

DIVISION 16

ELECTRICAL

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following:
 - 1. Raceways.
 - 2. Building wire and connectors.
 - 3. Supporting devices for electrical components.
 - 4. Electrical identification.
 - 5. Utility company electricity-metering components.
 - 6. Concrete equipment bases.
 - 7. Electrical demolition.
 - 8. Cutting and patching for electrical construction.

1.02 SUBMITTALS

- A. Product Data: For utility company electricity-metering components.
- B. Shop Drawings: Dimensioned plans and sections or elevation layouts and single-line diagram of electricity-metering component assemblies specific to this Project.

1.03 QUALITY ASSURANCE

- A. 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.
- B. Devices for Utility Company Electricity Metering: Comply with utility company published standards.
- C. Comply with NFPA 70.

1.04 COORDINATION

- A. Coordinate chases, slots, inserts, sleeves, and openings for electrical supports, raceways, and cable with general construction work.
- B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment that requires positioning before closing in the building.
- C. Coordinate electrical service connections to components furnished by utility companies.
 - 1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for service entrances and electricity-metering components.

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- D. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 8 Section "Access Doors and Frames."
- E. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.

PART 2 - PRODUCTS

2.01 RACEWAYS

- A. EMT: Electrical metallic tubing; ANSI C80.3, zinc-coated steel, with insulated throat compression fittings.
- B. FMC: Flexible metal conduit; zinc-coated steel.
- C. IMC: Intermediate metal conduit; ANSI C80.6, zinc-coated steel, with threaded fittings.
- D. LFMC: Liquidtight flexible metal conduit; zinc-coated steel with sunlight-resistant and mineral-oil-resistant plastic jacket.
- E. RMC: Rigid metal conduit; galvanized rigid steel; ANSI C80.1.
- F. RNC: Rigid nonmetallic conduit; NEMA TC 2, Schedule 40 PVC, with NEMA TC3 fittings.
- G. Raceway Fittings: Specifically designed for raceway type with which used.

2.02 WIRES, CABLES, AND CONNECTIONS

- A. Conductors, No. 10 AWG and Smaller: Solid or stranded copper.
- B. Conductors, Larger Than No. 10 AWG: Stranded copper.
- C. Insulation: Thermoplastic, rated 600 V, 75 deg C minimum, Type THW, THHN-THWN, or USE depending on application.
- D. Cable: Type MC with ground wire.
- E. Wire Connectors and Splices: Units of size, ampacity rating, material, type, and class suitable for service indicated.

2.03 SUPPORTING DEVICES

- A. Material: Cold-formed steel, with corrosion-resistant coating.
- B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.

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- C. Slotted-Steel Channel: Flange edges turned toward web, and 9/16-inch- (14-mm-) diameter slotted holes at a maximum of 2 inches (50 mm) o.c., in webs. Strength rating to suit structural loading.
- D. Nonmetallic Slotted Channel and Angle: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (203 mm) o.c., in at least one surface. Strength rating to suit structural loading.
- E. Slotted Channel Fittings and Accessories: Recommended by the manufacturer for use with the type and size of channel with which used.
 - 1. Materials: Same as channels and angles, except metal items may be stainless steel.
- F. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring-steel clamps or click-type hangers.
- G. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.
- H. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable-iron casting with hot-dip galvanized finish.
- I. Expansion Anchors: Carbon-steel wedge or sleeve type.
- J. Toggle Bolts: All-steel springhead type.
- K. Powder-Driven Threaded Studs: Heat-treated steel.

2.04 ELECTRICAL IDENTIFICATION

- A. Identification Device Colors: Use those prescribed by ANSI A13.1, NFPA 70, and these Specifications.
- B. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape, not less than 1 inch wide by 3 mils thick (25 mm wide by 0.08 mm thick).
- C. Tape Markers for Conductors: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.
- D. Color-Coding Cable Ties: Type 6/6 nylon, self-locking type. Colors to suit coding scheme.
- E. Underground Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape compounded for permanent direct-burial service, and with the following features:
 - 1. Not less than 6 inches wide by 4 mils thick (150 mm wide by 0.102 mm thick).
 - 2. Embedded continuous metallic strip or core.
 - 3. Printed legend that indicates type of underground line.

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- F. Engraved-Plastic Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched or drilled for mechanical fasteners 1/16-inch (1.6-mm) minimum thickness for signs up to 20 sq. in. (129 sq. cm) and 1/8-inch (3.2-mm) minimum thickness for larger sizes. Engraved legend in black letters on white background.
- G. Warning and Caution Signs: Preprinted; comply with 29 CFR 1910.145, Chapter XVII. Colors, legend, and size appropriate to each application.
 - 1. Interior Units: Aluminum, baked-enamel-finish, punched or drilled for mechanical fasteners.
 - 2. Exterior Units: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate with 0.0396-inch (1-mm), galvanized-steel backing. 1/4-inch (6-mm) grommets in corners for mounting.
- H. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers.

2.05 EQUIPMENT FOR UTILITY COMPANY'S ELECTRICITY METERING

- A. Comply with requirements of electrical power utility company for current transformer cabinets and meter sockets.

2.06 CONCRETE BASES

- A. Concrete Forms and Reinforcement Materials: As specified in Division 3 Section "Cast-in-Place Concrete."
- B. Concrete: 3000-psi (20.7-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.01 ELECTRICAL EQUIPMENT INSTALLATION

- A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom.
- B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- D. Right of Way: Give to raceways and piping systems installed at a required slope.

3.02 RACEWAY APPLICATION

- A. Outdoor Installations:
 - 1. Exposed: RMC.

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2. Concealed: RNC.
3. Underground, Single Run: RNC.
4. Underground, Grouped: RNC.
5. Connection to Vibrating Equipment: LFMC.
6. Boxes and Enclosures: NEMA 250, Type 3R or Type 4, unless otherwise indicated.

B. Indoor Installations:

1. Exposed: EMT except in wet or damp locations, use IMC.
2. Concealed in Walls or Ceilings: EMT.
3. In Concrete Slab: IMC.
4. Below Slab on Grade or in Crawlspace: RNC
5. Connection to Vibrating Equipment: FMC; except in wet or damp locations: LFMC.
6. Boxes and Enclosures: NEMA 250, Type 1, unless otherwise indicated.

3.03 RACEWAY AND CABLE INSTALLATION

- A. Conceal raceways and cables, unless otherwise indicated, within finished walls, ceilings, and floors.
- B. Keep legs of raceway bends in the same plane and keep straight legs of offsets parallel.
- C. Use RMC elbows where RNC turns out of slab.
- D. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or woven 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 wires.
- E. Install telephone and signal system raceways, 2-inch trade size (DN 53) and smaller, in maximum lengths of 150 feet (45 m) and with a maximum of two 90-degree bends or equivalent. Add pull boxes where necessary to accomplish this.
- F. Connect motors and equipment subject to vibration, noise transmission, or movement with a maximum of 72-inches (1830-mm) flexible conduit. Install LFMC in wet or damp locations. Install separate ground conductor across flexible connections.
- G. Set floor boxes level and trim after installation to fit flush to finished floor surface.

3.04 WIRING METHODS FOR POWER, LIGHTING, AND CONTROL CIRCUITS

- A. Application: Use wiring methods specified below to the extent permitted by applicable codes as interpreted by authorities having jurisdiction.
- B. Feeders and Branch Circuits: Insulated single conductors in raceway.
- C. Remote-Control Signaling and Power-Limited Circuits, Classes 1, 2, and 3: Insulated conductors in raceway unless otherwise indicated.

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3.05 WIRING INSTALLATION

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

3.06 ELECTRICAL SUPPORTING DEVICE APPLICATION

- A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, slotted channel system components.
- B. Dry Locations: Steel materials.
- C. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four with, 200-lb (90-kg) minimum design load for each support element.

3.07 SUPPORT INSTALLATION

- A. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.
- B. Size supports for multiple raceway or cable runs so capacity can be increased by a 25 percent minimum in the future.
- C. Support individual horizontal single raceways with separate, malleable-iron pipe hangers or clamps.
- D. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.
- E. Secure electrical items and their supports to building structure, using the following methods unless other fastening methods are indicated:
 - 1. Wood: Wood screws or screw-type nails.
 - 2. Gypsum Board: Toggle bolts. Seal around sleeves with joint compound, both sides of wall.
 - 3. Masonry: Toggle bolts on hollow block and expansion bolts on solid block. Seal around sleeves with mortar, both sides of wall.

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4. New Concrete: Concrete inserts with machine screws and bolts.
5. Structural Steel: Welded threaded studs.
 - a. Comply with AWS D1.1 for field welding.
6. Light Steel Framing: Sheet metal screws.
7. Fasteners for Damp, Wet, or Weather-Exposed Locations: Stainless steel.
8. Light Steel: Sheet-metal screws.
9. Fasteners: Select so load applied to each fastener does not exceed 25 percent of its proof-test load.

3.08 IDENTIFICATION MATERIALS AND DEVICES

- A. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.
- C. Self-Adhesive Identification Products: Clean surfaces before applying.
- D. Tag and label circuits designated to be extended in the future. Identify source and circuit numbers in each cabinet, pull and junction box, and outlet box. Color-coding may be used for voltage and phase identification.
- E. Install continuous underground plastic markers during trench backfilling, for exterior underground power, control, signal, and communication lines located directly above power and communication lines. Locate 6 to 8 inches (150 to 200 mm) below finished grade. If width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches (400 mm), overall, use a single line marker.
- F. Install warning, caution, and instruction signs where required to comply with 29 CFR 1910.145, Chapter XVII, and where needed to ensure safe operation and maintenance of electrical systems and of items to which they connect. Indoors install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

3.09 ELECTRICITY-METERING EQUIPMENT

- A. Install utility company metering equipment according to utility company's written requirements. Provide grounding and empty conduits as required by utility company.

3.10 FIRESTOPPING

- A. Apply firestopping to cable and raceway sleeves and other penetrations of fire-rated floor and wall assemblies to restore original undisturbed fire-resistance ratings of assemblies.

Firestopping installation is specified in Division 7 Section "Through-Penetration Firestop Systems."

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3.11 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger, in both directions, than supported unit. Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated.

3.12 DEMOLITION

- A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.
- B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.
- C. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches (50 mm) below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.
- D. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.

3.13 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.
- B. Repair, refinish and touch up disturbed finish materials and other surfaces to match adjacent undisturbed surfaces.

END OF SECTION 16050

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes grounding of electrical systems and equipment. Requirements specified in this Section may be supplemented by requirements of other Sections.

1.02 SUBMITTALS

- A. Product Data: For ground rods.
- B. Field quality-control test reports.

1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled under UL 467 as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70; for overhead-line construction and medium-voltage underground construction, comply with IEEE C2.
- C. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. 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:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Apache Grounding/Erico Inc.
 - 2. Boggs, Inc.
 - 3. Chance/Hubbell.
 - 4. Copperweld Corp.
 - 5. Dossert Corp.
 - 6. Erico Inc.; Electrical Products Group.
 - 7. Framatome Connectors/Burndy Electrical.
 - 8. Galvan Industries, Inc.
 - 9. Harger Lightning Protection, Inc.
 - 10. Hastings Fiber Glass Products, Inc.
 - 11. Heary Brothers Lightning Protection Co.

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12. Ideal Industries, Inc.
13. ILSCO.
14. Kearney/Cooper Power Systems.
15. Korns, C. C. Co.; Division of Robroy Industries.
16. Lightning Master Corp.
17. Lyncole XIT Grounding.
18. O-Z/Gedney Co.; a business of the EGS Electrical Group.
19. Raco, Inc.; Division of Hubbell.
20. Robbins Lightning, Inc.
21. Salisbury, W. H. & Co.
22. Superior Grounding Systems, Inc.
23. Thomas & Betts, Electrical.

2.02 GROUNDING CONDUCTORS

- A. For insulated conductors, comply with Division 16 Section "Conductors and Cables."
- B. Equipment Grounding Conductors: Insulated with green-colored insulation.
- C. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.
- D. Grounding Electrode Conductors: Stranded cable.
- E. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.
- F. Bare, Solid-Copper Conductors: ASTM B 3.
- G. Assembly of Bare, Stranded-Copper Conductors: ASTM B 8.
- H. Bare, Tinned-Copper Conductors: ASTM B 33.
- I. Copper Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
- J. Copper Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches (42 mm) wide and 1/16 inch (1.5 mm) thick.
- K. Tinned-Copper Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches (42 mm) wide and 1/16 inch (1.5 mm) thick.
- L. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulated spacer.
- M. Connectors: Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items. exothermic-welded type, in kit form, selected per manufacturer's written instructions.

2.03 GROUNDING ELECTRODES

- A. Ground Rods: Stainless steel.

- B. Ground Rods: Sectional type; stainless steel.
 - 1. Size: 5/8 by 96 inches (16 by 2400 mm) in diameter[per section].

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- B. In raceways, use insulated equipment grounding conductors.
- C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections.
- D. Underground Grounding Conductors: Use tinned-copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches (600 mm) below grade or bury 12 inches (300 mm) above duct bank when installed as part of the duct bank.
- E. Equipment Grounding Conductors: Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
 - 1. Install insulated equipment grounding conductors in feeders and branch circuits.
 - 2. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install an insulated equipment grounding conductor. Isolate equipment grounding 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. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
 - 4. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, 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.
 - a. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
 - 5. Metal Poles Supporting Outdoor Lighting Fixtures: Provide a grounding electrode in addition to installing an insulated equipment grounding conductor with supply branch-circuit conductors.
 - 6. Common Ground Bonding with Lightning Protection System: Bond electrical power system ground directly to lightning protection system grounding conductor at closest

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point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

- F. AWG for underground conductor, and bury 18 inches (450 mm) below grade, minimum.
- G. Ground Rods: 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.
 - 1. Drive ground rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
 - 2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except as otherwise indicated. Make connections without exposing steel or damaging copper coating.
- H. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- I. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers or supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.
- J. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
- K. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.
- L. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.
- M. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.
- N. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.
- O. Connections: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
 - 2. Make connections with clean, bare metal at points of contact.
 - 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.

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4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
 6. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
 7. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
 8. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
 9. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
 10. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
 11. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.
- P. Overhead Line Grounding: Comply with IEEE C2 except where stricter requirements are indicated. Use 2 or more parallel ground rods if a single ground rod electrode resistance to ground exceeds 25 ohms.
1. Drive ground rods to a depth of 12 inches (300 mm) below finished grade in undisturbed earth.
 2. Ground Rod Connections: Use clamp-type connectors listed for the purpose for underground connections and connections to rods.
 3. Lightning Arresters: Separate arrester grounds from other grounding conductors.
 4. Secondary Neutral and Tank of Transformer: Interconnect and connect to grounding conductor.
 5. Protect grounding conductors on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces..
- Q. Pad-Mounted Transformers and Switches: Install two ground rods and counterpoise circling pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 2 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 inches (450 mm) below grade and 6 inches (150 mm) from the foundation.

3.02 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing:
1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
 2. Test completed grounding system at each location where a maximum ground-resistance level is indicated and at service disconnect enclosure grounding terminal. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.
 3. Provide drawings locating each ground rod, 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. Nominal maximum values are as follows:
 - a. Equipment Rated 500 kVA and Less: 10 ohms.
 - b. Equipment Rated 500 to 1000 kVA: 5 ohms.
 - c. Equipment Rated More Than 1000 kVA: 3 ohms.
 - d. Overhead Distribution Line Equipment: 25 ohms.
 - e. Substations and Pad-Mounted Switching Equipment: 5 ohms.
 - f. Manhole Grounds: 10 ohms.

END OF SECTION 16060

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes general requirements for electrical field testing and inspecting. Detailed requirements are specified in each Section containing components that require testing. General requirements include the following:
1. Qualifications of testing agencies and their personnel.
 2. Suitability of test equipment.
 3. Calibration of test instruments.
 4. Coordination requirements for testing and inspecting.
 5. Reporting requirements for testing and inspecting.

1.02 QUALITY ASSURANCE

- A. Testing Agency Qualifications: As specified in each Section containing electrical testing requirements and in subparagraph and associated subparagraph below.
1. Independent Testing Agencies: Independent of manufacturers, suppliers, and installers of components to be tested or inspected.
 - a. Testing Agency's Field Supervisor for Power Component Testing: 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 Division 16 power component Sections.
- B. Test Equipment Suitability: Comply with NETA ATS, Section 5.2.
- C. Test Equipment Calibration: Comply with NETA ATS, Section 5.3.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 GENERAL TESTS AND INSPECTIONS

- A. If a group of tests are specified to be performed by an independent testing agency, prepare systems, equipment, and components for tests and inspections, and perform preliminary tests to ensure that systems, equipment, and components are ready for independent agency testing. Include the following minimum preparations as appropriate:
1. Perform insulation-resistance tests.
 2. Perform continuity tests.
 3. Perform rotation test (for motors to be tested).

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4. Provide a stable source of single-phase, 208/120-V electrical power for test instrumentation at each test location.
- B. Test and Inspection Reports: In addition to requirements specified elsewhere, report the following:
1. Manufacturer's written testing and inspecting instructions.
 2. Calibration and adjustment settings of adjustable and interchangeable devices involved in tests.
 3. Tabulation of expected measurement results made before measurements.
 4. Tabulation of "as-found" and "as-left" measurement and observation results.

END OF SECTION 16080

**SECTION 16120
CONDUCTORS AND CABLES**

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

1.02 SUBMITTALS

- A. Field quality-control test reports.

1.03 QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 - 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.

2.02 CONDUCTORS AND CABLES

- A. Available Manufacturers:
 - 1. Alcan Aluminum Corporation; Alcan Cable Div.
 - 2. American Insulated Wire Corp.; a Leviton Company.
 - 3. General Cable Corporation.
 - 4. Senator Wire & Cable Company.
 - 5. Southwire Company.
- B. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.
- C. Conductor Material: Copper complying with NEMA WC [7]; stranded conductor.

**SECTION 16120
CONDUCTORS AND CABLES**

- D. Conductor Insulation Types: Type THHN-THWN complying with NEMA WC [7].

2.03 CONNECTORS AND SPLICES

- A. Available Manufacturers:
 - 1. AFC Cable Systems, Inc.
 - 2. AMP Incorporated/Tyco International.
 - 3. Hubbell/Anderson.
 - 4. O-Z/Gedney; EGS Electrical Group LLC.
 - 5. 3M Company; Electrical Products Division.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.01 CONDUCTOR AND INSULATION APPLICATIONS

- A. Service Entrance: Type THHN-THWN, single conductors in raceway.
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and in Crawlspace: Type THHN-THWN, single conductors in raceway.
- E. Exposed Branch Circuits, including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- G. Branch Circuits Concealed in Concrete and below Slabs-on-Grade: Type THHN-THWN, single conductors in raceway.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord.
- I. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- J. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.02 INSTALLATION

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

**SECTION 16120
CONDUCTORS AND CABLES**

- B. 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.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 16 Section "Basic Electrical Materials and Methods."
- F. Seal around cables penetrating fire-rated elements according to Division 7 Section "Through-Penetration Firestop Systems."
- G. Identify and color-code conductors and cables according to Division 16 Section "Basic Electrical Materials and Methods."
- H. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- I. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.03 FIELD QUALITY CONTROL

- A. Testing: Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.
- B. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 16120

**SECTION 16130
RACEWAYS AND BOXES**

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. See Division 2 Section "Underground Ducts and Utility Structures" for exterior ductbanks, manholes, and underground utility construction.
- C. See Division 7 Section "Through-Penetration Firestop Systems" for firestopping materials and installation at penetrations through walls, ceilings, and other fire-rated elements.
- D. See Division 16 Section "Basic Electrical Materials and Methods" for supports, anchors, and identification products.
- E. See Division 16 Section "Wiring Devices" for devices installed in boxes and for floor-box service fittings.

1.02 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets indicated.
- B. Shop Drawings: Show fabrication and installation details of components for raceways, fittings, boxes, enclosures, and cabinets.

1.03 QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 - 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.

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RACEWAYS AND BOXES**

2.02 METAL CONDUIT AND TUBING

- A. Available Manufacturers:
 - 1. AFC Cable Systems, Inc.
 - 2. Alflex Inc.
 - 3. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 4. Electri-Flex Co.
 - 5. Grinnell Co./Tyco International; Allied Tube and Conduit Div.
 - 6. LTV Steel Tubular Products Company.
 - 7. Manhattan/CDT/Cole-Flex.
 - 8. O-Z Gedney; Unit of General Signal.
 - 9. Wheatland Tube Co.

- B. Rigid Steel Conduit: ANSI C80.1.

- C. Aluminum Rigid Conduit: ANSI C80.5.

- D. IMC: ANSI C80.6.

- E. EMT and Fittings: ANSI C80.3.
 - 1. Fittings: Compression type.

- F. FMC: Zinc-coated steel.

- G. LFMC: Flexible steel conduit with PVC jacket.

- H. Fittings: NEMA FB 1; compatible with conduit and tubing materials.

2.03 NONMETALLIC CONDUIT AND TUBING

- A. Available Manufacturers:
 - 1. American International.
 - 2. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 3. Arco Corp.
 - 4. Cantex Inc.
 - 5. Certainteed Corp.; Pipe & Plastics Group.
 - 6. Condux International.
 - 7. ElecSYS, Inc.
 - 8. Electri-Flex Co.
 - 9. Lamson & Sessions; Carlon Electrical Products.
 - 10. Manhattan/CDT/Cole-Flex.
 - 11. RACO; Division of Hubbell, Inc.
 - 12. Spiralduct, Inc./AFC Cable Systems, Inc.
 - 13. Thomas & Betts Corporation.

- B. ENT: NEMA TC 13.

- C. RNC: NEMA TC 2, Schedule 40 and Schedule 80 PVC.

**SECTION 16130
RACEWAYS AND BOXES**

- D. ENT and RNC Fittings: NEMA TC 3; match to conduit or tubing type and material.
- E. LFNC: UL 1660.

2.04 METAL WIREWAYS

- A. Available Manufacturers:
 - 1. Hoffman.
 - 2. Square D.
- B. Material and Construction: Sheet metal sized and shaped as indicated, NEMA 1 & 4X.
- C. 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.
- D. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
- E. Wireway Covers: Hinged type and Flanged-and-gasketed type.
- F. Finish: Manufacturer's standard enamel finish.

2.05 NONMETALLIC WIREWAYS

- A. Available Manufacturers:
 - 1. Hoffman.
 - 2. Lamson & Sessions; Carlon Electrical Products.
- B. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
- C. 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.
- D. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

2.06 BOXES, ENCLOSURES, AND CABINETS

- A. Available Manufacturers:
 - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 - 2. Emerson/General Signal; Appleton Electric Company.
 - 3. Erickson Electrical Equipment Co.
 - 4. Hoffman.

**SECTION 16130
RACEWAYS AND BOXES**

5. Hubbell, Inc.; Killark Electric Manufacturing Co.
 6. O-Z/Gedney; Unit of General Signal.
 7. RACO; Division of Hubbell, Inc.
 8. Robroy Industries, Inc.; Enclosure Division.
 9. Scott Fetzer Co.; Adalet-PLM Division.
 10. Spring City Electrical Manufacturing Co.
 11. Thomas & Betts Corporation.
 12. Walker Systems, Inc.; Wiremold Company (The).
 13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- E. Floor Boxes: Cast metal, fully adjustable, rectangular.
- F. Floor Boxes: Nonmetallic, nonadjustable, round.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.
- I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.
- J. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.

2.07 FACTORY FINISHES

- A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping.

PART 3 - EXECUTION

3.01 RACEWAY APPLICATION

- A. Outdoors:

**SECTION 16130
RACEWAYS AND BOXES**

1. Exposed: Rigid steel or IMC.
2. Concealed: Rigid steel or IMC.
3. Underground, Single Run: RNC.
4. Underground, Grouped: RNC.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
6. Boxes and Enclosures: NEMA 250, Type **3R**.

B. Indoors:

1. Exposed: EMT or RNC.
2. Concealed: EMT.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except use LFMC in damp or wet locations.
4. Damp or Wet Locations: Rigid steel conduit.
5. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
 - a. Damp or Wet Locations: NEMA 250, Type 4, nonmetallic.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits embedded in or in contact with concrete.

3.02 INSTALLATION

A. Complete raceway installation before starting conductor installation.

B. Support raceways as specified in Division 16 Section "Basic Electrical Materials and Methods."

C. Install temporary closures to prevent foreign matter from entering raceways.

D. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above finished slab.

E. Make bends and offsets so ID is not reduced. Keep legs of bends in same plane and keep straight legs of offsets parallel, unless otherwise indicated.

F. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

**SECTION 16130
RACEWAYS AND BOXES**

1. Install concealed raceways with a minimum of bends in shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
- G. Raceways Embedded in Slabs: Install in middle 1/3 of slab thickness where practical and leave at least 2 inches (50 mm) of concrete cover.
1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
 2. Space raceways laterally to prevent voids in concrete.
 3. Run conduit larger than 1-inch trade size parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 4. Change from nonmetallic tubing to rigid steel conduit, or IMC before rising above floor.
- H. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
1. Run parallel or banked raceways together on common supports.
 2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- I. Join raceways with fittings designed and approved for that purpose and make joints tight.
1. Use insulating bushings to protect conductors.
- J. Tighten set screws of threadless fittings with suitable tools.
- K. Terminations:
1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
 2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
- L. 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.
- M. Telephone and Signal System Raceways, 2-Inch Trade Size (DN 53) and Smaller: In addition to above requirements, install raceways in maximum lengths of 150 feet (45 m) and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.
- N. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-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:

**SECTION 16130
RACEWAYS AND BOXES**

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where otherwise required by NFPA 70.
- O. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches (150 mm) above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.
- P. Flexible Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.
- Q. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.
- R. Set floor boxes level and flush with finished floor surface.
- S. Set floor boxes level. Trim after installation to fit flush with finished floor surface.
- T. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.03 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 16130

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following:
1. Single and duplex receptacles, ground-fault circuit interrupters, and integral surge suppression units.
 2. Single- and double-pole snap switches and dimmer switches.
 3. Device wall plates.

1.02 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Field quality-control test reports.

1.03 QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. 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:
1. Wiring Devices:
 - a. Bryant Electric, Inc./Hubbell Subsidiary.
 - b. Eagle Electric Manufacturing Co., Inc.
 - c. Hubbell Incorporated; Wiring Device-Kellems.
 - d. Leviton Mfg. Company Inc.
 - e. Pass & Seymour/Legrand; Wiring Devices Div.

**SECTION 16140
WIRING DEVICES**

2.02 RECEPTACLES

- A. Straight-Blade-Type Receptacles: Comply with NEMA WD 1, NEMA WD 6, DSCC W-C-596G, and UL 498.
- B. Straight-Blade and Locking Receptacles: Heavy-Duty grade.
- C. GFCI Receptacles: Straight blade, non-feed-through type, Heavy-Duty grade, with integral NEMA WD 6, Configuration 5-20R duplex receptacle; complying with UL 498 and UL 943. Design units for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter.

2.03 PENDANT CORD/CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector, NEMA WD 6, Configurations L5-20P and L5-20R, Heavy-Duty grade.
 - 1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
 - 2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.04 SWITCHES

- A. Single- and Double-Pole Switches: Comply with DSCC W-C-896F and UL 20.
- B. Snap Switches: Heavy-Duty grade, quiet type.
- C. Combination Switch and Receptacle: Both devices in a single gang unit with plaster ears and removable tab connector that permit separate or common feed connection.
 - 1. Switch: 20 A, 120/277-V ac.
 - 2. Receptacle: NEMA WD 6, Configuration 5-15R.
- D. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on/off switches and audible frequency and EMI/RFI filters.
 - 1. Control: Continuously adjustable slider; with single-pole or three-way switching to suit connections.
 - 2. Incandescent Lamp Dimmers: Modular, 120 V, 60 Hz with continuously adjustable rotary knob, toggle switch, or slider; single pole with soft tap or other quiet switch; EMI/RFI filter to eliminate interference; and 5-inch (130-mm) wire connecting leads.
 - 3. 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.

2.05 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.

SECTION 16140
WIRING DEVICES

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Smooth, high-impact thermoplastic.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Wet Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in "wet locations."

2.06 FINISHES

A. Color:

1. Wiring Devices Connected to Normal Power System: Ivory , unless otherwise indicated or required by NFPA 70.
2. TVSS Devices: Blue.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install devices and assemblies level, plumb, and square with building lines.
- B. Install wall dimmers to achieve indicated rating after derating for ganging.
- C. Install unshared neutral conductors on line and load side of dimmers.
- D. 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, multigang wall plates.
- E. Remove wall plates and protect devices and assemblies during painting.
- F. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.02 IDENTIFICATION

- A. Comply with Division 16 Section "Basic Electrical Materials and Methods."
 1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.03 CONNECTIONS

- A. Ground equipment according to Division 16 Section "Grounding and Bonding."
- B. Connect wiring according to Division 16 Section "Conductors and Cables."

**SECTION 16140
WIRING DEVICES**

3.04 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.
 - 2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- B. Remove malfunctioning units, replace with new units, and retest as specified above.

END OF SECTION 16140

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following lighting control devices:
 - 1. Time switches.
 - 2. Outdoor photoelectric switches.
 - 3. Switch-box occupancy sensors.
 - 4. Indoor occupancy sensors.
 - 5. Outdoor motion sensors.
 - 6. Multipole contactors.
- B. See Division 16 Section "Wiring Devices" for wall-box dimmers and manual light switches.
- C. See Division 16 Section "Dimming Controls" for architectural dimming system equipment.

1.02 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show installation details for occupancy and light-level sensors.
 - 1. Lighting plan showing location, orientation, and coverage area of each sensor.
 - 2. Interconnection diagrams showing field-installed wiring.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

1.04 QUALITY ASSURANCE

- A. 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.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

2.02 GENERAL LIGHTING CONTROL DEVICE REQUIREMENTS

- A. Line-Voltage Surge Protection: An integral part of the devices for 120- and 277-V solid-state equipment. For devices without integral line-voltage surge protection, field-mounting surge protection shall comply with IEEE C62.41 and with UL 1449.

2.03 TIME SWITCHES

- A. Available Manufacturers:
1. Intermatic, Inc.
 2. Leviton Mfg. Company Inc.
 3. Lightolier Controls; a Genlyte Company.
 4. Square D.
 5. TORK.
 6. Watt Stopper (The).
- B. Digital Time Switches: Electronic, solid-state programmable units with alphanumeric display complying with UL 917.
1. Contact Configuration: DPST.
 2. Contact Rating: 30-A inductive or resistive, 240-V ac.
 3. Program: Single channel, 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
 4. Circuitry: Allow connection of a photoelectric relay as substitute for on and off function of a program on selected channels.
 5. Astronomical Time: All Selected channels.
 6. Battery Backup: For schedules and time clock.

2.04 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Available Manufacturers:
1. Intermatic, Inc.
 2. Square D.

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LIGHTING CONTROL DEVICES**

3. TORK.
 4. Watt Stopper (The).
- B. Description: Solid state, with DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, microprocessor input, and complying with UL 773A.
1. Light-Level Monitoring Range: 1.5 to 10 fc (16 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. Time Delay: 15-second minimum, to prevent false operation.
 3. Surge Protection: Metal-oxide varistor type, complying with IEEE C62.41 for Category A1 locations.
 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.

2.05 SWITCH-BOX OCCUPANCY SENSORS

- A. Available Manufacturers:
1. Bryant Electric; a Hubbell Company.
 2. Hubbell Lighting Inc.
 3. Leviton Mfg. Company Inc.
 4. Lightolier Controls; a Genlyte Company.
 5. Lithonia Lighting.
 6. MYTECH Corporation.
 7. Novitas, Inc.
 8. RAB Electric Manufacturing, Inc.
 9. Sensor Switch, Inc.
 10. TORK.
 11. Unenco Electronics; a Hubbell Company.
 12. Watt Stopper (The).
- B. Description: PIR type with integral power-switching contacts rated for 800 W at 120-V ac, suitable for incandescent light fixtures, fluorescent light fixtures with magnetic or electronic ballasts, or 1/6-hp motors; and rated for 1000 W at 277-V ac, suitable for incandescent light fixtures, fluorescent light fixtures with magnetic or electronic ballasts, or 1/3-hp motors, minimum.
1. Include ground wire.
 2. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (215 to 2150 lx); keeps lighting off when selected lighting level is present.

2.06 INDOOR OCCUPANCY SENSORS

- A. Available Manufacturers:

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LIGHTING CONTROL DEVICES**

1. Hubbell Lighting Inc.
2. Leviton Mfg. Company Inc.
3. Lithonia Lighting.
4. MYTECH Corporation.
5. Novitas, Inc.
6. RAB Electric Manufacturing, Inc.
7. Sensor Switch, Inc.
8. TORK.
9. Unenco Electronics; a Hubbell Company.
10. Watt Stopper (The).

B. Description: Wall- or ceiling-mounting, solid-state, PIR-type units with a separate relay unit.

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. **Sensor Output:** Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
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.
4. **Mounting:**
 - a. **Sensor:** Suitable for mounting in any position on a standard outlet box.
 - b. **Relay:** Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - c. **Time-Delay and Sensitivity Adjustments:** Recessed and concealed behind hinged door.
5. **Indicator:** LED, to show when motion is being detected during testing and normal operation of the sensor.
6. **Bypass Switch:** Override the on function in case of sensor failure.
7. **Automatic Light-Level Sensor:** Adjustable from 2 to 200 fc (215 to 2150 lx); keeps lighting off when selected lighting level is present.
8. **Detector Sensitivity:** Detect occurrences of 6-inch (150-mm) minimum movement of any portion of a human body that presents a target of at least 36 sq. in. (232 sq. cm).
9. **Detection Coverage (Room):** Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
10. **Detection Coverage (Corridor):** Detect occupancy within 90 feet (27 m) when mounted on a 10-foot- (3-m-) high ceiling.

2.07 MULTIPOLE CONTACTORS

A. Manufacturers:

1. Allen-Bradley/Rockwell Automation.
2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
3. Cutler-Hammer; Eaton Corporation.

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4. Fisher Pierce.
5. GE Industrial Systems; Total Lighting Control.
6. Grasslin Controls Corporation.
7. Hubbell Lighting Inc.
8. Lithonia Lighting.
9. MicroLite Corporation.
10. TORK.
11. Touchplate Technologies, Inc.
12. Watt Stopper (The).

B. Description: Electrically operated and mechanically held, complying with NEMA ICS 2 and UL 508.

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. Control-Coil Voltage: Match control power source.

2.08 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG, complying with Division 16 Section "Basic Electrical Materials and Methods [Conductors and Cables]."

PART 3 - EXECUTION

3.01 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve at least 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.02 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 16 Section "Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non power-limited conductors according to conductor manufacturer's written instructions.
- C. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
- D. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

SECTION 16145
LIGHTING CONTROL DEVICES

- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.03 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 16 Section "Basic Electrical Materials and Methods (Electrical Identification)."
- B. Label time switches and contactors with a unique designation.

3.04 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify actuation of each sensor and adjust time delays.
- B. Remove and replace lighting control devices where test results indicate that they do not comply with specified requirements.
- C. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

END OF SECTION 16145

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Molded-case circuit breakers.
 - 4. Enclosures.

1.02 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

1.03 QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

SECTION 16410
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

2.02 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Available Manufacturers:
1. General Electric Co.; Electrical Distribution & Control Division.
 2. Siemens Energy & Automation, Inc.
 3. Square D/Group Schneider.
- B. Fusible Switch, 1200 A 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.
- C. Nonfusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- D. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
 3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.03 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

- A. Manufacturers:
1. Eaton Corporation; Cutler-Hammer Products.
 2. General Electric Co.; Electrical Distribution & Control Division.
 3. Moeller Electric Corporation.
 4. Siemens Energy & Automation, Inc.
 5. Square D/Group Schneider.
- B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- C. Molded-Case Circuit-Breaker Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
 2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
 3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

SECTION 16410
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

2.04 ENCLOSURES

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
 - 1. Outdoor Locations: NEMA 250, Type 4X Stainless Steel.
 - 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.
- B. Concrete base is specified in Division 16 Section "Basic Electrical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.
- C. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.
- D. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.
- E. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."
- F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- G. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Basic Electrical Materials and Methods (Electrical Identification)."

3.02 FIELD QUALITY CONTROL

- A. Prepare for acceptance testing as follows:
 - 1. Inspect mechanical and electrical connections.
 - 2. Verify switch and relay type and labeling verification.
 - 3. Verify rating of installed fuses.
- B. Perform the following field tests and inspections and prepare test reports:
 - 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.

SECTION 16410
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

END OF SECTION 16410

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

1.02 SUBMITTALS

- A. Product Data: For each type of panelboard, overcurrent protective device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of panelboards and overcurrent protective devices.
 - d. UL listing for series rating of installed devices.
 - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
 - 3. Field quality-control test reports.
 - 4. Operation and maintenance data.

1.03 QUALITY ASSURANCE

- A. 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.
- B. Comply with NEMA PB 1.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
 - a. General Electric Co.; Electrical Distribution & Protection Div.
 - b. Siemens Energy & Automation, Inc.
 - c. Square D.

2.02 MANUFACTURED UNITS

- A. Enclosures: Surface-mounted cabinets. NEMA PB 1, Type 1.
1. Rated for environmental conditions at installed location.
 - a. Outdoor Locations: NEMA 250, Type 4X Stainless Steel.
 - b. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 4. Integral TVSS Device.
- B. Phase and Ground Buses: Hard-drawn, tin-plated copper, 98 percent conductivity.
- C. Conductor Connectors: Suitable for use with conductor material.
1. Ground Lugs and Bus Configured Terminators: Compression type.
- D. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.
- E. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- F. Panelboard Short-Circuit Rating:
1. UL label indicating series-connected rating with integral or remote upstream overcurrent protective devices. Include size and type of upstream device allowable, branch devices allowable, and UL series-connected short-circuit rating.

2.03 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- B. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.04 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.
 - 3. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
 - a. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - b. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
 - c. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
- B. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- C. Fuses are specified in Division 16 Section "Fuses."

2.05 ACCESSORY COMPONENTS AND FEATURES

- A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Furnish portable test set to test functions of solid-state trip devices without removal from panelboard.
- C. Fungus Proofing: Permanent fungicidal treatment for panelboard interior, including overcurrent protective devices and other components.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.

**SECTION 16442
PANELBOARDS**

- B. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."
- C. Mount top of trim 74 inches (1880 mm) above finished floor, unless otherwise indicated.
- D. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- E. Install overcurrent protective devices and controllers.
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- F. Install filler plates in unused spaces.
- G. 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.
- H. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Basic Electrical Materials and Methods (Electrical Identification)."
- I. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
- J. Ground equipment according to Division 16 Section "Grounding and Bonding."
- K. Connect wiring according to Division 16 Section "Conductors and Cables."

3.02 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Perform the following field tests and inspections and prepare test reports:
 - 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.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

END OF SECTION 16442

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following:
 - 1. Cartridge fuses rated 600 V and less for use in switches.

1.02 SUBMITTALS

- A. Product Data: For each fuse type indicated.
- B. Operation and maintenance data.

1.03 QUALITY ASSURANCE

- A. 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.
- B. Comply with NEMA FU 1.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Bussman, Inc.
 - 2. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.
 - 3. Ferraz Shawmut, Inc.
 - 4. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.02 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.01 FUSE APPLICATIONS

- A. Service Entrance: Class L, time delay.
- B. Feeders: Class L, time delay RK1, time delay J, fast acting RK5, time delay.
- C. Motor Branch Circuits: Class RK5, time delay.
- D. Other Branch Circuits: Class RK1, time delay RK5, time delay J, fast acting.

3.02 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.03 IDENTIFICATION

- A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 16491

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All work of this Section shall comply with the requirements of the Conditions of the Contract (General, Supplementary, and Special), with all Sections of Division 1 – General Requirements, with the Drawings, and with all other Contract Documents.

1.02 DESCRIPTION OF WORK INCLUDED

- A. Furnish and install a lighting fixture of the type indicated by letter at each location shown on the drawings.
- B. Furnish and install lamps for all lighting fixtures furnished as part of this electrical work.
- C. All materials, accessories, components and any other equipment necessary for the complete and proper installation and operation of all lighting fixtures, even those not usually indicated on the drawings nor specified but that are necessary for the proper installation and operation of the fixtures shall be furnished by the Contractor.
- D. Fixtures shall be manufactured in strict accordance with the Contract Documents. The Contractor shall be held responsible for the omission or absence of any detail, construction feature, etc. which may be required in the manufacture of the fixtures. The responsibility of accurately fabricating the fixtures to the fulfillment of this specification rests with the Contractor.
- E. Specifications and scale drawings are intended to convey the main features, function and character of the fixtures only, and do not undertake to illustrate or set forth every item or detail necessary for the work.
- F. The work shall include all labor, tools, equipment, transportation, insurance, temporary protection, and miscellaneous items essential to the proper installation of the lighting fixtures.

1.03 RELATED WORK SPECIFIED ELSEWHERE

- A. Related sections of electrical work: See sections of Division 16.

1.04 REFERENCE STANDARDS

- A. Materials and installation shall be in accordance with the latest revision of the National Electrical Code and any applicable Federal, State, and local codes and regulations.
- B. All fixtures and ballasts shall be manufactured in strict accordance with the appropriate and current requirements of the National Electric Code as verified by Underwriters' Laboratories, Inc., or other testing agency as acceptable to local code authorities. Such a listing shall be provided for each fixture type, and the appropriate label or labels shall be affixed to each fixture in a position concealing it from normal view.
- C. ANSI C78.379 – Electric Lamps – Incandescent and High-Intensity Discharge Reflector Lamps – Classification of Beam Patterns.

- D. ANSI C82.1 – Ballasts for Fluorescent Lamps – Specifications.
- E. ANSI C82.4 – Ballasts for High-Intensity Discharge and Low Pressure Sodium Lamps (Multiple Supply Type).
- F. ANSI/NFPA 70 – National Electric Code.
- G. ANSI/NFPA 101 – Life Safety Code.
- H. NEMA WD 6 – Wiring Device – Dimensional Requirements.
- I. ASHRAE/IESNA, Standard 90.1.

1.05 SUBMITTALS

- A. Shop drawings shall be submitted for approval for all lighting fixtures in accordance with the requirements of the Contract Documents. Shop Drawings shall clearly indicate the reference number of contract documents used in the development of the shop drawings and the names of the job, architect and lighting consultant. Shop drawings shall be complete submissions for approval and shall include complete fixture model numbers and complete lamp model numbers. Catalog Cuts lacking sufficient detail to indicate compliance with contract documents will not be acceptable. Where applicable shop drawings shall include the wiring diagram, scale plans, and details showing the method of installation of lamp holders, lamps, reflectors, transformers and secondary feeds as well as complete bill of materials. Where applicable, verify field dimensions and include them on shop drawings showing exact locations and lamp holders, and lamp shapes and lengths. Provide copies of approved shop drawings for owner’s use in maintenance and lamp replacement. All prior changes to shop drawings are to be “clouded” and dated prior to resubmission. No variation from the general arrangement and details indicated on the drawings shall be made on the shop drawings unless required to suit the actual conditions on the premises, and then only with the written acceptance of the Architect. All variations must be clearly marked as such on drawings submitted for approval.
- B. Review of shop drawings or samples does not waive contract requirements. Approval of the shop drawings or samples does not relieve the Contractor from the responsibility for deviations from the specifications or drawings unless he has provided a letter noting such deviations at time of submission, and received written approval for such deviations from the Architect. Approval of shop drawings or samples does not relieve the Contractor from responsibility for errors in the shop drawings or samples. Contractor shall be fully responsible for lighting fixtures that are manufactured or installed without approved shop drawings or fixtures not manufactured in accordance with requirements of the Architect and Lighting Consultant’s shop drawing reviews.
- C. Where indicated on the fixture schedule and contract drawings, supply complete photometric data for the fixture, including optical performance rendered by independent testing laboratory developed according to methods of the Illuminating Engineering Society of North America as listed below. Photometric data must be supplied for any fixture offered in substitution for a specified fixture.
 - 1. Coefficients of utilization

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LIGHTING FIXTURES**

2. Luminance table with data presented numerically, showing maximum luminance of the fixture at the shielding angles. Readings should be taken both crosswise and lengthwise in the case of fluorescent fixtures or fixtures with an asymmetric distribution
 3. Candela distribution data, presented graphically and numerically in 5°, 10°, 15°, etc.). Data developed for up and down quadrants normal, parallel, and at 22-1/2°, 45°, 67-1/2° to lamps if light output is asymmetric
 4. Zonal lumens stated numerically in 10° increments (5°, 15°, etc.) as above
 5. Area and roadway fixtures shall also include isocandela charts and IES roadway distribution classification.
- D. Submit samples of each fixture type as requested by the Architect for approval prior to manufacture. The samples shall be complete with specified lamp(s), ready for hanging, energizing, and examining, and shall be shipped, prepaid by Contractor, to the Lighting Consultant, or as otherwise advised. Samples must be actual working unit of materials to be supplied. Samples will be returned but should not be included in quantities listed for a project.

1.06 QUALITY ASSURANCE

- A. Materials, equipment and appurtenances as well as workmanship provided under this section shall conform to the highest commercial standard as specified and as indicated in the Contract Documents. The Contractor is solely responsible for the quality control of the Work.

1.07 WARRANTY

- A. The warranty provisions of the General Requirements, or of this section, shall apply except as noted hereinafter. The Contractor shall warrant the fixture, its finishes, and all of its component parts, except ballasts, to be free from defects for a minimum period of one year from date of acceptance if operated within rated voltage range. Replacement of faulty materials and the cost of labor required to make the replacement shall be the responsibility of the Contractor. Ballasts and neon lighting shall be warranted for five years.

PART 2 - PRODUCTS

2.01 LUMINAIRES

- A. Furnish products as specified in the lighting fixture schedule.
- B. The fixture manufacturers' catalog numbers listed in the fixture schedule may not indicate all the required accessories or hardware that is necessary for a complete installation. Furnish luminaires with all associated appurtenances including, but not necessarily limited to, lamps, ballasts, reflectors, lenses and/or louvers, sockets, holders, suspension accessories, pendants, canopies, recessing boxes, plaster frames, and similar items completely wired, assembled, installed and tested as specified and in the manner indicated. The Contractor shall furnish all materials, accessories, and any other equipment necessary for the complete and proper installation of all lighting fixtures included in this Contract.

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- C. Contractor shall provide the owner with two (2) each of any special tools required for relamping and maintenance of the lighting fixtures. They shall be new and shall be turned over to the owner when the project is completed.
- D. All recessed fluorescent, incandescent, and high intensity discharge lighting fixtures shall be provided with an integral, automatic resetting, thermal cut-out.
- E. All Alzak type of reflector cones and louvers used with any tri-phosphor type of fluorescent lamp shall be anodized in order to eliminate iridescence.
- F. Every lighting outlet shall have a lighting fixture unless otherwise directed. In instances where a specified type of fixture has not been assigned to an outlet, provide a complete fixture of the type and wattage designated for outlets of similar function and/or as directed by the Architect.
- G. All lighting fixtures shall be UL listed or assembled from UL components. All fixtures and ballasts must operate within the temperature limits of their design and as specified by Underwriters' Laboratories, Inc. in the applications and mounting conditions herein specified.
- H. All materials, accessories, and other related fixture parts shall be new and free from defects which in any manner may impair their character, appearance, strength, durability and function, and effectively protected from any damage or injury from the time of fabrication to the time of delivery and until final acceptance of the work.
- I. Fixture enclosures shall be fabricated with a minimum of #20 gauge (0.0359 inch) thick cold rolled sheet steel. Enclosures may be constructed of other metals, provided they are equivalent in mechanical strength and acceptable for the purpose. Lighting fixtures finished in vitreous porcelain enamel shall have a minimum of #20 gauge enameling steel. All sheet metal work shall be free from tool marks and dents, and shall have accurate angles bent as sharp as compatible with the gauges of the required metal. All intersections and joints shall be formed true to adequate strength and structural rigidity to prevent any distortion after assembly.
- J. Housings shall be so constructed that all electrical components are easily accessible and replaceable without removing fixtures from their mountings, or disassembly of adjacent construction.
- K. All castings shall be exact replicas of the approved patterns and shall be free of sand pits, blemishes, scales and rust, and shall be smoothly finished. Tolerance shall be provided for any shrinkage of the metal castings in order that the finished castings will accurately fit in their designated locations.
- L. All lamp sockets in lighting fixtures shall be suitable for the indicated lamps and shall be set so that lamps are positioned in optically correct relation to all lighting fixture components. If adjustable socket positions are provided, socket should be preset in factory for lamp and/or distribution specified. If different socket positions are specified for same fixture, sockets shall be preset for each type, and cartons marked accordingly.
- M. All fixtures shall be completely wired at the factory.
- N. If ceiling system requires, each recessed and semi-recessed fixture shall be furnished with a mounting frame or ring compatible with the ceiling in which they are to be installed. The frames and rings shall be one piece or constructed with electrically-welded butt joints, and of sufficient

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size and strength to sustain the weight of the fixture. Yokes, brackets and supplementary supporting members needed to mount lighting fixtures to carrier channels or other suitable ceiling members shall be furnished and installed by the Contractor. There should be no light leaks between ceiling trims of recessed lighting equipment and the ceilings, or when used in partially transparent ceilings. Verify the type of ceiling and suspension method prior to ordering fixtures. Owner's representative's favorable review of the shop drawings for both the ceiling system and the lighting fixtures, with "No Exception Taken" or "Approved" on the Owner's representative's stamp, will not relieve the Contractor of the ceiling/lighting fixture compatibility requirement.

- O. For steel and aluminum fixtures, all screws, bolts, nuts and other fastening and latching hardware shall be cadmium or equivalent plated. For stainless steel fixtures, all hardware shall be stainless steel. For bronze fixtures, all hardware shall be stainless steel or bronze.
- P. Welding shall be done with electrodes and/or methods recommended by the manufacturers of the metals being welded. Welds shall be continuous, except where spot welding is specifically permitted. Welds exposed to view shall be ground flush and dressed smooth. All welds on or behind surfaces which will be exposed to view shall be done so that finished surface will be free of imperfections such as pits, runs, splatter, cracks, warping, dimpling, depressions or other forms of distortion or discoloration. Remove weld spatter and welding oxides from all welded surfaces.
- Q. Extruded aluminum frame and trim shall be rigid and manufactured from quality aluminum without blemish in the installed produce. Miter cuts shall be accurate, joints shall be flush and without burrs and cuts alignment maintained with the light fixture located in its final position.
- R. Plastic for lenses and diffusers shall be formed of colorless 100% virgin acrylic as manufactured by Rohm & Haas, DuPont or equally acceptable manufacturers. The quality of the raw material must meet American Society of Testing Materials of Canada (ASTM) standards as tested by an independent test laboratory. Acrylic plastic lenses and diffusers shall be properly cast, molded or extruded as specified, and shall remain free of any dimensional instability, discoloration, embrittlement, or loss of light transmittance for at least 15 years. Glass used for lenses, refractors, and diffusers in incandescent lighting fixtures shall be tempered for high impact and heat resistance; the glass shall be crystal clear in quality with a transmittance of not less than 88%. For exterior fixtures use tempered Borosilicate glass, Corning #7740 or equal. For fixtures directly exposed to the elements and aimed above the horizontal, use Corning Vycor glass or equal. Where optical lenses are used, they shall be free from spherical and chromatic aberrations and other imperfections which may hinder the functional performance of the lenses.
- S. All lenses, louvers, or other light diffusing elements shall be removable, but positively held so that hinging or other normal motion will not cause them to drop out.
- T. All "open" metal halide fixture without protective lenses must have an exclusionary socket to prevent the use of lamps that are not "O" rated.

2.02 BALLASTS

A. Fluorescent Ballasts

- 1. All fixtures utilizing fluorescent lamps shall be furnished with ballasts with the following characteristics (unless otherwise noted below): Ballasts shall be solid state electronic ballasts that comply with the National Electric Code, Article 410 and be listed Class "P" per UL Standard 935. Line transient protection shall be provided per IEEE 587 and

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ANSI 82.41 guidelines. Ballasts shall provide a starting sequence consistent with ANSI C82.11. Ballasts shall meet FCC, Part 18 limits for EMI and RFI. Ballasts shall meet all State and Federal energy efficiency standards. Ballasts must have a sound rating of "A". Ballast shall have an auto reset temperature-sensing device to shut off the ballasts in the event of an overheating condition. Ballast shall be able to operate at plus or minus 10% of rated input voltage without damage to the ballast. Ballasts shall tolerate sustained short or open circuit conditions, and lamp failure conditions without damaging the ballasts or affecting ballast life. Ballasts shall be rated to operate in ambient temperatures up to 40 degrees C without damage to the ballast. Ballasts in fixture to be installed outdoors shall have a starting temperature of 0 degrees F or lower. Ballast case temperature shall not exceed 60 degrees C during normal operation. Ballast output frequency shall be between 20khz and 30khz or above 40kHz in order to minimize potential interference with infrared control devices. Ballasts shall have a power factor of .90 or greater. Ballasts shall be Osram-Sylvania, Advance, Universal, Robertson, or ESI, unless otherwise specified.

2. Ballast factors for T8 lamps shall be between .87 and .90 unless otherwise specified. Ballast factors for linear T5 lamps shall be between 0.87 and 1.1 unless otherwise specified. Ballasts factors for compact fluorescent lamps (T2, T4 and T5) shall be between .87 and 1.00 unless otherwise specified.
3. All ballasts for compact fluorescent lamps (T2, T4 and T5) must contain a lamp end-of-life detection and shut down circuit in accordance with ANSI/IEC standards.
4. All fluorescent fixtures calling for emergency battery back-up type ballasts shall consist of a high-temperature, maintenance-free nickel cadmium battery, a charger and electronic circuitry enclosed in one compact case to replace normal electronic ballast. Fluorescent emergency ballasts shall be capable of producing no less than 1100 lumens per 3' or 4' T-8 lamp for a period of not less than 90 minutes. Provide remote test button and indicator light where noted in schedule and on drawings. Emergency ballasts in all exterior fixtures shall be cold temperature rated down to 0°F starting temperature. Ballasts shall be manufactured by Bodine or approved equal.
5. All electronic fluorescent dimmable ballasts shall be provided as indicated in fixture schedule. Dimming shall be smooth and continuous without flicker down to specified minimum light output. Ballasts shall be capable of striking lamps at any level without first flashing to full light. Contractor is responsible for verifying compatibility between dimming ballasts and control devices. Ballasts shall be manufactured by Lutron, Advance, or Osram Sylvania, unless otherwise specified.

B. High Intensity Discharge (HID) Ballasts

1. Unless otherwise specified, all non-ceramic lamp metal halide fixtures shall be furnished with peak lead autotransformer type ballasts with a minimum operating power factor of 90 percent and a sound rating of A. Ballasts shall be pulse start if available unless otherwise specified. Ballasts shall be designed according to ANSI C84.2 and shall have a class H 180 degrees C or higher insulation system. Ballasts shall be UL listed per UL 1029. Ballasts shall be CBM certified. Ballasts shall be capable of operating in open or short circuit or lamp failure condition without damaging ballast or reducing ballast life. Ballasts shall be able to start lamps at -20 degrees F or below and shall be able to operate

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in ambient temperatures as high as 150 degrees F. Ballasts shall be Advance, Robertson, Universal, Osram Sylvania, or Venture unless otherwise specified.

2. All ceramic metal halide lamp fixtures shall be provided with electronic ballasts by Aromat, or approved equal, unless otherwise specified. All metal halide lamp and electronic ballast combinations must be approved by the lamp and ballast manufacturer as being compatible.
3. All high-pressure sodium fixtures shall be furnished with high power factor autotransformer, high power factor reactor, or lead type ballasts as required by the type and lamp wattage specified. Ballasts shall have a minimum operating power factor of 90 percent.

2.03 LAMPS

A. Incandescent Lamps

1. Incandescent lamps shall be provided as indicated in the fixture schedule. Incomplete or unclear lamp specifications must be clarified via the lamp submittal process of other formal requests for clarification. Any substitutions or cross-referencing must be approved with lamp submittals through the submittal process. Lamps shall be manufactured by General Electric, Osram-Sylvania, or Philips unless otherwise specified.
2. Incandescent Halogen lamps shall be used only in fixtures designed for such application. When required by the lamp manufacturer, a protective glass shielding shall be used in all open fixtures with certain halogen lamps.
3. Incandescent halogen lamps shall be warranted by the contractor for 60 days following acceptance of the work. Replace all failed lamps during that period at no cost.

B. Fluorescent Lamps

1. Fluorescent lamps shall be provided as indicated in the fixture schedule. Incomplete or unclear lamp specifications must be clarified via the lamp submittal process of other formal requests for clarification. Any substitutions or cross-referencing must be approved with lamp submittals through the submittal process. Lamps shall be manufactured by General Electric, Osram-Sylvania, or Philips.
2. Unless otherwise noted, all linear T5 or T8 fluorescent lamps, and 40 watt long twin tube lamps shall be NEMA RE835, (3500K color temperature, 80 minimum CRI), with a minimum 20,000 hour rated average life. All other compact fluorescent lamps shall be NEMA RE835, (3500K color temperature, 80 minimum CRI), with a minimum 10,000 hour rated average life.
3. When available, T8 fluorescent lamps shall have reduced mercury content and shall be considered non-hazardous waste by passing the EPA's Toxicity Characteristic Leaching Procedure (TCLP) at the end of life.
4. Linear fluorescent lamps shall be warranted by the contractor for 240 days following acceptance of the work. Compact fluorescent lamps shall be warranted by the contractor

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for 180 days following acceptance of the work. Replace all failed lamps during these periods at no cost.

C. HID Lamps

1. Metal halide lamps shall be provided as indicated in the fixture schedule. Lamps shall be pulse start type unless otherwise specified. All metal halide lamps of 150 watts or less shall be ceramic arc tube type with a 3000K color temperature, unless otherwise specified. Lamps shall be manufactured by General Electric, Osram-Sylvania, Philips, or Venture.
2. All metal halide lamps used in open fixtures must be "O" rated for open fixture use, and have an extended eyelet base, or functional equivalent.
3. High pressure sodium lamps shall be provided as indicated in fixture schedule. Lamps shall be manufactured by General Electric, Osram-Sylvania, or Philips.
4. HID lamps shall be warranted by the contractor for 180 days following acceptance of the work.

2.04 EXIT SIGNS

- A. General: Comply with UL 924; for sign colors and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 1. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum of rated lamp life.
- C. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 1. Battery: Sealed, maintenance-free, nickel-cadmium type with special warranty.
 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 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.

2.05 EMERGENCY LIGHTING UNITS

- A. General: Self-contained units complying with UL 924.
 1. Battery: Sealed, maintenance-free, lead-acid type with minimum 10-year nominal life and special warranty.
 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay

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disconnects lamps from battery, and battery is automatically recharged and floated on charger.

4. Wire Guard: Where indicated, heavy-chrome-plated wire guard protects lamp heads or fixtures.
5. Integral Time-Delay Relay: Holds unit on for fixed interval when power is restored after an outage; time delay permits high-intensity-discharge lamps to restrike and develop adequate output.

2.06 FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 16 Section "Basic Electrical Materials and Methods" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture).
- C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated, 12 gage 2.68 mm.
- E. Wires For Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).
- F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

2.07 INDOOR OCCUPANCY SENSORS

- A. 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:
 1. Hubbell Lighting.
 2. Leviton Mfg. Company Inc.
 3. Novitas, Inc.
 4. Sensor Switch, Inc.
 5. TORK.
 6. Watt Stopper (The).
- B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
 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. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.

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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.
 4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 6. Bypass Switch: Override the on function in case of sensor failure.
 7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.
- C. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. 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), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install suspended luminaires plumb using aircraft cable (or, if noted, rigid pendants supported from swivel hangers). Provide pendant length required to suspend luminaire at indicated height. Fixtures hung in continuous rows shall be installed level and in line with each other.
- C. In grid type ceilings support all luminaires from underside of roof or floor slab. In all cases fixtures larger than 2'x4' or heavier than 50 pounds shall be supported from underside of the roof or floor slab. Electrical Contractor shall furnish all necessary additional auxiliary supporting steel for fixtures not mounted on building framework, and where necessary, to span the ceiling channels of hung ceiling construction. Fixtures supported by ceiling framing members shall be securely attached to the framing members in a manner approved by the National Electric Code. In no case shall fixtures be supported from ducts, piping, or other equipment.

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1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches (150 mm) from fixture corners.
 2. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 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.
 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.
- D. Fixtures and/or fixture outlet boxes shall be provided with hangers to adequately support the complete weight of the fixture. Design of hangers and method of fastening other than herein specified shall be submitted to the Architect for approval. Fixtures mounted on outlet boxes shall be rigidly secured to a fixture stud in the outlet box. Hickies or extension pieces shall be installed where required to facilitate proper installation. Fixtures that weigh more than 50 pounds shall be supported independently of the outlet box.
1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 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.
 4. Continuous Rows: Suspend from cable.
- E. Locate surface, pendant, and recessed ceiling luminaires as indicated on the Architect's reflected ceiling plan lighting plan. Do not scale from or otherwise use electric lighting plans for location of fixtures.
- F. Install surface mounted luminaires and exit signs plumb and adjust to align with building lines and with each other. Secure to prohibit movement.
- G. Fasten surface mounted luminaires to grid ceiling T using bolts, screws, rivets, or suitable clips. Install clips to secure recessed grid-supported luminaires in place.
- H. Install recessed luminaires to permit component removal from below.
- I. Install recessed luminaires using accessories and fire stopping materials to meet regulatory requirements for fire rating. Refer to architectural finish schedules for locations where this occurs.
- J. Install wall mounted luminaires and exit signs at height as indicated on drawings or in schedule.
- K. Install accessories furnished with each luminaire.
- L. Connect luminaires and exit signs to branch circuit outlets provided under Section 16130 using conductors in flexible metal conduit or type MC cable. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire. Bond products and metal accessories to the branch circuit equipment grounding conductor.
- M. Install specified lamps in each luminaire.

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- N. The Electrical Contractor shall consult the Room Finish Schedule as to the type of ceiling construction and shall be responsible for installing the proper fixtures and hardware required for installation in or on a specific ceiling.
- O. Fixtures shall be installed so that no labels will be visible under normal operating conditions of the fixture.
- P. Do not install lenses, trims, reflectors, cones, baffle, louvers and decorative elements until completion if ceiling installation, plastering, painting, and clean-up. All non-removable lenses, trims, reflectors, cones, baffle, louvers and decorative elements shall be protected from damage during construction.
- Q. Lighting fixture locations in mechanical and electrical equipment rooms are approximate. Coordinate mounting height and location of lighting fixtures to clear mechanical, electrical and plumbing equipment and to illuminate adequately meters, gages and equipment. Secure pendant mounted fixtures appropriately in areas of high air movement.
- R. The Contractor shall coordinate all his lighting fixture drawings with the drawings and details of the Architectural, Structural, Electrical, Mechanical, and other related trades to assure a perfect and efficient installation.

3.02 FIELD QUALITY CONTROL

- A. Operate each luminaire after installation and connection. Inspect for proper connection, operation, and lamp type.

3.03 ADJUSTING

- A. Adjust all downlight/washlights to aim flat against nearest adjacent walls.
- B. All adjustable lighting units shall be aimed, focused, locked, etc., by the Contractor under the supervision of the Lighting Consultant. All aiming and adjusting shall be carried out after the entire installation is complete. All ladders, scaffolds, etc. required shall be furnished by the Contractor. As aiming and adjusting is completed, locking setscrews and bolts and nuts shall be tightened securely. Where possible, units shall be focused during the normal working day. However, where daylight interferes with seeing, aiming shall be accomplished at night.
- C. Adjust exit sign directional arrows as indicated.
- D. Replace all failed lamps and incandescent lamps that have been used extensively for temporary or construction lighting concurrent with Owner's final acceptance of project.

3.04 CLEANING

- A. Fixtures shall be thoroughly cleaned of all dust dirt, debris and fingerprints. Visible components that are scratched, marked, dented or deformed shall be replaced.

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3.05 DISPOSAL

- A. All ballasts containing PCB's and batteries shall be treated as hazardous waste and be disposed of as regulated by the Environmental Protection Agency's Universal Waste Rule. Any state regulations more stringent shall take precedence.
- B. All fluorescent and HID lamps shall be treated as hazardous waste and be disposed of as regulated by the Environmental Protection Agency's Universal Waste Rule. Any state regulations more stringent shall take precedence. Lamps recognized as having reduced mercury content and passing the Toxicity Characteristic Leaching Procedure (TCLP) shall be excluded.

3.06 MAINTENANCE MANUALS

- A. The Contractor shall be responsible for obtaining from his supplying lighting manufacturers, for each type of lighting fixture, a recommended maintenance manual including:
 - 1. Tools required
 - 2. Types of cleaners to be used
 - 3. Replacement parts identification lists
 - 4. Final, as-built shop drawings

END OF SECTION 16511