - 2.8.2.2.6.** Synertech Moulded Products; a division of Oldcastle Precast, Inc.
- 2.8.2.3.** Standard: Comply with SCTE 77.
- 2.8.2.4.** Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
- 2.8.2.5.** Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
- 2.8.2.6.** Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- 2.8.2.7.** Cover Legend: Molded lettering, "ELECTRIC."
- 2.8.2.8.** Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- 2.8.2.9.** Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.
- 2.8.3.** Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete.
 - 2.8.3.1.** Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.8.3.2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

2.8.3.2.1. Armorcast Products Company.

2.8.3.2.2. Carson Industries LLC.

2.8.3.2.3. CDR Systems Corporation; Hubbell Power Systems.

2.8.3.2.4. NewBasis.

2.8.3.2.5. Nordic Fiberglass, Inc.

2.8.3.2.6. Oldcastle Precast, Inc.; Christy Concrete Products.

2.8.3.2.7. Synertech Moulded Products; a division of Oldcastle Precast, Inc.

2.8.3.3. Standard: Comply with SCTE 77.

2.8.3.4. Color of Frame and Cover: Gray.

2.8.3.5. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.

2.8.3.6. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.

2.8.3.7. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

2.8.3.8. Cover Legend: Molded lettering, "ELECTRIC."

2.8.3.9. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

2.8.3.10. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.9. SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

2.9.1. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

- 2.9.1.1. Tests of materials shall be performed by an independent testing agency.
- 2.9.1.2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
- 2.9.1.3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

3. PART 3 - EXECUTION

3.1. PATHWAY APPLICATION

- 3.1.1. Outdoors: Apply pathway products as specified below unless otherwise indicated:
 - 3.1.1.1. Exposed Conduit: GRC, IMC, RNC, Type EPC-40-PVC.
 - 3.1.1.2. Concealed Conduit, Aboveground: GRC, IMC, EMT.
 - 3.1.1.3. Underground Conduit: RNC, Type EPC-40-PVC concrete encased.
 - 3.1.1.4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 - 3.1.1.5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- 3.1.2. Indoors: Apply pathway products as specified below unless otherwise indicated:
 - 3.1.2.1. Exposed, Not Subject to Physical Damage: EMT, ENT.
 - 3.1.2.2. Exposed, Not Subject to Severe Physical Damage: EMT.
 - 3.1.2.3. Exposed and Subject to Severe Physical Damage: GRC, IMC. Pathway locations include the following:
 - 3.1.2.3.1. Loading dock.
 - 3.1.2.3.2. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - 3.1.2.3.3. Mechanical rooms.
 - 3.1.2.3.4. Gymnasiums

- 3.1.2.4.** Concealed in Ceilings and Interior Walls and Partitions: EMT, ENT.
- 3.1.2.5.** Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric-Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
- 3.1.2.6.** Damp or Wet Locations: GRC.
- 3.1.2.7.** Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway
- 3.1.2.8.** Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway.
- 3.1.2.9.** Pathways for Concealed General Purpose Distribution of Optical-Fiber or Communications Cable: General-use, optical-fiber-cable pathway.
- 3.1.2.10.** Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- 3.1.3.** Minimum Pathway Size: 1/2-inch (16-mm) trade size. Minimum size for optical-fiber cables is 1 inch (27 mm).
- 3.1.4.** Pathway Fittings: Compatible with pathways and suitable for use and location.
 - 3.1.4.1.** Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - 3.1.4.2.** PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 - 3.1.4.3.** EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
 - 3.1.4.4.** Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

- 3.1.5. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- 3.1.6. Install surface pathways only where indicated on Drawings.
- 3.1.7. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2. INSTALLATION

- 3.2.1. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- 3.2.2. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- 3.2.3. Complete pathway installation before starting conductor installation.
- 3.2.4. Comply with requirements in Division 26 Section "Hangers and Supports for Electrical Systems" for hangers and supports.
- 3.2.5. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- 3.2.6. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications wiring conduits for which only two 90-degree bends are allowed. Support within 12 inches (300 mm) of changes in direction.
- 3.2.7. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- 3.2.8. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- 3.2.9. Pathways Embedded in Slabs:
 - 3.2.9.1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot (3-m) intervals.
 - 3.2.9.2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.

- 3.2.9.3.** Arrange pathways to keep a minimum of 1 inch (25 mm) of concrete cover in all directions.
- 3.2.9.4.** Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
- 3.2.9.5.** Change from ENT to GRC before rising above floor.
- 3.2.10.** Stub-ups to Above Recessed Ceilings:
 - 3.2.10.1.** Use EMT, IMC, or RMC for pathways.
 - 3.2.10.2.** Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- 3.2.11.** Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.
- 3.2.12.** Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- 3.2.13.** Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- 3.2.14.** Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- 3.2.15.** Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to conduit assembly to assure a continuous ground path.
- 3.2.16.** Cut conduit perpendicular to the length. For conduits of 2-inch (53-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- 3.2.17.** Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.
- 3.2.18.** Surface Pathways:
 - 3.2.18.1.** Install surface pathway for surface electrical outlet boxes only where indicated on Drawings.

- 3.2.18.2.** Install surface pathway with a minimum 2-inch (50-mm) radius control at bend points.
- 3.2.18.3.** Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- 3.2.19.** Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 - 3.2.19.1.** 3/4-Inch (21-mm) Trade Size and Smaller: Install pathways in maximum lengths of 50 feet (15 m).
 - 3.2.19.2.** 1-Inch (27-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
 - 3.2.19.3.** Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- 3.2.20.** Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway sealing fittings according to NFPA 70.
- 3.2.21.** Install devices to seal pathway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
 - 3.2.21.1.** Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 3.2.21.2.** Where an underground service pathway enters a building or structure.
 - 3.2.21.3.** Where otherwise required by NFPA 70.
- 3.2.22.** Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- 3.2.23.** Expansion-Joint Fittings:

- 3.2.23.1.** Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
- 3.2.23.2.** Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - 3.2.23.2.1.** Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - 3.2.23.2.2.** Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - 3.2.23.2.3.** Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - 3.2.23.2.4.** Attics: 135 deg F (75 deg C) temperature change.
- 3.2.23.3.** Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
- 3.2.23.4.** Install expansion fittings at all locations where conduits cross building or structure expansion joints.
- 3.2.23.5.** Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

3.2.24. Flexible Conduit Connections: Comply with NEMA RV 3. Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

3.2.24.1. Use LFMC in damp or wet locations subject to severe physical damage.

3.2.24.2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

3.2.25. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

3.2.26. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

3.2.27. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

3.2.28. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

3.2.29. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.2.30. Set metal floor boxes level and flush with finished floor surface.

3.2.31. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3. INSTALLATION OF UNDERGROUND CONDUIT

3.3.1. Direct-Buried Conduit:

3.3.1.1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.

3.3.1.2. Install backfill as specified in Division 31 Section "Earth Moving."

- 3.3.1.3.** After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
- 3.3.1.4.** Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of elbow.
- 3.3.1.5.** Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - 3.3.1.5.1.** Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
 - 3.3.1.5.2.** For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
- 3.3.1.6.** Underground Warning Tape: Comply with requirements in Division 26 Section "Identification for Electrical Systems."

3.4. INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- 3.4.1.** Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- 3.4.2.** Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

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- 3.4.3.** Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- 3.4.4.** Install handholes with bottom below frost line.
- 3.4.5.** Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- 3.4.6.** Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- 3.5. SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS**

 - 3.5.1.** Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 28 Section "Sleeves and Sleeve Seals for Electronic Safety and Security Pathways and Cabling."
- 3.6. FIRESTOPPING**

 - 3.6.1.** Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."
- 3.7. PROTECTION**

 - 3.7.1.** Protect coatings, finishes, and cabinets from damage and deterioration.

 - 3.7.1.1.** Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 3.7.1.2.** Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

1. PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- 1.1.1.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- 1.2.1.** This Section includes the following:

- 1.2.1.1.** Intrusion detection with hard-wired, modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.

- 1.2.2.** Intrusion detection system shall be integrated with detention monitoring and control system specified in Division 28 Section "PLC Electronic Detention Monitoring and Control Systems", which also defines systems integration.

- 1.2.3.** Related Sections include the following:

- 1.2.3.1.** Division 28 Section "Conductors And Cables For Electronic Safety And Security" for cabling between central-station control units and field-mounted devices and controllers.

1.3. DEFINITIONS

- 1.3.1.** LCD: Liquid-crystal display.

- 1.3.2.** LED: Light-emitting diode.

- 1.3.3.** PIR: Passive infrared.

- 1.3.4.** RFI: Radio-frequency interference.

- 1.3.5.** UPS: Uninterruptible power supply.

- 1.3.6.** Protected or Protection Zone: A space or area for which an intrusion must be detected and uniquely identified, the sensor or group of sensors assigned to perform the detection, and any interface equipment between sensors and communication link to central-station control unit.

- 1.3.7.** Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes.

- 1.3.8.** Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.

1.4. SUBMITTALS

- 1.4.1.** Product Data: Components for sensing, detecting, systems integration, and control, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.

- 1.4.2.** Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.

- 1.4.2.1.** Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify programmable logic controllers, networks and control interface devices and media to be used. Describe characteristics of network and other data communication lines.

- 1.4.2.2.** Raceway Riser Diagrams: Detail raceway runs required for intrusion detection and for systems integration. Include designation of devices connected by raceway, raceway type, and size, and type and size of wire and cable fill for each raceway run.

- 1.4.2.3.** UPS: Sizing calculations.

- 1.4.2.4.** Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building.

- 1.4.2.5.** Central-Station Control-Unit Console Layout: At 1" = 8'-0" scale, showing required artwork and device identification.

- 1.4.2.6.** Device Address List: Coordinate with final system programming.

- 1.4.2.7.** System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.

- 1.4.2.8. Details of surge-protection devices and their installation.
- 1.4.2.9. Sensor detection patterns and adjustment ranges.
- 1.4.3. Equipment and System Operation Description: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are not acceptable.
- 1.4.4. Samples for Initial Selection: For units with factory-applied color finishes.
- 1.4.5. Samples for Verification: For each type of exposed finish required.
- 1.4.6. Qualification Data: For Installer, intrusion detection systems integrator and testing agency.
- 1.4.7. Field quality-control test reports.
- 1.4.8. Operation and Maintenance Data: For intrusion detection system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1.4.8.1. Data for each type of product, including features and operating sequences, both automatic and manual.
 - 1.4.8.2. Central-station control-unit hardware and software data.
- 1.4.9. Warranty: Special warranty specified in this Section.
- 1.4.10. Other Information Submittals:
 - 1.4.10.1. Test Plan and Schedule: Test plan defining all tests required to ensure that system meets technical, operational, and performance specifications within 60 days of date of Contract award.
 - 1.4.10.2. Examination reports documenting inspections of substrates, areas, and conditions.
 - 1.4.10.3. Anchor inspection reports documenting inspections of built-in and cast-in anchors.

1.5. QUALITY ASSURANCE

1.5.1. Installer Qualifications:

1.5.1.1. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association.

1.5.1.2. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1.5.2. Intrusion Detection Systems Integrator Qualifications: An experienced intrusion detection equipment supplier and Installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.

1.5.3. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the National Burglar & Fire Alarm Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Owner's insurance underwriter.

1.5.3.1. Testing Agency's Field Supervisor: Person currently certified as an advanced alarm technician by the National Burglar & Fire Alarm Association to supervise on-site testing specified in Part 3.

1.5.4. Product Options: Drawings indicate size, profiles, and dimensional requirements of detection devices and central-station control units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

1.5.5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5.6. FMG Compliance: FMG-approved and -labeled intrusion detection devices and equipment.

1.5.7. Comply with NFPA 70.

1.6. PROJECT CONDITIONS

1.6.1. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

- 1.6.1.1. Altitude: Sea level to 4000 feet (1220 m).
- 1.6.1.2. Central-Station Control Unit: Rated for continuous operation in an ambient of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, non-condensing.
- 1.6.1.3. Interior, Controlled Environment: System components, except central-station control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambients of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, non-condensing.
- 1.6.1.4. Interior, Uncontrolled Environment: System components installed in non-temperature-controlled interior environments shall be rated for continuous operation in ambients of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, non-condensing.
- 1.6.1.5. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h).
- 1.6.1.6. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings shall be rated, listed, and installed according to NFPA 70.

1.7. WARRANTY

- 1.7.1. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fail in materials or workmanship within specified warranty period.
 - 1.7.1.1. Warranty Period: Two years from date of Substantial Completion.

1.8. EXTRA MATERIALS

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

1.8.1.1. Intrusion Detection Devices: Furnish quantity equal to five percent of the number of units of each type installed, but no fewer than one of each type.

1.8.1.2. Fuses: Three of each kind and size.

1.8.1.3. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.

1.8.1.4. Security Fasteners: Furnish no fewer than 1 box for every 50 boxes or fraction thereof, of each type and size of security fastener installed.

2. PART 2 - PRODUCTS

2.1. MANUFACTURERS

2.1.1. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

2.1.1.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.1.1.2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2. FUNCTIONAL DESCRIPTION OF SYSTEM

2.2.1. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.

2.2.1.1. Alarm Signal: Display at central-station control unit and actuate audible and visual alarm devices.

- 2.2.1.2.** Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or controller failure.
 - 2.2.1.3.** Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or controller.
 - 2.2.2.** System Control: Central-station control unit shall directly monitor intrusion detection units and connecting wiring.
 - 2.2.3.** System Control: Central-station control unit shall directly monitor intrusion detection devices, perimeter detection units, and connecting wiring in a multiplexed distributed control system or as part of a network.
 - 2.2.4.** System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.
 - 2.2.5.** Operator Commands:
 - 2.2.5.1.** Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
 - 2.2.5.2.** Acknowledge Alarm: To indicate that alarm message has been observed by operator.
 - 2.2.5.3.** Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
 - 2.2.5.4.** Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
 - 2.2.5.5.** Protected Zone Test: Initiate operational test of a specific protected zone.
 - 2.2.5.6.** System Test: Initiate system-wide operational test.
 - 2.2.5.7.** Print Reports.
 - 2.2.6.** Timed Control at Central-Station Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.

- 2.2.7.** Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:
- 2.2.7.1.** Switch selected lights.
 - 2.2.7.2.** Shift elevator control to a different mode.
 - 2.2.7.3.** Open a signal path between certain intercommunication stations.
 - 2.2.7.4.** Shift sound system to "listening mode" and open a signal path to certain system speakers.
 - 2.2.7.5.** Switch signal to selected monitor from closed-circuit television camera in vicinity of sensor signaling an alarm.
- 2.2.8.** Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When central-station control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
- 2.2.9.** Response Time: Two seconds between actuation of any alarm and its indication at central-station control unit.
- 2.2.10.** Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from central-station control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at central-station control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.
- 2.2.11.** Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

2.3. SYSTEM COMPONENT REQUIREMENTS

- 2.3.1.** Compatibility: Detection devices and their communication features, connecting wiring, and central-station control unit shall be selected and configured with accessories for full compatibility.
- 2.3.2.** Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
 - 2.3.2.1.** Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits."
 - 2.3.2.2.** Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements in Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
- 2.3.3.** Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V RMS injected into power supply lines at 10 to 10,000 MHz.
- 2.3.4.** Tamper Protection: Tamper switches on detection devices, controllers, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Central-station control-unit alarm display shall identify tamper alarms and indicate locations.
- 2.3.5.** Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to central-station control unit.
- 2.3.6.** Anti-masking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to central-station control unit as an alarm signal.

2.3.7. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to central-station control unit.

2.3.8. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at central-station control unit for calibration, sensitivity, and alarm condition.

2.4. ENCLOSURES

2.4.1. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping non-corrosive liquids.

2.4.2. Interior Electronics: NEMA 250, Type 12.

2.4.3. Exterior Electronics: NEMA 250, Type 4X fiberglass.

2.4.4. Corrosion Resistant: NEMA 250, Type 4X PVC.

2.4.5. Screw Covers: Where enclosures are accessible to inmates, secure with security fasteners of type appropriate for enclosure.

2.5. SECURE AND ACCESS DEVICES

2.5.1. Manufacturers:

2.5.1.1. ADEMCO Group; Pittway Corporation.

2.5.1.2. Continental Instruments.

2.5.1.3. Honeywell International Inc.

2.5.2. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.

2.5.3. Key-Operated Switch: Change protected zone between secure and access conditions.

2.6. DOOR AND WINDOW SWITCHES

2.6.1. Manufacturers:

2.6.1.1. ADEMCO Group; Pittway Corporation.

2.6.1.2. Aleph International Corporation.

2.6.1.3. Amseco; Division of Kobishi America, Inc.

2.6.1.4. FBI; Pittway Corporation.

2.6.1.5. GE Interlogix; General Electric Company.

2.6.2. Description: Balanced-magnetic switch, complying with UL 634, installed on frame with integral over current device to limit current to 80 percent of switch capacity. Bias magnet and minimum of two encapsulated reed switches shall resist compromise from introduction of foreign magnetic fields.

2.6.3. Flush-Mounted Switches: Unobtrusive and flush with surface of door and window frame.

2.6.4. Overhead Door Switch: Balanced-magnetic type, listed for outdoor locations, and having door-mounting magnet and floor-mounting switch unit.

2.6.5. Remote Test: Simulate movement of actuating magnet from central-station control unit.

2.7. PIR SENSORS

2.7.1. Manufacturers:

2.7.1.1. ADEMCO Group; Pittway Corporation.

2.7.1.2. Aleph International Corporation.

2.7.1.3. Crow Electronic Engineering, Inc.

2.7.1.4. Digital Security Controls, Ltd.

2.7.1.5. FBI; Pittway Corporation.

2.7.1.6. Honeywell International Inc.

2.7.1.7. NAPCO Security Systems, Inc.

2.7.1.8. Optex.

2.7.1.9. Richardson Electronics, Ltd.

2.7.1.10. Visonic Inc.

2.7.2. Description: Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within their protected zone and by being insensitive to general thermal variations.

2.7.2.1. Wall-Mounting Unit Maximum Detection Range: 125 percent of indicated distance for individual units and not less than 50 feet (15 m). Provide adjustable coverage pattern as indicated.

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- 2.8.2.3.** Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor controller.
- 2.8.2.4.** Controller: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
- 2.8.2.5.** Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

2.9. CENTRAL-STATION CONTROL UNITS

2.9.1. Manufacturers:

- 2.9.1.1.** ADEMCO Group; Pittway Corporation.
- 2.9.1.2.** Amseco; Division of Kobishi America, Inc.
- 2.9.1.3.** DAQ Electronics, Inc.
- 2.9.1.4.** Or approved equal.

2.9.2. Description: Panel shall provide supervision of sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.

2.9.3. Construction: Modular, with separate and independent alarm and supervisory system modules. Alarm-initiating protected zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are not acceptable.

2.9.4. Comply with UL 609.

2.9.5. Alarm Indication: Audible signal sounds and an LED lights at central-station control unit identifying protected zone originating the alarm. Annunciator panel displays a common alarm light and an audible tone.

2.9.6. Alarm Indication: Audible signal sounds and a plain-language identification of protected zone originating the alarm appears on LED display at central-station control unit.

- 2.9.7.** Alarm Indication: Audible signal sounds and a plain-language identification of protected zone originating the alarm appears on LED display at central-station control unit. Annunciator panel alarm light and audible tone identify protected zone signaling an alarm.
 - 2.9.7.1.** Alarm activation sounds a bell.
- 2.9.8.** Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Include the following:
 - 2.9.8.1.** Acknowledge alarm.
 - 2.9.8.2.** Silence alarm.
 - 2.9.8.3.** System reset.
 - 2.9.8.4.** LED test.
- 2.9.9.** Resetting Controls: Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists.
- 2.9.10.** Timing Unit: Solid state, programmable, 365 days.
 - 2.9.10.1.** Astronomic Control: For automatic control of light switching at dawn and dusk.
 - 2.9.10.2.** Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
 - 2.9.10.3.** Override Capability: Programmed shutdown of lighting and other items shall be overridden by using override push buttons or by entering commands over telephone data links.
- 2.9.11.** Alphanumeric Display and System Controls: Arranged for interface between operator and addressable system components, including annunciation and supervision. Display alarm, supervisory, component status messages, and programming and control menu.
 - 2.9.11.1.** Display: LCD, 40 characters, minimum.
 - 2.9.11.2.** Keypad: Arranged to permit entry and execution of programming, display, and control commands.

- 2.9.12.** Alphanumeric Display and System Controls: Arranged for interface between operator at central-station control unit and addressable system components, including annunciation, supervision, and test.
- 2.9.12.1.** Display: A minimum of 80 characters; alarm, supervisory, and component status messages; and indicate control commands to be entered into system for testing of sensors.
- 2.9.12.2.** Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- 2.9.13.** Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.
- 2.9.14.** Power Supply Circuits: Central-station control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.
- 2.9.15.** UPS: Comply with Division 26 Section "Static Uninterruptible Power Supply." UPS shall be sized to provide a minimum of six hours of central-station control-unit operation.
- 2.9.16.** Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.

2.10. ANNUNCIATOR

- 2.10.1.** Manufacturers:
- 2.10.1.1.** ADEMCO Group; Pittway Corporation.
- 2.10.1.2.** Amseco; Division of Kobishi America, Inc.
- 2.10.1.3.** DAQ Electronics, Inc.
- 2.10.1.4.** Or approved equal.
- 2.10.2.** Power and Signal Inputs: From central-station control unit.

- 2.10.3.** Visual Displays: Modular-lighted type with displays as indicated and engraved legend for each protected zone annunciated.
 - 2.10.4.** Light Source: Duplicate LEDs for "alarm signals," visible at a distance of 30 feet (9.2 m).
 - 2.10.5.** Signals Annunciated: "Secure," "access," and "alarm" shall be distinctly indicated for each protected zone by green, yellow, and red displays, respectively. Annunciate alarm condition by flashing light and steady alarm tone until silence-reset switch is operated.
 - 2.10.6.** Audible Alarm: Unit mounted within annunciator cabinet; sounds for alarm conditions and is silenced by silence-reset switch on unit. Alarm shall sound again when condition is normalized until silence-reset switch is reset.
 - 2.10.7.** Silence-Reset Switch: Resets annunciator to normal condition after alarm condition is restored.
 - 2.10.8.** Test Switch: Tests annunciator LEDs.
 - 2.10.9.** Cabinet: Two hinged doors, one behind the other. Metal outer door frame with minimum 1/4-inch- (6-mm-) thick, clear acrylic vision lite. Steel inner door with mounting surface for annunciator modules. Both doors shall have flush tumbler locks and tamper switches. Comply with Division 26 Section "Raceway and Boxes for Electrical Systems."
 - 2.10.9.1.** Graphics: Integrate LED displays with graphic display panel to form a graphic annunciator.
 - 2.10.10.** Electrical Power: Annunciator shall be powered by UPS of central-station control unit.
- 2.11. CENTRAL-STATION CONTROL UNIT**
- 2.11.1.** Manufacturers:
 - 2.11.1.1.** ADEMCO Group; Pittway Corporation.
 - 2.11.1.2.** Alarm Controls Corp.
 - 2.11.1.3.** Diebold, Incorporated.
 - 2.11.1.4.** Honeywell International Inc.
 - 2.11.1.5.** Or approved equal.
 - 2.11.2.** Microprocessor System: Standard personal computer of modular design.

- 2.11.2.1.** CPU Word Size: 64 bits or larger.
- 2.11.2.2.** Operating Speed: 500 MHz or faster.
- 2.11.2.3.** Memory: 258 MB or more.
- 2.11.2.4.** Ports (Minimum):
 - 2.11.2.4.1.** Two USB ports.
 - 2.11.2.4.2.** COM 1 and COM 2.
 - 2.11.2.4.3.** One enhanced parallel port.
 - 2.11.2.4.4.** Two serial ports, with adjustable data transmission rates from 9.6 to 57.6 Kbps, selectable in software.
- 2.11.2.5.** Video Card: Supports at least 256 colors at a resolution of 1280 by 1024 pixels at a minimum rate of 70 Hz.
- 2.11.3.** Monitor: Not less than 17 inches (430 mm) with minimum resolution of 1280 by 1024 pixels, non-interlaced, and a maximum dot pitch of 0.28 mm.
- 2.11.4.** Keyboard: 101 keys, standard commercial type.
- 2.11.5.** Peripherals: Special function keyboards for frequently used operator commands such as the following:
 - 2.11.5.1.** Help.
 - 2.11.5.2.** Acknowledge alarm.
 - 2.11.5.3.** Place protected zone in Access.
 - 2.11.5.4.** Place protected zone in Secure.
 - 2.11.5.5.** Protected zone Test.
 - 2.11.5.6.** System Test.
 - 2.11.5.7.** Print Reports.
 - 2.11.5.8.** Change Operator.
 - 2.11.5.9.** Security Lighting Controls.
 - 2.11.5.10.** Display Graphics.
- 2.11.6.** Disk Storage:

- 2.11.6.1.** Hard disk with controller having a maximum average access time of 10 ms, and a disk with at least 60 gigabytes of formatted storage.
- 2.11.6.2.** Floppy Disk: Drive and controller for standard 3-1/2-inch high-density diskettes.
- 2.11.6.3.** Removable Disk Storage: 100 MB (minimum) drive and controller, with 10 diskettes.
- 2.11.6.4.** CD-ROM Drive: 650 MB Read-Only data storage, 650 MB recording capacity using CD-R technology, with software and 10 CD-R blank disks and 1 test disk.
- 2.11.6.5.** Modem: 56K, v.90 data/fax with error detection, auto answer/autodial, and call progress detection, suitable for operating on unconditioned voice grade telephone lines.
- 2.11.7.** Alarm Printer: Listed in UL 1610 and labeled as an integral part of intrusion detection system. Dot matrix with graphics capability, red and black ribbon, with minimum speed of 200 characters per second. Selectable character spacing of 10, 13, or 14 per inch. Tractor drive is suitable for fanfold paper. Furnish 25,000 sheets of printer paper and 12 ribbons.
- 2.11.8.** Report Printer: Laser printer, minimum 600 dpi resolution, minimum 2 MB of RAM, printing speed of 8 pages per minute with 100 sheet automatic feed paper cassette. Furnish 2000 sheets of paper and 5 toner cartridges.
- 2.11.9.** Electrical Power:
 - 2.11.9.1.** Normal System Power Supply: 120 V, 60 Hz, through a locked disconnect device and an isolation transformer in central-station control unit. Central-station control unit shall supply power to all components connected to it, unless otherwise indicated.
 - 2.11.9.2.** Power for Central-Station Control Unit: UPS sized for full load of unit.
 - 2.11.9.3.** Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy. Capacity adequate to operate the system, including audible trouble signal devices for up to six hours and audible and visual alarm devices under alarm conditions for an additional one hour.

2.11.9.4. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within 24 hours.

2.11.9.5. Annunciation: Indicate a change in system condition and switching of system or component to backup power.

2.12. CENTRAL-STATION CONTROL-UNIT SOFTWARE

2.12.1. Support:

2.12.1.1. Multi-user operator with multiple tasks for each user.

2.12.1.2. Support operation and management of all peripheral devices.

2.12.1.3. File management functions for disk I/O.

2.12.1.4. Printer spooling.

2.12.1.5. Monitor status of UPS.

2.12.2. Operator Commands:

2.12.2.1. Help.

2.12.2.2. Acknowledge alarm.

2.12.2.3. Place protected zone in Access.

2.12.2.4. Place protected zone in Secure.

2.12.2.5. Protected zone Test.

2.12.2.6. System Test.

2.12.2.7. Print Reports.

2.12.2.8. Change Operator.

2.12.2.9. Security Lighting Controls.

2.12.2.10. Display Graphics.

2.12.2.11. Command Input Errors: Supervise inputs to ensure that they are correct for proper execution. Provide automatic help when a command cannot be executed due to operator input error.

- 2.12.3.** System Access Control: Define system operator capability and functions through password-protected operations at three operator levels. Allow operator level change only by top-level operators and managers.
 - 2.12.3.1.** Activate tamper alarm after three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period.
 - 2.12.3.2.** Allow at least 32 passwords.
 - 2.12.3.3.** Display operator's name or initials in console's first field.
 - 2.12.3.4.** Report: Print operator's name or initials, action, date, and time on system printer at log-on and log-off. Do not display or print passwords.
 - 2.12.3.5.** Define and assign passwords for the following:
 - 2.12.3.5.1.** System commands.
 - 2.12.3.5.2.** Access to system software.
 - 2.12.3.5.3.** Access to application software.
 - 2.12.3.5.4.** Individual protected zones to be accessed.
 - 2.12.3.5.5.** Access to database.
- 2.12.4.** Alarm-Monitoring Software: Monitor all sensors, central-station control units, UPS, and data transmission circuits and notify operator of an alarm condition. Print alarms in red on alarm printer and display on console's text and graphic maps.
 - 2.12.4.1.** Alarm Display:
 - 2.12.4.1.1.** Display higher-priority alarms first.
 - 2.12.4.1.2.** Oldest unacknowledged alarm has highest priority.
 - 2.12.4.1.3.** Operator acknowledgment of one alarm is not acknowledgment of any other alarm and may not inhibit reporting of subsequent alarms.
 - 2.12.4.1.4.** Type of alarm, location of alarm, and secondary alarm messages.

- 2.12.4.1.5.** Date and time (to nearest second) of occurrence and operator response.
 - 2.12.4.1.6.** A unique message field with a width of at least 60 characters for each alarm. Allow operator to edit assignment of messages to a protected zone or sensor.
 - 2.12.4.1.7.** 25 secondary messages shall have a field of 4 lines of 60 characters each to allow further information to be entered by operator for each alarm.
 - 2.12.4.1.8.** Store most recent 1000 alarms and allow the data to be recalled, but not edited, by operator using the report generator.
- 2.12.5.** Monitor Display Software: Display text and graphic maps that integrate protected zone status. Use for various components and real-time data. Use uniform color codes on all displays as follows:
 - 2.12.5.1.** FLASHING RED to alert operator that a protected zone has gone into alarm or that primary power has failed.
 - 2.12.5.2.** RED to alert operator that a protected zone is in alarm and that alarm has been acknowledged.
 - 2.12.5.3.** YELLOW to advise operator that a protected zone is in access.
 - 2.12.5.4.** GREEN to indicate that a protected zone is secure or that power is on.
- 2.12.6.** System Test Software: Enable operator to initiate a test of entire system or a particular portion of system. Store results of each test for future display, or print them out in report form.
- 2.12.7.** Report Generator Software: Commands to generate reports for displaying, printing, and storing on disk and tape. Store reports by type, date, and time and print each on report printer. Provide printer spooling. Generating reports shall not interrupt system operations. Allow operator to select report-generation mode, either periodic automatic or on request. Report headers shall automatically include time and date of printing and name of operator generating the report. Exact format of each report type shall be operator configurable. Allow operator to request, at any time, an immediate printout of any report.

- 2.12.7.1.** Periodic Automatic Report Modes: Allow for specifying, modifying, or inhibiting the report to be generated, time the initial report is to be generated, time interval between reports, end of period, and output peripheral.
- 2.12.7.2.** Alarm Report: Include all alarms recorded by the system over an operator-selectable time. Include such information as type of alarm (intrusion, tamper, etc.), type of sensor, location, time, and action taken.
- 2.12.7.3.** System Test Report: This report documents the operational status of all system components following a system test.
- 2.12.7.4.** Access and Secure Report: This report documents all protected zones placed in access condition, time placed in access condition, and time placed in secure condition.

2.13. AUDIBLE AND VISUAL ALARM DEVICES

2.13.1. Manufacturers:

- 2.13.1.1.** ADEMCO Group; Pittway Corporation.
- 2.13.1.2.** Alarm Controls Corporation.
- 2.13.1.3.** Amseco; Division of Kobishi America, Inc.
- 2.13.1.4.** Edwards Signaling.
- 2.13.1.5.** Gentex Corporation; Fire Protection Group.
- 2.13.1.6.** Potter Electric Signal.
- 2.13.1.7.** Richardson Electronics, Ltd.
- 2.13.1.8.** Wheelock, Inc.

2.13.2. Bell: Central-station control unit 10 inches (254 mm) in diameter, rated to produce a minimum sound output of 84 dB at 10 feet (3 m) from central-station control unit.

2.13.2.1. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.

2.13.3. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at 3 feet (1 m), plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use: two minutes on and five minutes off.

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2.14.6.2. Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.

2.14.7. Protective Coatings for Heat-Treated Alloy Steel:

2.14.7.1. Zinc chromate, ASTM F 1135, Grade 3 or 4; for exterior applications and interior applications where indicated.

2.14.7.2. Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide, unless otherwise indicated.

3. PART 3 - EXECUTION

3.1. EXAMINATION

3.1.1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of intrusion detection.

3.1.1.1. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.

3.1.1.2. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of intrusion detection.

3.1.2. Inspect built-in and cast-in anchor installations, before installing intrusion detection, to verify that anchor installations comply with requirements. Prepare inspection reports.

3.1.2.1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Re-inspect after repairs or replacements are made.

3.1.2.2. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.

3.1.3. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.

3.1.4. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. SYSTEM INSTALLATION

3.2.1. Comply with UL 681.

- 3.2.2.** Security Fasteners: Where accessible to inmates, install intrusion detection components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project.

3.3. WIRING INSTALLATION

- 3.3.1.** Wiring Method: Install wiring in metal raceways according to Division 26 Section "Raceway and Boxes for Electrical Systems." Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
- 3.3.2.** Wiring Method: Install wiring in raceways except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
- 3.3.3.** Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.
- 3.3.4.** Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- 3.3.5.** Wires and Cables:
- 3.3.5.1.** Conductors: Size as recommended in writing by system manufacturer, unless otherwise indicated.
- 3.3.5.2.** 120-V Power Wiring: Install according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables," unless otherwise indicated.

- 3.3.5.3.** Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable, unless otherwise indicated or if manufacturer recommends shielded cable, according to Division 28 Section "Conductors and Cables for Electronic Safety and Security."
 - 3.3.5.4.** Computer and Data-Processing Cables: Install according to Division 28 Section "Conductors and Cables for Electronic Safety And Security."
 - 3.3.5.5.** Television Signal Transmission Cables: Install according to Division 28 Section "Conductors and Cables for Electronic Safety And Security."
 - 3.3.6.** Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
 - 3.3.7.** Install power supplies and other auxiliary components for detection devices at controllers, unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
 - 3.3.8.** Identify components with engraved, laminated-plastic or metal nameplate for central-station control unit and each terminal cabinet, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."
- 3.4. GROUNDING**
- 3.4.1.** Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
 - 3.4.2.** Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
 - 3.4.3.** Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.5. FIELD QUALITY CONTROL

3.5.1. Pre-testing: After installation, align, adjust, and balance system and perform complete pre-testing to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pre-testing. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

3.5.1.1. Report of Pre-testing: After pre-testing is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.

3.5.2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

3.5.3. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

3.5.4. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

3.5.5. Perform the following field tests and inspections and prepare reports:

3.5.5.1. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

3.5.5.2. Operational Tests: Schedule tests after pre-testing has been successfully completed. Test all modes of system operation and intrusion detection at each detection device. Test for detection of intrusion and for false alarms in each protected zone. Test for false alarms by simulating activities outside indicated detection patterns.

3.5.5.3. Electrical Tests: Comply with NFPA 72, Section A-7. Minimum required tests are as follows:

3.5.5.3.1. Verify the absence of unwanted voltages between circuit conductors and ground.

3.5.5.3.2. Test all conductors for short circuits using an insulation-testing device.

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3.7. ADJUSTING

- 3.7.1.** Occupancy Adjustments: When requested within 12 months of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.

END OF SECTION

PART 1 - GENERAL

1.01 FIRE ALARM SYSTEM DESCRIPTION AND SCOPE OF WORK:

- A. This Section includes the materials, equipment, fabrication, installation and tests in conformity with applicable codes and Authorities Having Jurisdiction (AHJ) for the Fire Alarm System. A New Fire Alarm system shall include, but not be limited to, Fire Alarm Initiating Devices, Fire Alarm Notification Appliances, Fire Alarm Power Supplies, Auxiliary Control Devices, Remote Annunciator, Wiring, Raceways and all accessories required to provide a complete in-place and operating Fire Alarm System.
- B. New Fire Alarm System is a Manual/Automatic individually addressable Fire Alarm System.
- C. The scope of the new Fire Alarm work is as indicated on the approved DSA (Division of the State Architect) Drawings and Schematic Diagrams.
- D. The New Fire Alarm System shall be connected to a UL listed Central Monitoring Station.
- E. The Fire Alarm System shall comply with requirements of the 2007 NFPA Standard No. 72 for protected premises signaling systems except as modified and supplemented by this specification. The system field wiring shall be supervised either electrically or by software-directed polling of field devices.
- F. The Fire Alarm System shall be manufactured by an ISO 9001 certified company and meet the requirements of BS EN9001: ANSI/ASQC Q9001.
- G. The FACP and peripheral devices shall be manufactured 100% by a single U.S. Manufacturer (or division thereof).
- H. The Fire Alarm Contractor performing this work shall be certified by the Major Equipment Manufacturer. The Single Source Fire Alarm Contractor to provide submittals, Fire Alarm Equipment/Devices as specified, install all devices and equipment, perform all programming on the Main Fire Alarm Control Panel and provide all testing of the Fire Alarm System to the satisfaction of DSA Project Inspector.

- I. The installing company shall employ NICET (minimum Level II Fire Alarm Technology) technicians on site to guide the final check-out and to ensure the system's integrity.
- J. Prior to bid the Electrical Contractor shall visit the Site and review the existing conditions, review respective Fire Alarm Plans and allow for all construction that is necessary for a complete in-place installation of the new Fire Alarm System.
- K. Related Work: Consult all other Sections, Determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete installation.
 - 1. Electrical Divisions

1.02 FIRE ALARM SYSTEM PERFORMANCE AND FUNCTION OPERATION:

- A. A new Fire Detection System shall be installed in accordance to the Project Specifications and DSA approved Drawings.
- B. Basic Performance:
 - 1. Alarm, trouble and supervisory signals from all intelligent reporting devices shall be encoded on an NFPA Style 4 class B Signaling Line Circuit (SLC).
 - 2. Initiation Device Circuits (IDC) shall be wired Class B.
 - 3. Notification Appliance Circuits (NAC) shall be wired style Y, Class B
 - 4. All circuit shall be Power-Limited per UL 864 requirements.
 - 5. Digitized electronic signals shall employ check digits or multiple polling.
 - 6. Alarm Signals arriving at the main FACP shall not be lost following a power failure (or outage) until the Alarm Signal is processed and recorded.
- C. Basic System Functional Operation
When a Fire Alarm condition is detected and reported by one of the System Initiating Devices, the following functions shall immediately occur:
 - 1. The System Alarm LED shall flash.
 - 2. A local piezo sounder in the Control Panel shall sound.
 - 3. A backlit 80-character LCD display shall indicate all information associated with the Fire Alarm Condition, including the type of alarm point and its location within the protected premises.

4. Printing and history storage equipment shall log the information associated each new Fire Alarm Control Panel Condition, along with time and date of occurrence.
5. 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.
6. Signals initiated by Initiating Devices shall be transmitted to Central Monitoring Station.

1.03 SUBMITTALS:

- A. The Contractor shall send to the Architect seven (7) copies of a complete Submittal Package based upon the DSA (Division of the State Architect) Approved Plans and Specifications including the following items: (Any deviation from the DSA Approved Drawings and the following list may result in the initial submission being returned marked "REJECTED – NOT REVIEWED.")
 1. Complete Bill of Material, per the "Fire Alarm List of Equipment". List all components of the Fire Alarm System including the Manufacturers Catalog Number and the current California State Fire Marshal Listing Number for each device and equipment.
 2. Provide Manufacturers Data/Catalog cut sheets with respective SFM listing number for each Fire Alarm product and component as specified on "Fire Alarm List of Equipment".
 3. Provide Manufacturers Data/Catalog cut sheets with respective SFM listing number for each Fire Alarm Cable that will be furnished for this Project.
 4. Clearly mark on each Data/Catalog cut sheet the specific item(s) being submitted for review by the Engineer.
 5. Shop Drawings shall include the following:
 - a. Fire Alarm Floor Plans showing locations of all new Fire Alarm Devices and Equipment to include each Initiating Fire Alarm Device address, each Visual Notification Fire Alarm Devices Candela rating, each Notification Fire Alarm Devices circuit number.
 - b. Complete Conduits/raceways routing to all new Fire Alarm Devices and Equipment
 - c. Fire Alarm Riser Diagram of the complete Fire Alarm System showing all Fire Alarm Devices and Equipment, conduit and wire types and sizes with Interior Fire Alarm Legend.

- d. Fire Alarm Site Plan showing location of all new Fire Alarm Power Supplies, all new Fire Alarm conduits and raceways routing, all new Fire Alarm pull boxes location, conduit and wire types and sizes with Exterior Fire Alarm Conduit and Wiring Schedule.
 6. Main Fire Alarm Control Panel and Fire Alarm Power Supplies Back-up New Batteries Calculations showing the total stand-by current and alarm current to meet the specified system requirements.
 7. Voltage Drop calculation for each Notification Fire Alarm Circuit.
- B. Record Drawings:
1. At Project completion Furnish Record Drawings utilizing Shop-Drawings submission with updated field condition. Record Drawings shall include but not to be limited to the following:
 - a. Fire Alarm Floor Plans showing actual locations of all new Fire Alarm Devices and Equipment to include each Initiating Fire Alarm Device address per as-built addressable loop print-out, each Visual Notification Fire Alarm Devices Candela rating, each Notification Fire Alarm Devices circuit number, each Notification Alarm Circuit End of the Line Resistor location, etc.
 - b. Fire Alarm Riser Diagram of the complete Fire Alarm System showing all Initiating and Notification Fire Alarm Devices and Equipment to include each Initiating Fire Alarm Device address per as-built Addressable Loop Print-out, each Visual Notification Fire Alarm Devices Candela rating, each Notification Fire Alarm Devices circuit number, conduit and wire types and sizes with Interior Fire Cable Alarm Legend.
 - c. Fire Alarm Site Plan showing actual locations of Main fire Alarm control Panel, of all Fire Alarm Power Supplies, actual exterior Fire Alarm Conduits and Raceways routing, all Fire Alarm pull boxes locations, conduits and wires types and sizes with Exterior Fire Alarm Conduit and Wiring Schedule.
 - d. As-Built Main Fire Alarm Control Panel and all Fire Alarm Power Supplies Back-up Batteries Calculations and as-built Voltage Drop Calculations for each Notification Alarm Circuit.
 2. The Owner will not accept the final Record Drawings submission until the Engineer has accepted the Record Drawings.
- C. Manuals:
1. Submit simultaneously with the shop drawings, complete operating and maintenance manuals listing the manufacturer's name(s), including technical data sheets.

2. Wiring diagrams shall indicate internal wiring for each device and the interconnections between the items of equipment.
 3. Provide a clear and concise description of operation that gives, in detail, the information required to properly operate the equipment and system
- D. Software Modifications
1. Provide the services of a factory trained and authorized technician to perform all system software modifications, upgrades or changes. Response time of the technician to the site shall not exceed 4 hours.
 2. Provide all hardware, software, programming tools and documentation necessary to modify the fire alarm system on site. Modification includes addition and deletion of devices, circuits, zones and changes to system operation and custom label changes for devices or zones. The system structure and software shall place no limit on the type or extent of software modifications on-site. Modification of software shall not require power-down of the system or loss of system fire protection while modifications are being made.
- E. Certifications:
1. Together with the Shop Drawing/Data submittal, submit a letter of certification from the Major Equipment Manufacturer of the Main Fire Alarm Control Panel that the proposed Contractor is an Authorized Dealer and Installer of their equipment and that the proposed supervisor of the installation and the proposed performer of contract maintenance is an authorized representative of the Major Equipment Manufacturer. Include names and addresses in the certification.
- F. At Project completion
1. Furnish to the Owner a complete Operational/ Maintenance Manual and reproducible record drawings (as-built) for the Fire Alarm System installation as described in section 1.03B above.
 2. Furnish to the Owner revised as-built addressable Loop Printout for complete Fire Alarm System.
 3. Provide Testing Procedures.
 4. Provide a complete and signed "Record Of Completion " as found In NFPA 72-2002 to Architect, Engineer, DSA, Project Inspector, Owner, And Local Fire Authority.

1.04 GUARANTY:

- A. All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one (1) year from the date of acceptance. The full cost of maintenance, labor and materials required to correct any defect during this one year period shall be included in the submittal bid.

1.05 APPLICABLE STANDARDS AND SPECIFICATIONS:

The specifications and standards listed below form a part of this specification. The system shall fully comply with the latest issue of these standards.

- A. National Fire Protection Association (NFPA) - USA:
 - 1. No.13-2007 Standard for the installation of Sprinkler System
 - 2. No.70-2007 National Electrical Code with California Amendments
 - 3. No. 72-2007 National Fire Alarm Code.
 - 4. No. 90A – Standard for installation of Air Conditioning and Ventilating Systems
 - 5. No. 101-2006 Life Safety Code
- B. Underwriters Laboratories Inc. (UL) - USA:
 - 1. No. 268 Smoke Detectors for Fire Protective Signaling Systems.
 - 2. No. 864 Control Units for Fire Protective Signaling Systems.
 - 3. No. 268A Smoke Detectors for Duct Applications.
 - 4. No. 521 Heat Detectors for Fire Protective
 - 5. No. 464 Audible Signaling Appliances.
 - 6. No. 38 Manually Actuated Signaling Boxes.
 - 7. No. 346 Water flow Indicators for Fire Protective Signaling Systems.
 - 8. No. 1971 Visual Notification Appliances.
- C. Santa Cruz County Fire Authority Regulations
- D. California State Fire Marshall Regulations
- E. California Fire Code Section 1007, 2007 Edition with California Amendments
- F. California Mechanical Code Section 1009, 2007 Edition
- G. California Electrical Code 2007 Edition

1.06 QUALITY ASSURANCE

- A. Acceptable Manufacturers:
 - 1. The only acceptable Manufacturer is Notifier. This is the standard throughout the District.
- B. Installer Qualifications: Firm with at least 5 years of successful installation experience on projects with fire alarm Systems work similar to that required for this project Firm with factory authorized Service organization and spare parts stock. The installing company shall employ NICET (minimum Level II Fire Alarm Technology) technicians on site to guide the final checkout and to ensure the system's integrity.
- C. All equipment and accessories to be the product of one manufacturer regularly engaged in manufacture of fire alarm systems and whose products have been in satisfactory use in similar service for not less than 5 years.
- D. Supply all equipment and accessories new, free from defects, and listed by Underwriters' Laboratories, Inc. or Factory Mutual Research Corporation.
- E. Supply all equipment and accessories in compliance with the applicable standards listed in article 1.05 of this section and with all applicable national, state and local codes.
- F. All control equipment shall have Transient Protection to comply with UL 864.
- G. Where Fire Alarm circuits leave building, additional Transient Protection shall be provided for each circuit.
- H. System control shall be UL listed for Power Limited Application and all circuits shall be marked in accordance with NEC Article 760-23.
- I. Devices shall be UL listed under Standard #497B

1.07 APPROVALS:

- A. The system shall have proper listing and/or approval from the following nationally recognized agencies:
 - 1. UL Underwriters Laboratories Inc.
 - 2. FM Factory Mutual

3. ULC Underwriters Laboratories Canada
4. MEA Material Equipment Acceptance (NYC)
5. CSFM California State Fire Marshal
6. The Fire Alarm Control Panel shall meet UL Standard 864, (Control Units).
7. The system shall be listed by the national agencies as suitable for extinguishing release applications.

PART 2 - PRODUCTS

2.01 EQUIPMENT AND MATERIAL, GENERAL:

- A. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protective signaling system, meeting the National Fire Alarm Code.
- B. All equipment and components shall be installed in strict compliance with manufacturers' recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.
- C. All Equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

2.02 CONDUIT AND WIRE:

- A. Conduit:
 1. Conduit shall be in accordance with The National Electrical Code (NEC), local and state requirements.
 2. All wiring shall be installed in conduit or in metal raceway. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit.
 3. Cable must be separated from any open conductors of Power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, as per NEC Article 760-29.
 4. Wiring for 24 volt control, alarm notification, emergency communication and similar power-limited auxiliary functions may be run in the same conduit as initiating and signaling line circuits.

All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.

5. Conduits shall not enter the Fire Alarm Control Panel, or any other remotely mounted Control Panel equipment or back boxes, except where conduit entry is specified by the FACP manufacturer.
6. Conduit shall be ¾ inch minimum UON on the drawings.
7. All fire alarm conduits in concealed location shall have painted red strips down two-side 180 degree apart.

B. Wire:

1. All fire alarm system wiring shall be new.
2. Wiring shall be in accordance with local, state and national codes [e.g., NEC Article 760] and as recommended by the manufacturer of the Fire Alarm System. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 16 AWG (1.02 mm) for Initiating Device Circuits and Signaling Line Circuits, and 12 AWG (1.63 mm) for Notification Appliance Circuits.
3. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
4. Wiring used for the multiplex communication loop shall be twisted and shielded and support a minimum wiring distance of 10,000 feet (254m). The system shall support up to 1,000 ft. (25.4 m) of untwisted, unshielded wire. The system shall permit use of IDC and NAC wiring in the same conduit with the communication loop.
5. All field Fire Alarm wiring shall be completely supervised. In the event of a primary power failure, disconnected standby battery, removal of any internal modules, or any open circuits in the field wiring: a trouble signal will be activated unit system and its associated field wiring are restore to normal condition.
6. Wires in junction boxes and terminal cabinets shall be identified with permanent Brady type tags. The fire alarm cable shall be marked in accordance with NEC.
7. The Fire Alarm Control Panel shall be capable of T-Tapping Class B (NFPA Style 4) Signaling Line Circuits (SLC's). Systems, which do not allow or have restrictions in, for example, the amount of T-Taps, length of T-taps etc. is not acceptable.
8. All wiring shall be checked and tested to insure that there are not grounds, opens and shorts.
9. Wire nuts splices are not allowed.

10. All final terminations of the field wiring shall be made by or under the direct supervision of the Fire Alarm System Manufacturer's representative. Any damage to the Panel as a result of the contractor terminating wires or powering up the panel without supervision of an authorized representative of the Fire Alarm Panel Manufacturer shall be charged to the installing contractor.
 11. All exterior and interior Fire Alarm wiring shall be of type as specified on respective Fire Alarm Plans and as approved by DSA. Substitutions will not be permitted.
 12. Identify conductors within each junction box, cabinet and enclosure where a tap, splice, or termination is made. Identify conductors with permanent metal tags or by plastic-coated, self-sticking, printed markers or by heat-shrink type sleeves. Wire the alarm initiating and notification signal devices so that removal will cause the system trouble device to sound. Each conductor used for the same specific function shall be distinctively color-coded. Use two different color codes for each interior alarm circuit; one for each loop. Each circuit color code wire shall remain uniform throughout circuit.
- C. Terminal Boxes, Junction Boxes and Cabinets:
1. All boxes and cabinets shall be UL listed for their use and purpose.
 2. Paint red all boxes containing wiring fire alarm wiring and identify with 2-1/2" high white letter marking as "FA".
 3. Terminal cabinets with identified pressure type terminal strips
- D. Initiating Circuits shall be arranged to serve like categories (manual, smoke, water flow). Mixed category circuitry shall not be permitted except on signaling line circuits connected to intelligent reporting devices.
- E. The Fire Alarm Control Panel shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the Main Power Distribution Panel as FIRE ALARM. Fire Alarm Control Panel Primary Power wiring shall be 12 AWG. The Control Panel Cabinet shall be grounded securely to either a cold water pipe or grounding rod.

2.03 MAIN FIRE ALARM CONTROL PANEL:

- A. The new Main Fire Alarm Control Panel is as specified on the fire alarm drawings.

- B. The FACP shall be capable of coding Notification circuits in March Time (120 PPM), Temporal, and California Code.
- C. All interfaces and associated equipment are to be protected so that they will not be affected by voltage surges or line transients, consistent with UL standard 864 requirements.
- D. Field Charging Power Supply: The FCPS is a device designed for use as either a remote 24-volt power supply or used to power Notification Appliances.
 - 1. The FCPS shall offer up to 6.0 amps (4.0 amps continuous) of regulated 24 volt power. It shall include an integral charger designed to charge 7.0 amp hour batteries and to support 24 hour standby.
 - 2. The Field Charging Power Supply shall have two input triggers. The input trigger shall be a Notification Appliance Circuit (from the fire alarm control panel) or a relay. Four outputs (two Style Y or Z and two style Y) shall be available for connection to the Notification devices.
 - 3. The FCPS shall include an attractive surface mount backbox.
 - 4. The Field Charging Power Supply shall include the ability to delay the AC fail delay per 2007 NFPA requirements.
 - 5. The FCPS include power limited circuitry, UL standards.
- E. Specific System Operations
 - 1. Smoke Detector Sensitivity Adjust: A means shall be provided for adjusting the sensitivity of any or all analog intelligent smoke detectors in the system from the control panel. Sensitivity range shall be within the allowed UL window.
 - 2. Alarm Verification: Each intelligent addressable smoke detector in the system shall be independently selected and enabled to be alarm verified. The alarm verification delay shall be programmable from 5 to 30 seconds. The FACP shall keep a count of the number of times that each detector has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.
 - 3. Point Disable: Any device in the system may be enabled or disabled through the system keypad.
 - 4. Read Status: The system shall be able to display the following status functions:
 - a. Device status
 - b. Device types.
 - c. View analog detector values.

- d. Device zone assignments.
- e. Custom device labels.
- f. All program Parameters.
- g. Zone status
- h. Notification appliance circuit status
- i. System parameters

F. System parameters.

1. System Status Reports: Upon command from an operator of the system, a status report will be generated and printed, listing system status.
2. System History Recording and Reporting: The Fire Alarm Control Panel shall contain a History Buffer that will be capable of storing up to 650 system alarms/troubles/operator actions. Each of these activations will be stored and time and date stamped with the actual time of the activation. The contents of the History Buffer may be manually reviewed, one event at a time, or printed in its entirety.
3. Automatic Detector Maintenance Alert: The Fire Alarm Control Panel shall automatically interrogate each intelligent smoke detector and shall analyze the detector responses over a period of time. If any intelligent smoke detector in the system responds with a reading that is below or above normal limits, then the system will enter the Trouble Mode, and the particular detector will be annunciated on the system display, and printed on the optional printer. This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.
4. Pre-alarm Function: The system shall provide two levels of pre-alarm warning to give advance notice of a possible fire situation. Both pre-alarm levels shall be fully field adjustable. The first level shall give an audible indication at the panel. The second level shall give an audible indication and may also activate control relays. The system shall also have the ability to activate local detector sounder bases at the pre-alarm level, to assist in avoiding nuisance alarms.
5. Software Zones: The FACP shall provide 56 software zones. All addressable devices may be field programmed to be grouped into software zones for control activation and annunciation purposes.

G. Circuit Arrangement

1. Alarm initiating circuits of the low voltage type and arranged for operation from normally open contact devices.
2. Provide means whereby any zone may be disconnected from the system. Removing any zone or circuit shall leave the remainder of the system in normal operating condition, and light an individual trouble lamp which shall remain lighted until the circuit is restored to normal operating condition.
3. Arrange circuits so that if an open circuit occurs in the horn it shall not prevent other audible signals on the same circuit from sounding.
4. Each circuit is individually fused.

H. Circuit Supervision

1. Each Alarm Initiating Circuit, Alarm Indicating Circuit, shall be supervised against the occurrence of a break or ground fault condition in the field wiring. These conditions shall cause a trouble signal to sound in the control panel until manually silenced by an off switch
2. Each circuit has individual trouble lamps (amber) and alarm lamps (red).

I. Trouble Signals

1. Arrange the trouble circuit for ring back operation to prevent switch disarrangement during normal supervisory condition. Automatic reset arrangement is acceptable in lieu of ring back operation.
2. System trouble switch off and on lamps shall be visible through the control panel door.

2.04 SYSTEM COMPONENTS:

A. Horns, Strobes and combination Horn/Strobes

1. Shall be flush-mounted in all finished areas and surface mounted in all equipment, storage and mechanical rooms and shall be provided for all locations as shown on respective Fire Alarm Plans.
2. See NFPA 72, 2007, section 7.4 for Audible Notification Appliance characteristics and audible level requirements and restrictions.
3. Exterior Horn: shall be mounted in an approved weather proof box manufactured by Wheelock and shall be capable of being flush or surface mounted.

4. Strobe and combination Horn/Strobes: Candela rating shall be 15, 30, 75 or 110 as required per NFPA-72, Section 7.5.2 and as indicated on the DSA Approved Fire Alarm Plans. The flash rate shall not exceed two flashes per second (2 Hz) nor be less than one flash every second (1Hz) throughout the listed voltage range of the appliances. Combination Horn/Strobes shall operate simultaneously from one power source.

B. Addressable Devices - General

1. Addressable Devices shall provide an address-setting means using rotary decimal switches.
2. Addressable Devices shall use simple to install and maintain decade (numbered 0 to 9) type address switches. Devices which use a binary address setting method, such as a dip switch, are not an allowable substitute.
3. Detectors shall be intelligent and addressable, and shall connect with two wires to the Fire Alarm Control Panel Signaling Line Circuits.
4. Addressable Smoke and Thermal Detectors shall provide dual alarm and power LEDs. Both LEDs shall flash under normal conditions indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. If required, the flashing mode operation of the detector LEDs shall be optional through the system field program. An output connection shall also be provided in the base to connect an external remote alarm LED.
5. The Duct Detectors shall have the same features described in 2.04-B.4. Variations in duct air velocity between 400 and 4,000 FPM shall not cause any false alarms. Factory set the detector sensitivity and provides for field adjustment from the FACP. Within the range of UL defined sensitivity. Mount the detectors head in an enclosure suitable for mounting to an air duct. Provide an air sampling tube that extends into the duct air stream. Provide an LED remote alarm indicator, ceiling mounted directly below each duct detector
6. The Fire Alarm Control Panel shall permit detector sensitivity adjustment through field programming of the system. Sensitivity shall be automatically adjusted by the panel on a time-of-day basis.

7. Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72.
8. The Detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper proof feature. An optional base shall be available with a built-in (local) sounder rated at 85 DBA minimum.
9. The Detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.
10. Detectors shall also store an internal identifying type code that the control panel shall use to identify the type of device (ION, PHOTO, THERMAL).

C. Addressable Pull Box (Manual Pull Station)

1. Manual fire alarm stations shall be non-code, single action, non-break glass type, equipped with key lock so that they may be tested without operating the handle and with terminal block for field wiring in flush station box.
2. Manual Pull Stations must be designed such that after an actual activation, they cannot be restored to normal except by key reset.
3. Control and Operating mechanism shall be operable with one hand and shall not require tight grasping, pinching or twisting of the wrist. Maximum force required to activate controls shall be no greater than 5 pounds per CBC 1117B.6.
4. An operated station shall automatically condition itself so as to be visually detected, as operated, at a minimum distance of 100 feet (30.5 m) front or side.
5. Manual stations shall have clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches (44 mm) or larger.
6. Manual Pull Stations shall be suitable for flush mounting on matching back-box.

7. Addressable pull boxes shall, on command from the control panel, send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key.
 8. All operated stations shall have a positive, visual indication of operation and utilize a key type reset.
- D. Addressable Photoelectric Smoke Detector
1. The Detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.
- E. Intelligent Thermal Detectors
1. Thermal Detectors shall be intelligent addressable devices rated at 135 degrees Fahrenheit (58 degrees Celsius) and have a rate-of-rise element rated at 15 degrees F (9.4 degrees C) per minute. It shall connect via two wires to the fire alarm control panel signaling line circuit.
- F. Intelligent Duct Smoke Detector
1. The in-duct Smoke Detector housing shall accommodate either an intelligent ionization detector or an intelligent photoelectric detector, of that provides continuous analog monitoring and alarm verification from the panel.
 2. When sufficient smoke is sensed, an alarm signal is initiated at the FACP, and appropriate action taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system.
- G. Addressable Dry Contact Monitor Module
1. Addressable Monitor Modules shall be provided as required to connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the fire alarm control panel SLCs.
 2. The Monitor Module shall mount in a 4-inch square (101.6 mm square), 2-1/8 inch (54 mm) deep electrical box.
 3. The IDC zone shall be suitable for Style D or Style B operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.

4. For difficult to reach areas, the Monitor Module shall be available in a miniature package and shall be no larger than 2-3/4 inch (70 mm) x 1-1/4 inch (31.7 mm) x 1/2 inch (12.7 mm). This version need not include Style D or an LED.
- H. Two Wire Detector Monitor Module
1. Addressable Monitor Modules shall be provided as required to connect one supervised IDC zone of conventional 2-wire smoke detectors or alarm initiating devices (any N.O. dry contact device).
 2. The two-wire Monitor Module shall mount in a 4-inch square (101.6 mm square), 2-1/8 inch (54 mm) deep electrical box or with an optional surface backbox.
 3. The IDC zone may be wired for Class A or B (Style D or Style B) operation. An LED shall be provided that shall flash under normal conditions, indicating that the Monitor Module is operational and in regular communication with the control panel.
- I. Addressable Control Module
1. Addressable Control Modules shall be provided to supervise and control the operation of conventional NACs of compatible, 24 VDC powered, polarized audio/visual notification appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay.
 2. The Control Module shall mount in a standard 4-inch square (101.6 mm square), 2-1/8 inch (54 mm) deep electrical box, or to a surface mounted back box.
 3. The Control Module NAC may be wired for Style Z or Style Y (Class A/B) with up to 1 amp of inductive A/V signal, or 2 amps of resistive A/V signal operation, or as a dry contact (Form-C) relay. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100% of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.
 4. Audio/visual power shall be provided by a separate supervised power circuit from the main fire alarm control panel or from a supervised, UL listed remote power supply.
 5. The Control Module shall be suitable for pilot duty applications and rated for a minimum of 0.6 amps at 30 VDC.

J. Isolator Module

1. Isolator Modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC Class A or Class B branch. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC loop segment or branch. At least one isolator module shall be provided for each floor or protected zone of the building.
2. If a wire-to-wire short occurs, the Isolator Module shall automatically open-circuit (disconnect) the SLC. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section.
3. The Isolator Module shall not require any address setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.
4. The Isolator Module shall mount in a standard 4-inch (101.6 mm) deep electrical box or in a surface mounted back box. It shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

K. Addressable Relay Module

1. Addressable Relay Modules shall be provided for HVAC control and other building functions. The relay shall be form C and rated for a minimum of 2.0 Amps resistive or 1.0 Amps inductive. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100% of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.

2.05 BATTERIES:

- A. Shall be 12 volt, Gell-Cell type (two required).
- B. The Batteries shall have sufficient capacity to power the fire alarm system for not less than twenty-four hours plus 5 minutes of alarm upon a normal AC power failure.
- C. The Batteries are to be completely maintenance free.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Installation shall be in accordance with the NEC, NFPA 72, local and state codes, as shown on the drawings, and as recommended by the major equipment manufacturer. No work shall begin prior to obtaining stamped approved drawings for the Division of the State Architect Stamp drawing must be kept on Project Site at all times
- B. Install Fire Alarm System in accordance with Manufacturer's written instructions, as shown on the drawings and as specified herein.
- C. Install Smoke Detectors heads not more than two weeks prior to final inspection. If necessary, shroud Smoke Detectors in polyethylene sacks ("Baggies) until construction is completed in any one area. Test the detectors in place.
- D. All conduit, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Smoke Detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke detectors from contamination and physical damage.
- E. All fire detection and alarm system devices, control panels and remote annunciator shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas.
- F. All fire alarm equipment should be relatively free of dirt and dust. There should be necessary keys and minor spare parts in the fire alarm control panel left by the installing company. The installing company should also have attached the control panel their 24 hours emergency number. Conduit runs should be straight and run parallel to building line. Check for proper support, box and fitting covers, etc. All exterior wire and conduit should be rain and water tight. Underground runs should be approved materials for that type application
- G. Wire should be neatly terminated at terminal strips and protected from physical damage. The use of "wire-nut" type connectors will not be permitted. Splices will not be permitted in underground exterior pull boxes.

- H. Provide color coding for all fire alarm circuit conductors. Do not transpose colors.
- I. All wiring shall be checked and tested to insure that there are no grounds, opens or shorts.

3.02 VISUAL INSPECTIONS

- A. Prior to testing, contractor to conduct a visual inspection of the systems components and installation.
- B. Check panel marking
 - 1. Annunciator display with devices identified. Lamp test to assure all lamps functioning for system acceptance test.
 - 2. Check that special keys, tool, etc., are ready available to restore tested devices back to normal.
 - 3. Prior to testing establish means of silencing audible devices.

3.03 TESTS

- A. The Contractor shall test fully the completed fire alarm system in accordance with NFPA-72 in the presence of the Owner's Representative and under the direction of the factory authorized representative. Testing shall include each and every device and equipment of the entire Fire Alarm System.
- B. Provide the service of a competent, factory-trained engineer or technician authorized by the manufacturer of the equipment to technically supervise and participate during all of the adjustments and tests for the system. Make all adjustments and tests in the presence of the Owner, Architect, Jurisdictional Fire Marshal, the Inspector of Record, General Contractor and Electrical Contractor.
- C. The system shall be completely tested prior to final acceptance testing in compliances with NFPA-72 Chapter 7-2. All points shall be tested from point of initiation to the final point or points of annunciation. All circuits shall be tested for continuity and ability to transmit the required signal correctly to the FACP. Any problem due to wrong wire type, wire twist, impedance, mismatches, noise filtering or shielding shall be completely corrected during pre-testing and prior to any final acceptance tests.

- D. When the system has been completed and prior to the final inspection, furnish testing equipment and perform the following tests on both normal and battery power:
1. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
 2. Open initiating device circuits to see if trouble signal actuates.
 3. Open audible signal circuits to see if the trouble signal actuates.
 4. Ground initiating devices circuits and verify response of trouble signals.
 5. Ground audible sign circuits and verify response of trouble signals.
 6. Check installation, supervision, operation and sensitivity of smoke detectors as recommended by the manufacture to ascertain that they will avoid false alarm signals and will function as specified.
 7. Contractor shall furnish to the Owner one approved smoke test device.
 8. Proceed to operate a Manual Pull Station, Products of Combustion Detector, and each Sprinkler System Flow Switch to Initiate Alarm condition.
 9. Central Station notification: Verify that one set of conductors in the terminal cabinet becomes a short circuit on any "trouble" condition and that the other set becomes a short circuit on any "alarm" condition. Verify that the conductor groups are labeled properly.
 10. Upon determination that all items being tested have operated satisfactorily, or as designed, restore initiated devices to normal and reset Fire Alarm Control Panel. During this period of time the audible alarm devices may be silenced.
 11. Visually check all switches, lamps and meters, for normal position and operation before closing control panel and notify fire department tests are complete.
 12. When any defects are detected, make repairs or install replacement components, and repeat the tests as required by the Authority Having Jurisdiction.
- E. Test Report:
1. Provide a complete report listing every device, the date it was tested, the results and the date retested (if failure occurred during the previous test). The test report shall indicate that every device tested successfully.
 2. Submit two typed copies of the test report in a neatly bound folder for review and approval. Failure to comply with this will result in a delay of final testing and acceptance.

- F. Functional performance testing:
1. After the approval of the test report, provide a schedule of final testing to be done in the presence of the inspector of Record (IOR) from Division of the State Architect, Electrical Engineer and District's Representative. The schedule must be received by the Engineer a minimum of 2 weeks prior to the Final Test Date and must list the dates and time slots in which the various systems can be tested.
 2. Coordination of the Final Test dates with all parties (General Contractor; Inspector of Record – IOR; Electrical Engineer; District Representative and others) shall be the sole responsibility of the Contractor. If a party is required to be present during any phase of testing to activate a device, ensure that the party or a qualified representative of the party is present throughout that phase of the testing.
- G. In the event that the system fails to function properly during the testing as a result of inadequate pre-testing or preparation, the contractor shall bear all costs incurred by the necessity for retesting including test equipment, transportation, subsistence and the engineer's hourly rate.
- H. Contractor shall replace at no costs to the District all Devices, which are found defective or do not operate within factory specified tolerances.
- I. Contractor shall submit the testing agency's final report for review prior to project closeout and final acceptance by the District. Test report shall indicate test dates, devices tested, results, observation, deficiencies and remedies. Test report shall be included in the operation and maintenance manuals.

Upon successful completion of tests, the Contractor shall so certify in writing to the Owner's representative.

3.04 FINAL INSPECTION:

- A. At the final inspection an authorized representative of the manufacturer of the major equipment shall demonstrate that the systems function properly in every respect.

END OF SECTION