

- BASIC ELECTRICAL MATERIALS AND METHODS

GENERAL

RELATED DOCUMENTS

Drawings and Data:

1. **Electrical drawings are generally diagrammatic and location of outlets and equipment is approximate; exact routing of raceways, locations of outlets and equipment shall be governed by structural conditions and obstructions. This is not to be construed to permit system redesign. All outlets and equipment shall be interconnected as the Contract Documents indicate. Any relocation of outlets or equipment must be approved by the Architect.**
2. **Include minor details not usually shown or specified, but necessary for proper installation and operation of a system or piece of equipment in work.**

SUMMARY

A. This Section includes the following electrical materials and methods:

1. **Supporting devices for electrical components.**
2. **Concrete equipment bases.**
3. **Electrical demolition.**
4. **Cutting and patching for electrical construction.**
5. **Touchup painting.**

B. Related sections: The following Sections contain requirements that relate to this Section:

1. **Division 16 Section "Wires and Cables."**
2. **Division 16 Section "Electrical Identification."**

SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

1. **Product Data for each type of product specified.**

QUALITY ASSURANCE

A. Comply with NFPA 70 for components and installation.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. **The Terms "Listed and Labeled": As defined in the National Electrical Code, Article 100.**

SEQUENCING AND SCHEDULING

- A. Coordinate electrical equipment installation with other building components.
- B. Arrange for chases, slots, and openings in building structure during progress of construction to allow for electrical installations.
- C. Coordinate installing required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work.
- E. Coordinate connecting electrical service to components furnished under other Sections.
- F. Coordinate connecting electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

- PRODUCTS

SUPPORTING DEVICES

- A. Channel and angle support systems, hangers, anchors, sleeves, brackets, fabricated items, and fasteners are designed to provide secure support from the building structure for electrical components.
 - 1. Material: Steel, except as otherwise indicated, protected from corrosion with zinc coating or with treatment of equivalent corrosion resistance using approved alternative finish or inherent material characteristics.
 - 2. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel, except as otherwise indicated.
- B. Steel channel supports have 9/16-inch diameter holes at a maximum of 8 inches in at least 1 surface.
 - 1. Fittings and accessories mate and match with channels and are from the same manufacturer.
- C. 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.
- D. Sheet-Metal Sleeves: 0.0276-inch or heavier galvanized sheet steel, round tube, closed with welded longitudinal joint.
- E. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.
- F. 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.
- G. Expansion Anchors: Carbon-steel wedge or sleeve type.
- H. Toggle Bolts: All-steel springhead type.
- I. Power-Driven Threaded Studs: Heat-treated steel.

CONCRETE EQUIPMENT BASES

- A. **Forms and Reinforcing Materials:** As specified in Division 3 Section "Cast-in-Place Concrete."
- B. **Concrete:** 3000-psi, 28-day compressive strength as specified in Division 3 Section "Cast-in-Place Concrete."

TOUCHUP PAINT

- A. **For Equipment:** Provided by equipment manufacturer and selected to match equipment finish.
- B. **For Nonequipment Surfaces:** Matching type and color of undamaged, existing adjacent finish.
- C. **For Galvanized Surfaces:** Zinc-rich paint recommended by item manufacturer.

EXECUTION

EQUIPMENT INSTALLATION REQUIREMENTS

- A. Install components and equipment to provide the maximum possible headroom where mounting heights or other location criteria are not indicated.
- B. Install items level, plumb, and parallel and perpendicular to other building systems and components, except where otherwise indicated.
- C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- D. Give right of way to raceways and piping systems installed at a required slope.
- E. Install access doors and panels to provide access to electrical materials and equipment.

ELECTRICAL SUPPORTING METHODS

- A. **Damp Locations and Outdoors:** Hot-dip galvanized materials or nonmetallic, U-channel system components.
- B. **Dry Locations:** Steel materials.
- C. **Support Clamps for PVC Raceways:** Click-type clamp system.
- D. Conform to manufacturer's recommendations for selecting supports.
- E. **Strength of Supports:** Adequate to carry all present and future loads, times a safety factor of at least 4; 200-lb-minimum design load.

INSTALLATION

- A. Install devices to securely and permanently fasten and support electrical components.
- B. **Raceway Supports:** Comply with NFPA 70 and the following requirements:

1. **Conform to manufacturer's recommendations for selecting and installing supports.**
 2. **Install individual and multiple raceway hangers and riser clamps to support raceways from building structure and not from suspended ceiling support wires, except as noted below. Provide U bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.**
 - a. **Raceway directly associated with fixtures or equipment located on the suspended ceiling, and conduits not larger than 3/4" trade size serving outlets within the room under the suspended ceiling may be supported from the ceiling wire.**
 - b. **Support no more than two (2) conduits from the same suspended ceiling wire. Install conduits minimum of 24 inches above ceiling so as to not limit accessibility.**
 3. **Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.**
 4. **Spare Capacity: Size supports for multiple conduits so capacity can be increased by a 25 percent minimum in the future.**
 5. **Support individual horizontal raceways with separate, malleable iron pipe hangers or clamps.**
 6. **Hanger Rods: 1/4-inch diameter or larger threaded steel, except as otherwise indicated.**
 7. **Spring Steel Fasteners: Specifically designed for supporting single conduits or tubing. May be used in lieu of malleable iron hangers for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits within the same area, above suspended ceilings and for fastening raceways to channel and slotted angle supports.**
 8. **In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports, with no weight load on raceway terminals.**
- C. **Vertical Conductor Supports: Install simultaneously with conductors.**
- D. **Miscellaneous Supports: Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices except where components are mounted directly to structural features of adequate strength.**
- E. **In open overhead spaces, cast boxes threaded to raceways need not be separately supported, except where used for fixture support; support sheet-metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 24 inches from the box.**
- F. **Sleeves: Install for cable and raceway penetrations of concrete slabs and walls, except where core-drilled holes are used. Install 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.**
- G. **Firestopping: Apply to cable and raceway penetrations of fire-rated floor and wall assemblies. Perform firestopping as specified in Division 7 Section "Firestopping" to reestablish the original fire-resistance rating of the assembly at the penetration.**
- H. **Fastening: Unless otherwise indicated, securely fasten electrical items and their supporting hardware to the building structure. Perform fastening according to the following:**

1. Fasten by means of wood screws or screw-type nails on wood; toggle bolts on hollow masonry units; concrete inserts or expansion bolts on concrete or solid masonry; and by machine screws, welded threaded studs, or spring-tension clamps on steel.
 2. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts, machine screws, or wood screws.
 3. Welding to steel structure may be used only for threaded studs; not for conduits, pipe straps, or any other items.
 4. In partitions of light steel construction use sheet-metal screws.
 5. Drill holes in concrete beams so holes more than 1-1/2 inches deep do not cut main reinforcing bars.
 6. Drill holes in concrete so holes more than 3/4 inch deep do not cut main reinforcing bars.
 7. Fill and seal holes drilled in concrete and not used.
 8. Select fasteners so the load applied to any fastener does not exceed 25 percent of the proof-test load.
- I. Install concrete pads and bases according to requirements of Division 3 Section "Cast-in-Place Concrete."

DEMOLITION

- A. Where electrical work to remain is 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 Indicated to Be Demolished: Remove exposed electrical installation in its entirety.
- C. Abandoned Work: Cut and remove buried raceway and wiring indicated to be abandoned in place, 2 inches below the surface of adjacent construction. Cap and patch surface to match existing finish.
- D. Removal: Remove demolished material from the Project site.
- E. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.
- F. Perform demolition in phases as indicated.
- G. Coordinate the shut-off and disconnection of services with the Owner and the utility company.

CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for electrical installations. Perform cutting by skilled mechanics of the trades involved.
- B. Repair disturbed surfaces to match adjacent undisturbed surfaces.

TOUCHUP PAINTING

- A. Thoroughly clean damaged areas and provide primer, intermediate, and finish coats to suit the degree of damage at each location.**
- B. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.**

RACEWAYS, BOXES, AND CABINETS

GENERAL

SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Raceways include the following:
 - 1. Rigid metal conduit.
 - 2. Intermediate metal conduit.
 - 3. Electrical metallic tubing (EMT).
 - 4. Flexible metal conduit.
 - 5. Liquidtight flexible conduit.
 - 6. Rigid nonmetallic conduit.
 - 7. Wireway.
- C. Boxes, enclosures, and cabinets include the following:
 - 1. Device boxes.
 - 2. Outlet boxes.
 - 3. Pull and junction boxes.
 - 4. Cabinets and hinged cover enclosures.
- D. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 7 Section "Firestopping."

QUALITY ASSURANCE

- A. Comply with NFPA 70 "National Electrical Code" for components and installation.
- B. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.
- C. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL, ETL, or CSA.
- D. Comply with NECA "Standard of Installation".
- E. Coordinate layout and installation of raceway and boxes with other construction elements to ensure adequate headroom, working clearance, and access.
- F. Coordinate with other Work, including metal and concrete deck installation, as necessary to interface installation of electrical raceways and components with other Work.

- PRODUCTS

MANUFACTURERS

- A. **Available Manufacturers:** Subject to compliance with requirements, manufacturers offering Products that may be incorporated in the Work include, but are not limited to, the following:
1. **Metal Conduit and Tubing:**
 - a. Allied Tube and Conduit, Grinnell Co.
 - b. Anixter Brothers, Inc.
 - c. Flexcon, Inc., Coleman Cable Systems, Inc.
 - d. Spiraduct, Inc.
 - e. Triangle PWC, Inc.
 - f. Wheatland Tube Co.
 2. **Nonmetallic Tubing and Conduit:**
 - a. Anamet, Inc., Anaconda Metal Hose.
 - b. Carlon.
 - c. Certainteed Corp, Pipe & Plastics Group.
 - d. Condux International, Electrical Products.
 - e. Thomas & Betts Corp.
 3. **Conduit Bodies and Fittings:**
 - a. American Electric, Construction Materials Group.
 - b. Emerson Electric Co., Appleton Electric Co.
 - c. Carlon.
 - d. Hubbell, Inc., Killark Electric Manufacturing Co.
 - e. General Signal, O-Z/Gedney Unit.
 - f. Spring City Electrical Manufacturing Co.
 4. **Wireway:**
 - a. Hoffman Engineering Co.
 - b. Keystone/Rees, Inc.
 - c. Square D Co.
 5. **Boxes, Enclosures, and Cabinets:**
 - a. Butler Manufacturing Co., Walker Division.
 - b. Cooper Industries, Midwest Electric.
 - c. Erickson Electrical Equipment Co.
 - d. American Electric, FL Industries.
 - e. Hoffman Engineering Co., Federal-Hoffman, Inc.
 - f. Hubbell Inc., Killark Electric Manufacturing Co.
 - g. General Signal, O-Z/Gedney.
 - h. Racor, Inc., Hubbell Inc.
 - i. Robroy Industries, Inc., Electrical Division.
 - j. Spring City Electrical Manufacturing Co.
 - k. Square D Co.
 - l. Thomas & Betts Corp.

METAL CONDUIT AND TUBING

- A. **Rigid Steel Conduit: ANSI C80.1.**
- B. **Rigid Aluminum Conduit: ANSI C80.5.**
- C. **Intermediate Metal Conduit: ANSI C80.6.**
- D. **Electrical Metallic Tubing and Fittings: ANSI C80.3 with steel compression-type fittings.**
- E. **Flexible Metal Conduit: Zinc-coated steel.**
- F. **Liquidtight Flexible Metal Conduit: Flexible steel conduit with PVC jacket.**
- G. **Fittings: NEMA FB 1, compatible with conduit/tubing materials.**

NON-METALLIC CONDUIT

- A. **Rigid Nonmetallic Conduit (RNC): NEMA TC 2, Schedule 40 or 80 PVC.**
- B. **PVC Conduit and Tubing Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.**

WIREWAYS

- A. **Material: Sheet metal sized and shaped as indicated, without knockouts.**
- B. **Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireway as required for complete system.**
- C. **Select features where not otherwise indicated, as required to complete wiring system and to comply with NEC.**

OUTLET AND DEVICE BOXES

- A. **Sheet Metal Boxes: NEMA OS 1.**
 - 1. **Minimum size 4 inch square by 1-1/2 inches deep.**
- B. **Cast Metal Boxes: NEMA FB 1, type FD, cast ferrous alloy box with gasketed cover.**

PULL AND JUNCTION BOXES

- A. **Small Sheet Metal Boxes: NEMA OS 1.**
- B. **Cast Metal Boxes: NEMA FB 1, cast steel with gasketed cover.**

CABINETS AND ENCLOSURES

- A. **Hinged Cover Enclosures: NEMA 250, steel enclosure with continuous hinge cover and flush latch. Finish inside and out with manufacturer's standard enamel.**

- B. **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.**

EXECUTION

EXAMINATION

- A. **Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of the raceway system. Do not proceed with installation until unsatisfactory conditions have been corrected.**

WIRING METHODS

- A. **Outdoors: Use the following wiring methods:**
 - 1. **Exposed: Rigid or intermediate metal conduit.**
 - 2. **Concealed: Rigid or intermediate metal conduit.**
 - 3. **Underground, Single Run: Rigid nonmetallic conduit.**
 - 4. **Underground, Grouped: Rigid nonmetallic conduit.**
 - 5. **Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): Liquidtight flexible metal conduit.**
 - 6. **Boxes and Enclosures: NEMA Type 3R or Type 4.**
- B. **Indoors: Use the following wiring methods:**
 - 1. **Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): Flexible metal conduit, except in wet or damp locations use liquidtight flexible metal conduit.**
 - 2. **Damp or Wet Locations: Rigid steel conduit.**
 - 3. **Exposed: Electrical metallic tubing or rigid metal conduit.**
 - 4. **Concealed: Electrical metallic tubing.**
 - 5. **Boxes and Enclosures: NEMA Type 1, except in damp or wet locations use NEMA Type 4, stainless steel.**
 - 6. **Concealed in Concrete or Masonry Walls: Rigid steel conduit or rigid non-metallic conduit.**

INSTALLATION

- A. **Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.**

- B. Install a separate ground wire in all raceways.
- C. Minimum conduit size: 3/4 inch
- D. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors.
- E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot water pipes. Install horizontal raceway runs above water and steam piping.
- F. Install raceways level and square and at proper elevations. Provide adequate headroom.
- G. Complete raceway installation before starting conductor installation.
- H. Support raceway as specified in Division 16 Section "Supporting Devices."
- I. Use temporary closures to prevent foreign matter from entering raceway.
- J. Make bends and offsets so the inside diameter is not reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.
- K. Use raceway fittings compatible with raceway and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, except as otherwise indicated.
- L. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions, except as otherwise indicated.
- M. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
 - 1. Run parallel or banked raceways together, on common supports where practical.
 - 2. Make bends in parallel or banked runs from same center line to make bends parallel. Use factory elbows only where they can be installed parallel; otherwise, provide field bends for parallel raceways.
 - 3. Install expansion fittings in all raceways at building expansion joints.
- N. Raceways under slabs and underground:
 - 1. Curves and bends: Use rigid steel conduit half-lap wrapped with corrosion protective tape.
 - 2. Depth: Minimum 24 inches below finished grade.
 - 3. Minimum size: 1 inch except for single floor outlets 3/4 inch.
 - 4. Transition non-metallic conduit to rigid steel before rising above grade on floor.
 - 5. Protect conduit with half-lap wrapping with corrosion protective tape for 3 inches minimum both sides of transition point.
- O. Join raceways with fittings designed and approved for the purpose and make joints tight.
 - 1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
 - 2. Use insulating bushings to protect conductors.

- P. Set screw fittings not permitted.
- Q. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely, and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.
- R. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.
- S. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.
- T. Telephone and Signal System Raceways 2-Inch Trade Size and Smaller: In addition to the above requirements, install in maximum lengths of 150 feet and with a maximum of two 90-deg bends or equivalent. Install pull or junction boxes where necessary to comply with these requirements.
- U. Install raceway sealing fittings according to the manufacturer's written instructions. Locate fittings at suitable, approved, 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 and elsewhere as indicated:
 1. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces and air-conditioned spaces.
 2. Where otherwise required by the NEC.
- V. Stub-Up Connections:
 1. Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs, and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6 inches above the floor. Where equipment connections are not made under this Contract, install screwdriver-operated threaded flush plugs flush with floor.
 2. Extend rigid steel conduits to all panel and cabinets with locknuts both inside and outside of the box. Provide insulated grounding bushings on all feeder conduits.
- W. Flexible Connections: Use maximum of 6 feet of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors and transformers. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.
- X. Surface Metal Raceway: Install a separate green ground conductor in raceway from the junction box supplying the raceway to receptacle or fixture ground terminals.
 1. Select each surface metal raceway outlet box to which a lighting fixture is attached to be of sufficient diameter to provide a seat for the fixture canopy.
 2. Where a surface metal raceway is used to supply a fluorescent lighting fixture having central stem suspension with a backplate and a canopy (with or without extension ring), the backplate and canopy will serve as the outlet box and no separate outlet box need be provided.

3. Provide surface metal raceway outlet box, in addition to the backplate and canopy, at the feed-in location of each fluorescent lighting fixture having end stem suspension.
 4. Where a surface metal raceway extension is made from an existing outlet box on which a lighting fixture is installed (provide a backplate slightly smaller than the fixture canopy), no additional surface mounted outlet box need be installed.
- Y. Install hinged cover enclosures and cabinets plumb. Support at each corner.
- Z. Provide grounding connections for raceway, boxes, and components as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.
1. Full Height Demountable Partitions: Serve from above ceiling with flexible conduit within the partition.
- AA. Outlet and Device Boxes:
1. Flush mount with plaster rings in all finished areas.
 2. Offset all boxes that are back to back in the same wall.
 3. Coordinate location of boxes above counter splashes and built-ins.

PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, to ensure that coatings, finishes, and cabinets are without damage or deterioration at 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 touch-up coating recommended by the manufacturer.

CLEANING

- A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

WIRES AND CABLES

GENERAL

SUMMARY

- A. This Section includes building wires and cables and associated splices, connectors, and terminations for wiring systems rated 600 volts and less.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 7 Section "Firestopping."

QUALITY ASSURANCE

- A. Testing Firm Qualifications: In addition to the requirements specified in Division 1 Section "Quality Control Services," an independent testing firm shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or shall be a full member company of the International Electrical Testing Association (NETA).
 - 1. Testing Firm's Field Supervisor Qualifications: A person currently certified by the NETA National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Comply with NFPA 70 "National Electrical Code" for components and installation.
- C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The Terms "Listed and Labeled": As defined in the "National Electrical Code," Article 100.

SEQUENCING AND SCHEDULING

- A. Coordination: Coordinate layout and installation of cable with other installations.
 - 1. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the Architect.

DELIVERY, STORAGE, AND HANDLING

- A. Deliver wire and cable according to NEMA WC-26.

PRODUCTS

MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements. Provide products by one of the following:
 - 1. Wires and Cables:
 - a. American Insulated Wire Corporation, Leviton Manufacturing Co.

- b. Brand-Rex Cable Systems, Brintec Corp.
- c. Carol Cable Company, Inc.
- d. Senator Wire & Cable Co.
- e. Southwire Co.

2. Connectors for Wires and Cables:

- a. AFC, Monogram Co.
- b. AMP, Inc.
- c. Anderson, Square D Co.
- d. Electrical Products Division, 3M Co.
- e. O-Z/Gedney Unit, General Signal.

BUILDING WIRES AND CABLES

- A. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as specified in Part 3 "Applications" Article.
- B. Rubber Insulation: Conform to NEMA WC 3.
- C. Thermoplastic Insulation: Conform to NEMA WC 5.
- D. Cross-Linked Polyethylene Insulation: Conform to NEMA WC 7.
- E. Ethylene Propylene Rubber Insulation: Conform to NEMA WC 8.
- F. Solid conductor for 10 AWG and smaller; stranded conductor for larger than 10 AWG.

CONNECTORS AND SPLICES

- A. UL-listed factory-fabricated wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated. Select to comply with Project's installation requirements and as specified in Part 3 "Applications" Article.

EXECUTION

EXAMINATION

- A. Examine raceways and building finishes to receive wires and cables for compliance with installation tolerances and other conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

APPLICATIONS

- A. Service Entrance: Type RHW or THWN, copper conductor, in raceway.
- B. Feeders: Type XHHW-2, copper conductor, in raceway.
- C. Feeders: Type RHH/RHW-2, copper conductor, in raceway.
- D. Branch Circuits: Type THHN/THWN, in raceway or type MC, metal-clad cable, with additional integral ground wire both with copper conductor.
- E. Fire Alarm Circuits: Power-limited fire protective signaling circuit cable.

INSTALLATION

- A. Install wires and cables as indicated, according to manufacturer's written instructions and the NECA "Standard of Installation."

- B. Remove existing wire from raceway before pulling in new wire and cable.
- C. Pull conductors into raceway simultaneously where more than one is being installed in same raceway.
 - 1. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.
 - 2. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
- D. Install exposed cable, parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.
- E. Conductor Splices: Keep to minimum.
 - 1. Install splices and tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
 - 2. Use splice and tap connectors that are compatible with conductor material.
- F. Wiring at Outlets: Install with at least 12 inches of slack conductor at each outlet.
- G. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.
- H. Install cables within handholes, underground pull box, and manholes by routing around the perimeter of the box, support cables with integral inserts.
- I. Install MC cable with support 6 feet on centers and within 12 inches of every termination.

FIELD QUALITY CONTROL

- A. Testing: Upon installation of wires and cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA Standard ATS, Section 7.3.1. Certify compliance with test parameters.
- B. Correct malfunctioning products at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.

· WIRING DEVICES

GENERAL

SUMMARY

- A. This Section includes various types of receptacles, connectors, switches, and finish plates.

SUBMITTALS

- A. Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
1. Product data for each product specified.
 2. Operation and maintenance data for materials and products specified in this Section to include in the "Operating and Maintenance Manual" specified in Division 1.

QUALITY ASSURANCE

- A. Comply with NFPA 70 "National Electrical Code" for devices and installation.
- B. Listing and Labeling: Provide products that are listed and labeled for their applications and installation conditions and for the environments in which installed.
1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.

COORDINATION

- A. Wiring Devices for Owner Furnished Equipment: Match devices to plug connectors for Owner-furnished equipment.

PRODUCTS

MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in 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. Wiring Devices:
 - a. Arrow Hart Div., Cooper Industries.
 - b. Hubbell Inc.
 - c. Leviton Mfg. Co., Inc.
 - d. Pass & Seymour/Legrand.
 2. Exterior/Wet Location Plates:
 - a. TayMac

b. C.W. Cole & Co., Inc.

WIRING DEVICES

- A. Comply with NEMA Standard WD 1, "General Purpose Wiring Devices."
- B. Enclosures: NEMA 1 equivalent, except as otherwise indicated.
- C. Color: White except as otherwise indicated or required by Code.
- D. Color: Red for devices connect to emergency circuits.
- E. Receptacles, Straight-Blade and Locking Type: Comply with UL Standard 498, "Electrical Attachment Plugs and Receptacles," heavy-duty grade except as otherwise indicated.
- F. Receptacles, Straight-Blade, Special Features: Comply with the basic requirements specified above for straight-blade receptacles of the class and type indicated, and with the following additional requirements:
 - 1. Ground-Fault Circuit Interrupter (GFCI) Receptacles: UL Standard 943, "Ground Fault Circuit Interrupters," feed-through type, with integral NEMA 5-20R duplex receptacle arranged to protect connected downstream receptacles on the same circuit. Design units for installation in a 2-3/4-inch deep outlet box without an adapter.
- G. Snap Switches: Quiet-type a.c. switches, NRTL listed and labeled as complying with UL Standard 20 "General Use Snap Switches," and with Federal Specification W-S-896.
- H. Wall Plates: Single and combination types that mate and match with corresponding wiring devices. Features include the following:
 - 1. Color: White. Red for devices on emergency.
 - 2. Plate-Securing Screws: Metal with heads colored to match plate finish.
 - 3. Material for Finished Spaces: White, smooth plastic.
 - 4. Material for Unfinished Spaces: White, smooth plastic.
- I. Material for exterior and wet locations:
 - 1. Material: Polycarbonate or cast aluminum door.
 - 2. Listing: "Suitable for wet locations while in use".

EXECUTION

INSTALLATION

- A. Install devices and assemblies plumb and secure.
- B. Install wall plates when painting is complete.
- C. Exterior Receptacles: Mount outlet box recessed 2 inches from finished surface with gasketing between enclosure and finish surface.
- D. Arrangement of Devices: Except as otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates. Above countertop mount horizontal.
- E. Protect devices and assemblies during painting.

- F. Adjust locations at which floor service outlets and telephone/power service poles are installed to suit the indicated arrangement of partitions and furnishings.
- G. Install GFCI receptacles at all exterior, toilets, wet locations, and within 6 feet of a sink.

IDENTIFICATION

- A. Comply with Division 16 Section "Electrical Identification."
 - 1. Switches: Where 3 or more switches are ganged, and elsewhere where indicated, identify each switch with approved legend engraved on wall plate.
 - 2. Receptacles: Identify the panelboard and circuit number from which served for emergency power circuits only. Use machine-printed, pressure-sensitive, abrasion-resistant label tape on face of plate and durable wire markers or tags within outlet boxes.

FIELD QUALITY CONTROL

- A. Testing: Test wiring devices for proper polarity and ground continuity. Operate each operable device at least 6 times.
- B. Test ground-fault circuit interrupter operation with local fault simulations according to manufacturer recommendations.
- C. Replace damaged or defective components.

CLEANING

- A. General: Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

ELECTRICAL IDENTIFICATION

I GENERAL

SUMMARY

- A. This Section includes identification of electrical materials, equipment, and installations.

QUALITY ASSURANCE

- A. Comply with NFPA 70.

SEQUENCING AND SCHEDULING

- A. Coordinate installing electrical identification after completion of finishing where identification is applied to field-finished surfaces.
- B. Coordinate installing electrical identifying devices and markings prior to installing acoustical ceilings and similar finishes that conceal such items.

PRODUCTS

MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements.

RACEWAY AND CABLE LABELS

- A. **Manufacturer's Standard Products:** Where more than one type is listed for a specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.
- B. Conform to ANSI A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway or cable size.
 - 1. Color: Black legend on orange field.
 - 2. Legend: Indicates voltage and service.
- C. **Adhesive Labels:** Preprinted, flexible, self-adhesive vinyl. Legend is overlaminated with a clear, weather- and chemical-resistant coating.
- D. **Pretensioned, Wraparound Plastic Sleeves:** Flexible, preprinted, color-coded, acrylic bands sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.
- E. **Colored Adhesive Tape:** Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- F. **Underground Line Warning Tape:** Permanent, bright-colored, continuous-printed, vinyl tape with the following features:
 - 1. Size: Not less than 6 inches wide by 4 mils thick.
 - 2. Compounded for permanent direct-burial service.

3. Embedded continuous metallic strip or core.
 4. Printed Legend: Indicates type of underground line.
- G. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.
- H. Aluminum, Wraparound Marker Bands: Bands cut from 0.014-inch-thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.
- I. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, except as otherwise indicated, with eyelet for fastener.
- J. Aluminum-Faced Card-Stock Tags: Weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch thick, laminated with moisture-resistant acrylic adhesive, and punched for the fastener. Preprinted legends suit each application.
- K. Brass or Aluminum Tags: Metal tags with stamped legend, punched for fastener. Dimensions: 2 by 2 inches by 0.05 inch.

ENGRAVED NAMEPLATES AND SIGNS

- A. Manufacturer's Standard Products: Where more than one type is listed for a specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.
- B. Engraving stock, melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 sq. in., 1/8 inch thick for larger sizes.
1. Engraved Legend: Black letters on white face.
 2. Punched for mechanical fasteners.
- C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend, and size as indicated or as otherwise required for the application. 1/4-inch grommets in corners for mounting.
- D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose acetate butyrate signs with 0.0396-inch, galvanized steel backing, with colors, legend, and size appropriate to the application. 1/4-inch grommets in corners for mounting.
- E. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers.

MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties with the following features:
1. Minimum Width: 3/16 inch.
 2. Tensile Strength: 50 lb minimum.
 3. Temperature Range: Minus 40 to 185 deg F.
 4. Color: As indicated where used for color coding.
- B. Paint: Alkyd-urethane enamel over primer as recommended by enamel manufacturer.

EXECUTION

INSTALLATION

- A. Install identification devices according to manufacturer's written instructions.

- B. **Install labels where indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.**
- C. **Lettering, Colors, and Graphics:** Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations used in the Contract Documents or required by codes and standards. Use consistent designations throughout the Project.
- D. **Sequence of Work:** Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.
- E. **Self-Adhesive Identification Products:** Clean surfaces of dust, loose material, and oily films before applying.
- F. **Install painted identification as follows:**
 - 1. **Clean surfaces of dust, loose material, and oily films before painting.**
 - 2. **Prime Surfaces:** For galvanized metal, use single-component, acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy-duty, acrylic-resin block filler. For concrete surfaces, use clear, alkali-resistant, alkyd binder-type sealer.
 - 3. **Apply one intermediate and one finish coat of silicone alkyd enamel.**
 - 4. **Apply primer and finish materials according to manufacturer's instructions.**
- G. **Install Circuit Identification Labels on Boxes:** Label externally as follows:
 - 1. **Exposed Boxes:** Pressure-sensitive, self-adhesive plastic label on cover.
 - 2. **Concealed Boxes:** Permanent marker, legibly denoted on cover.
 - 3. **Labeling Legend:** Permanent, waterproof listing of panel and circuit number or equivalent.
- H. **Identify Paths of Underground Electrical Lines:** During trench backfilling, for exterior underground power, control, signal, and communications lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope do not exceed an overall width of 16 inches, use a single line marker.
- I. **Color-Code Conductors:** Secondary service, feeder, and branch circuit conductors throughout the secondary electrical system.
 - 1. **208/120-V System:** As follows:
 - a. **Phase A: Black.**
 - b. **Phase B: Red.**
 - c. **Phase C: Blue.**
 - d. **Neutral: White.**
 - e. **Ground: Green.**
 - 2. **480/277-V System:** As follows:
 - a. **Phase A: Brown.**
 - b. **Phase B: Orange.**
 - c. **Phase C: Yellow.**
 - d. **Neutral: Grey.**
 - e. **Ground: Green.**

3. **Factory-apply color the entire length of the conductors, except the following field-applied, color-coding methods may be used in lieu of factory-coded wire for sizes larger than No. 10 AWG.**
 - a. **Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last 2 turns of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors as specified. Adjust tape bands to avoid obscuring cable identification markings.**
- J. **Feeder Circuit Identification: Use metal tags or aluminum wraparound marker bands for cables, feeders, and power circuits in pull boxes, junction boxes and manholes.**
 1. **Legend: 1/4-inch-steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.**
 2. **Fasten tags with nylon cable ties; fasten bands using integral ears.**
- K. **Apply identification to conductors as follows:**
 1. **Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source and circuit number. Use color coding for voltage and phase indication of secondary circuit.**
 2. **Multiple Control and Communications Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color coding, or cable marking tape.**
 3. **Identify raceways and cables of certain systems with color banding as follows:**
 - a. **Bands: Colored adhesive marking tape. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of 2-color markings in contact, side by side.**
 - b. **Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25 feet in congested areas.**
 - c. **Colors: As follows:**
 - 1) **Fire-Alarm System: Red.**
- L. **Apply warning, caution, and instruction signs and stencils as follows:**
 1. **Install warning, caution, and instruction signs where indicated or required to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved, plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.**
- M. **Install identification as follows:**
 1. **Apply equipment identification labels of engraved plastic laminate on each major unit of equipment, including central or master unit of each system. This includes communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Except as otherwise indicated, provide a single line of text with 1/2-inch-high lettering on 1-1/2-inch-high label; where 2 lines of text are required, use lettering 2 inches high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment.**
 - a. **Panelboards, electrical cabinets, and enclosures.**
 - b. **Access doors and panels for concealed electrical items.**

- c. **Electrical switchgear and switchboards.**
 - d. **Contactors.**
 - e. **Control devices.**
 - f. **Transformers.**
 - g. **Fire-alarm master station or control panel.**
2. **Apply designation labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.**
3. **For panelboards, provide framed, typed circuit schedules with explicit description including actual area room names and numbers that is agreeable to Architect and/or Owner and identification of items controlled by each individual breaker.**

UTILITY COORDINATION

GENERAL

SUMMARY

- A. This Section specifies administrative and supervisory requirements necessary for Project coordination with all serving utilities companies providing power, telephone/data, and cable TV, including, but not necessarily limited to:
1. Coordination.
 2. Administrative and supervisory personnel.
 3. General installation provisions.
- B. Include in the base contract price any and all utility company charges for service lines, utility relocations, and any other charges for service to this Project.
- C. Payment of power company charges are included in this contract. If power company charges are not available at time of bidding, state clearly in the bid that these charges are not included or the allowance provided.

COORDINATION

- A. Coordination: Coordinate construction activities included under various Sections of these Specifications to assure efficient and orderly installation of each part of the Work. Coordinate construction operations included under different Sections of the Specifications that are dependent upon each other for proper installation, connection, and operation.
1. Where installation of one part of the Work is dependent on installation of other components, either before or after its own installation, schedule construction activities in the sequence required to obtain the best results.
 2. Where availability of space is limited, coordinate installation of different components to assure maximum accessibility for required maintenance, service and repair.
 3. Make adequate provisions to accommodate items scheduled for later installation.
 4. Installer shall notify local operating company in writing of telephone interface connection requirements to ensure proper and timely interfacing of building telecommunication systems with the operating company's systems.
 5. Provide two (2) sets of construction drawing to each of the serving utilities area representatives within one (1) week of "Notice to Proceed".
 6. Information on the drawings is for general reference. Exact information and drawings for installation to be obtained directly from the utility company.
 7. Coordinate with other electrical work including wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of telephone system with other work.
 8. Sequence installation of telephone system with other work to minimize possibility of damage and soiling during remainder of construction.

SUBMITTALS

- A. **Coordination Drawings:** Prepare and submit coordination Drawings where close and careful coordination is required for installation of products and materials fabricated off-site by separate entities, and where limited space availability necessitates maximum utilization of space for efficient installation of different components.
 - 1. Show the interrelationship of components shown on separate Shop Drawings.
 - 2. Indicate required installation sequences.
 - 3. Comply with requirements contained in Section "Submittals."
- B. **Submit shop drawing of the Service Entrance Section and/or service equipment to the serving utility for their approval.**

CODES AND STANDARDS:

- A. **Electrical Code compliance:** Comply with applicable local code requirements of the authority having jurisdiction and the NEC.
- B. **Utilities Code and Standards:** Comply with all applicable codes and standards of the serving utility.

EXECUTION

GENERAL INSTALLATION PROVISIONS

- A. **Utility's Instructions:** Comply with the utility's installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in Contract Documents.
- B. **Coordinate temporary enclosures with required inspections and tests, to minimize the necessity of uncovering completed construction for that purpose.**
- C. **Mounting Heights:** Where mounting heights are not indicated, install individual components at standard mounting heights recognized within the industry for the particular application indicated. Refer questionable mounting height decisions to the Architect for final decision.

GROUNDING

I GENERAL

SUMMARY

- A. This Section includes grounding of electrical systems and equipment and basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other Sections of these Specifications.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 16 Section "Wires and Cables" for requirements for grounding conductors.

SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with UL 467.
- C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

PRODUCTS

MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements.

GROUNDING AND BONDING PRODUCTS

- A. Governing Requirements: Where types, sizes, ratings, and quantities indicated are in excess of National Electrical Code (NEC) requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

WIRE AND CABLE GROUNDING CONDUCTORS

- A. Comply with Division 16 Section "Wires and Cables." Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding.
 - 1. Material: Copper. Use only copper wire for both insulated and bare grounding conductors.
- B. Equipment Grounding Conductors: Insulated with green color insulation.
- C. Grounding-Electrode Conductors: Stranded cable.

- D. **Underground Conductors:** Bare, tinned, stranded, except as otherwise indicated.
- E. **Bare Copper Conductors:** Conform to the following:
 - 1. **Solid Conductors:** ASTM B 3.
 - 2. **Assembly of Stranded Conductors:** ASTM B 8.
 - 3. **Tinned Conductors:** ASTM B 33.

MISCELLANEOUS CONDUCTORS

- A. **Grounding Bus:** Bare, annealed-copper bars of rectangular cross section.
- B. **Braided Bonding Jumpers:** Copper tape, braided No. 30 AWG bare copper wire, terminated with copper ferrules.
- C. **Bonding Straps:** Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.

CONNECTOR PRODUCTS

- A. **Pressure Connectors:** High-conductivity-plated units.
- B. **Bolted Clamps:** Heavy-duty type.
- C. **Exothermic-Welded Connections:** Provided in kit form and selected per manufacturer's written instructions for specific types, sizes, and combinations of conductors and connected items.

GROUNDING ELECTRODES

- A. **Grounding Rods:** Copper-clad steel.
 - 1. **Size:** 3/4 inch by 120 inches.
- B. **Plate Electrodes:** Copper, square or rectangular shape. Minimum 0.10 inch thick, size as indicated.

EXECUTION

APPLICATION

- A. **Equipment Grounding Conductors:** Comply with NEC Article 250 for types, sizes, and quantities of equipment grounding conductors, except where specific types, larger sizes, or more conductors than required by NEC are indicated.
 - 1. **Install equipment grounding conductor with circuit conductors.**
 - 2. **Nonmetallic Raceways:** Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
- B. **Separately Derived Systems:** Where NEC requires grounding, ground according to NEC Paragraph 250-26.
- C. **Metal Poles Supporting Outdoor Lighting Fixtures:** Ground pole to a grounding electrode in addition to separate equipment grounding conductor run with supply branch circuit.

INSTALLATION

- A. **General:** Ground electrical systems and equipment according to NEC requirements, except where Drawings or Specifications exceed NEC requirements.

- B. **Grounding Rods:** Locate a minimum of 1-rod length from each other and at least the same distance from any other grounding electrode.
 - 1. Drive until tops are 2 inches below finished floor or final grade, except as otherwise indicated.
 - 2. Interconnect with grounding-electrode conductors. Use exothermic welds, except as otherwise indicated. Make these connections without damaging copper coating or exposing steel.
- C. **Grounding Conductors:** Route along the shortest and straightest paths possible, except as otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- D. **Underground Grounding Conductors:** Use bare copper wire. Bury at least 24 inches below grade.
- E. **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.**
- F. **Ufer Ground (Concrete-Encased Ground Electrode):** Fabricate according to NEC Paragraph 250-8(v), using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG. Where base of concrete foundation is less than 20 feet in length, coil excess conductor within base of concrete foundation. Bond grounding conductor to reinforcing steel to at least 4 locations, and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode external to concrete.

CONNECTIONS

- A. **General:** Make connections so possibility of galvanic action or electrolysis 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 assure high conductivity and to make contact points closer in order of galvanic series.
 - 2. Make connections with clean, bare metal at points of contact.
 - 3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- B. **Exothermic-Welded Connections:** Use for connections to structural steel and for underground connections, except those at test wells. Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- C. **Equipment Grounding-Wire 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.
- D. **Noncontact Metal Raceway Terminations:** Where 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 both entrances and exits with grounding bushings and bare grounding conductors, except as otherwise indicated.
- E. **Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. Where these requirements are not available, use those specified in UL 486A and UL 486B.**

- F. **Compression-Type Connections:** Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by manufacturer of connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
- G. **Moisture Protection:** Where insulated grounding conductors are connected to grounding rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

TRANSFORMERS

I GENERAL

SUMMARY

- A. This Section includes general-purpose and specialty dry-type transformers and voltage regulators with windings rated 600 V or less.

SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
1. Product data for each product specified, including dimensioned plans, sections, and elevations. Show minimum clearances and installed features and devices.
 2. Wiring diagrams of products differentiating between manufacturer-installed and field-installed wiring.
 3. Operation and maintenance data for materials and products to include in the "Operating and Maintenance Manual" specified in Division 1.
 4. Field test reports of tests and inspections conducted according to Part 3 of this Section.

QUALITY ASSURANCE

- A. Comply with NFPA 70 "National Electrical Code."
- B. Comply with IEEE C2 "National Electrical Safety Code."
- C. Listing and Labeling: Products are listed and labeled.
1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.

PRODUCTS

MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Transformers:
 - a. Eaton Corp.; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical distribution and Control Division.
 - c. Square D Co.
 - d. Siemens Energy and Automation, Inc.

TRANSFORMERS, GENERAL

- A. **Transformers:** Factory-assembled and -tested, air-cooled units of types specified, designed for 60-Hz service.
- B. **Cores:** Grain-oriented, nonaging silicon steel.
- C. **Coils:** Continuous windings without splices except for taps.
- D. **Internal Coil Connections:** Brazed or pressure type.

GENERAL-PURPOSE, DRY-TYPE TRANSFORMERS

- A. **Comply with NEMA Standard ST 20 "Dry-Type Transformers for General Applications."**
- B. **Transformers:** Two-winding type, 3-phase units using one coil per phase in primary and secondary.
- C. **Low Sound Level Units:** Where indicated, minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE Standard C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."
- D. **Features and Ratings:** As follows:
 - 1. **Enclosure:** Indoor, ventilated.
 - 2. **Enclosure:** Exterior; totally enclosed, nonventilated, suitable for outdoor use.
- E. **Insulation Class:** 185 deg C or 220 deg C class for transformers 15 kVA or smaller; 220 deg C class for transformers larger than 15 kVA.
 - 1. **Insulation Temperature Rise:** 150 deg C maximum rise above 40 deg C, for 220 deg C class insulation; 115 deg C maximum rise for 185 deg C class insulation.
- F. **Taps:** For transformers 3 KVA and larger, full capacity taps in high-voltage winding shall be six (6) 2.5 percent taps, 2 above and 4 below, rated high voltage.
- G. **Accessories:** The following accessory items are required where indicated:
 - 1. **Wall-Mounting Brackets:** Manufacturer's standard brackets for transformers up to 75 kVA.

SOURCE QUALITY CONTROL

- A. **Factory Tests:** Design and routine tests conform to referenced standards.

EXECUTION

INSTALLATION

- A. **Arrange equipment to provide adequate spacing for access and for cooling air circulation.**
- B. **Identify transformers and install warning signs according to Division 16 Section "Basic Electrical Materials and Methods".**
- C. **Loosen internal mounting bolts for proper functioning of vibration isolation.**
- D. **Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not furnished, use those specified in UL 486A and UL 486B.**

GROUNDING

- A. Ground transformers and systems served by transformers according to Division 16 Section "Grounding."

FIELD QUALITY CONTROL

- A. **Test Objectives:** To ensure transformer installation is operational within industry and manufacturer's tolerances, install according to Contract Documents, and suitable for energizing.
- B. **Tests:** include the following minimum inspections and tests according to the manufacturer's instructions. Conform to IEEE Standard Test Code C57.12.91 for dry-type units, test method, and data correction factors.
 - 1. **Inspect accessible components for cleanliness, mechanical, and electrical integrity, for presence of damage or deterioration, and to ensure removal of temporary shipping bracing. Do not proceed with tests until deficiencies are corrected.**
 - a. Include internal inspection through access panels and covers.
 - b. Inspect bolted electrical connections for tightness according to manufacturer's published torque values or, where not available, those of UL standards 486A and 486B.
 - 2. **Insulation Resistance:** Perform megohmmeter test of primary and secondary winding-to-winding and winding-to-ground. Use a minimum test voltage of 1,000 V d.c. Minimum insulation resistance is 500 megohms.
 - 3. **Duration of Each Test:** 10 minutes.
 - 4. **Temperature Correction:** Correct results for test temperature deviation from 20° C standard.
- C. **Test Failures:** Correct deficiencies identified by tests and retest. Verify that equipment meets the specified requirements.

ADJUSTING

- A. After completing installation, cleaning, and testing, touch up scratches and mars on finish to match original finish.
- B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment throughout the normal operating cycle of the facility. Record voltages and tap settings to submit with test results.
- C. Adjust buck-boost transformer connections to provide optimum voltage conditions at utilization equipment throughout the normal operating cycle of the facility.

PANELBOARDS

GENERAL

SUMMARY

- A. This Section includes lighting and power panelboards and associated auxiliary equipment rated 600 V and less.
- B. Related Sections include the following:
 - 1. Division 16 Section "Basic Electrical Materials and Methods" for general materials and installation methods.
 - 2. Division 16 Section "Electrical Identification" for labeling materials.

SUBMITTALS

- A. Product Data: For each type of panelboard, accessory item, and component specified.
- B. Shop Drawings: For panelboards. Include dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, and voltage rating. Include the following:
 - 1. Enclosure type with details for types other than NEMA 250, Type 1.
 - 2. Bus configuration and current ratings.
 - 3. Short-circuit current rating of panelboard.
 - 4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.
 - 5. Wiring Diagrams: Details of schematic diagram including control wiring and differentiating between manufacturer-installed and field-installed wiring.
- C. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
- D. Maintenance Data: For panelboard components to include in the maintenance manuals specified in Division 1. Include manufacturer's written instructions for testing circuit breakers.

QUALITY ASSURANCE

- A. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
- B. Comply with NFPA 70.
- C. Comply with NEMA PB 1.

PRODUCTS

MANUFACTURERS

- A. **Manufacturers:** Subject to compliance with requirements, provide products by the following:
1. Eaton Corp.; Cutler-Hammer Products.
 2. General Electric Co.; Electrical Distribution & Control Div.
 3. Square D Co.
 4. Siemens.

PANELBOARD FABRICATION

- A. **Enclosures:** Flush- or surface-mounted cabinets as indicated. NEMA PB 1, Type 1, unless otherwise indicated to meet environmental conditions at installed location.
1. Outdoor Locations: NEMA 250, Type 3R.
 2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
- B. **Directory Frame:** Metal, mounted inside each panelboard door.
- C. **Equipment Ground Bus:** Adequate for feeder and branch-circuit equipment ground conductors. Bonded to box.
- D. **Service Equipment Approval:** Listed for use as service equipment for panelboards with main service disconnect.
- E. **Future Devices:** Equip with mounting brackets, bus connections, and necessary appurtenances, for the overcurrent protective device ampere ratings indicated for future installation of devices.
- F. **Special Features:** Include the following features for panelboards as indicated:
1. Isolated Equipment Ground Bus Where Indicated: Adequate for branch-circuit equipment ground conductors; insulated from box.
 2. Hinged Front Cover: Entire front trim hinged to box with standard door within hinged trim cover.
- G. **Extra Gutter Space:** Dimensions and arrangement as indicated.
1. Subfeed: Overcurrent protective device or lug provision as indicated.
- H. **Feed-through Lugs:** Sized to accommodate feeders indicated.

LOAD CENTERS

- A. Load center type panelboards are not permitted.

LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. **Branch Overcurrent Protective Devices:** Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- B. **Doors:** In panelboard front, with concealed hinges. Secure with flush catch and tumbler lock, all keyed alike.

DISTRIBUTION PANELBOARDS

- A. **Doors:** In panelboard front, except omit in fusible-switch panelboard, unless otherwise indicated. Secure door with vault-type latch with tumbler lock, all keyed alike.
- B. **Branch-Circuit Breakers:** Where overcurrent protective devices are indicated to be circuit breakers, use bolt-on circuit breakers, except circuit breakers 225-A frame size and greater may be plug-in type where individual positive-locking device requires mechanical release for removal.

OVERCURRENT PROTECTIVE DEVICES

- A. **Molded-Case Circuit Breaker: NEMA AB 1, handle lockable.**
 - 1. **Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting capacity rating to meet available fault current.**
 - 2. **Application Listing: Appropriate for application, including Type SWD for switching fluorescent lighting loads and Type HACR for heating, air-conditioning, and refrigerating equipment.**
 - 3. **Circuit Breakers, 200 A and Larger: Trip units interchangeable within frame size.**
 - 4. **Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.**

TRANSIENT VOLTAGE SURGE SUPPRESSORS

- A. **See Drawings.**
- B. **Impulse sparkover voltage coordinated with system circuit voltage.**
- C. **Factory mounted with UL-recognized mounting device.**

EXECUTION

INSTALLATION

- A. **Install panelboards and accessory items according to NEMA PB 1.1**
- B. **Mounting Heights: Top of trim 74 inches above finished floor, unless otherwise indicated.**
- C. **Mounting: Plumb and rigid without distortion of box. Mount flush panelboards uniformly flush with wall finish.**
- D. **Circuit Directory: Type directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing.**
- E. **Install filler plates in unused spaces.**
- F. **Provision for Future Circuits at Flush Panelboards: Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.**
- G. **Wiring in Panelboard Gutters: Arrange conductors into groups, and bundle and wrap with wire ties after completing load balancing.**

IDENTIFICATION

- A. **Identify field-installed wiring and components and provide warning signs as specified in Division 16 Section "Electrical Identification."**
- B. **Panelboard Nameplates: Label each panelboard with engraved laminated-plastic or metal nameplates mounted with corrosion-resistant screws.**

GROUNDING

- A. **Make equipment grounding connections for panelboards as indicated.**
- B. **Provide ground continuity to main electrical ground bus as indicated.**

CONNECTIONS

- A. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Make insulation-resistance tests of each panelboard bus, component, and connecting supply, feeder, and control circuits.
 - 2. Make continuity tests of each circuit.
- B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test 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, remove and replace with new units, and retest.

ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges as directed.

CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

- FUSES

GENERAL

SUMMARY

A. This Section includes the following:

1. Fuses.

SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each fuse type specified.

C. Product Data for each fuse type specified. Include the following:

1. Descriptive data and time-current curves.
2. Let-through current curves for fuses with current-limiting characteristics.
3. Coordination charts and tables and related data.
4. Fuse size for elevator feeder and disconnect applications.

QUALITY ASSURANCE

A. Source Limitations: Obtain fuses from one source and by a single manufacturer.

B. Comply with NFPA 70 for components and installation.

C. Listing and Labeling: Provide fuses specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

EXTRA MATERIALS

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

1. Spare Fuses: Furnish quantity equal to 20 percent of each fuse type and size installed, but not less than 1 set of 3 of each type and size.

PRODUCTS

MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide fuses by one of the following:

1. Cooper Industries, Inc.; Busmann Div.
2. Ferraz Shawmut.
3. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

CARTRIDGE FUSES

- A. **Characteristics:** NEMA FU 1, nonrenewable cartridge fuse, class as specified or indicated, current rating as indicated, voltage rating consistent with circuit voltage.

EXECUTION

EXAMINATION

- A. **Examine utilization equipment nameplates and installation instructions to verify proper fuse locations, sizes, and characteristics.**
- B. **Do not proceed with installation until unsatisfactory conditions have been corrected.**

FUSE APPLICATIONS

- A. **Provide type as shown on the drawings and size as required by utilization equipment.**

INSTALLATION

- A. **Install fuses in fusible devices as indicated. Arrange fuses so fuse ratings are readable without removing fuse.**
- B. **Verify ratings and class to suit actual motor and equipment served.**

IDENTIFICATION

- A. **Install typewritten labels on inside door of each fused switch to indicate fuse replacement information.**

DISCONNECT SWITCHES AND CIRCUIT BREAKERS

GENERAL

SUMMARY

- A. This Section includes individually and group mounted switches and circuit breakers used for the following:
1. Service Entrance Section and switchboards.
 2. Panelboards.
 3. Feeder and equipment disconnect.
 4. Feeder branch-circuit protection.
 5. Motor disconnect.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
1. Division 16 Section "Wiring Devices" for attachment plugs and receptacles, and snap switches used for disconnect switches.
 2. Division 16 Section "Switchboards" for individually enclosed, fused power-circuit devices used as feeder disconnect switches.
 3. Division 16 Section "Fuses" for fuses in fusible disconnect switches.

SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product Data for switches, circuit breakers, and accessories specified in this Section. Include the following:
1. Descriptive data and time-current curves.
 2. Let-through current curves for circuit breakers with current-limiting characteristics.
 3. Coordination charts and tables and related data.
- C. Wiring diagrams detailing wiring for power and control systems and differentiating between manufacturer-installed and field-installed wiring.
- D. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
- E. Field test reports indicating and interpreting test results.
- F. Maintenance data for tripping devices to include in the operation and maintenance manual specified in Division 1.

QUALITY ASSURANCE

- A. Testing Agency Qualifications: In addition to the requirements specified in Division 1 Section "Quality Control," an independent testing agency shall meet OSHA criteria for accreditation of

testing laboratories, Title 29, Part 1907, or shall be a full member company of the InterNational Electrical Testing Association (NETA).

1. **Testing Agency's Field Supervisor:** Person currently certified by NETA or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.
- B. **Source Limitations:** Obtain disconnect switches and circuit breakers from one source and by a single manufacturer.
- C. **Comply with NFPA 70 for components and installation.**
- D. **Listing and Labeling:** Provide disconnect switches and circuit breakers specified in this Section that are listed and labeled.
 1. **The Terms "Listed" and "Labeled":** As defined in the National Electrical Code, Article 100.

PRODUCTS

MANUFACTURERS

- A. **Manufacturers:** Subject to compliance with requirements, provide disconnect switches and circuit breakers by one of the following:
 1. **Fusible Switches:**
 - a. **Eaton Corp.; Cutler-Hammer Products.**
 - b. **General Electric Co.; Electrical Distribution and Control Division.**
 - c. **Siemens Energy & Automation, Inc.**
 - d. **Square D Co.**
 2. **Molded-Case Circuit Breakers:**
 - a. **Eaton Corp.; Cutler-Hammer Products.**
 - b. **General Electric Co.; Electrical Distribution and Control Division.**
 - c. **Siemens Energy & Automation, Inc.**
 - d. **Square D Co.**

DISCONNECT SWITCHES

- A. **Enclosed, Nonfusible Switch:** NEMA KS 1, Type HD, with lockable handle.
- B. **Enclosed, Fusible Switch, 800 A and Smaller:** NEMA KS 1, Type HD, clips to accommodate specified fuses, enclosure consistent with environment where located, handle lockable with 2 padlocks, and interlocked with cover in CLOSED position.
- C. **Enclosure:** NEMA KS 1, Type 1, unless otherwise specified or required to meet environmental conditions of installed location.
 1. **Outdoor Locations:** Type 3R.

CIRCUIT BREAKERS

- A. **Molded-Case Circuit Breaker:** NEMA AB 1, with lockable handle.
- B. **Characteristics:** Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting rating to meet available fault current.
- C. **Application Listing:** Appropriate for application, including switching fluorescent lighting loads or heating, air-conditioning, and refrigerating equipment.

- D. **Circuit Breakers, 200 A and Larger:** Trip units interchangeable within frame size.
- E. **Molded-Case Switch:** Where indicated, molded-case circuit breaker without trip units.
- F. **Lugs:** Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.
- G. **Accessories:** As indicated.
- H. **Enclosure:** NEMA AB 1, Type 1, unless otherwise specified or required to meet environmental conditions of installed location.
 - 1. **Outdoor Locations:** Type 3R.

EXECUTION

INSTALLATION

- A. Install disconnect switches and circuit breakers in locations as indicated, according to manufacturer's written instructions.
- B. Install disconnect switches and circuit breakers level and plumb.
- C. Install wiring between disconnect switches, circuit breakers, control, and indication devices.
- D. Connect disconnect switches and circuit breakers and components to wiring system and to ground as indicated and instructed by manufacturer.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- E. Verify rating and settings to suit actual motor or equipment served.
- F. Identify each disconnect switch and circuit breaker according to requirements specified in Division 16 Section "Electrical Identification."

FIELD QUALITY CONTROL

- A. **Testing Agency:** Provide the services of a qualified independent testing agency to perform specified field quality-control testing.
- B. **Testing:** After installing disconnect switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. **Procedures:** Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.5 for disconnect switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
- C. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

ADJUSTING

- A. Set field-adjustable disconnect switches and circuit-breaker trip ranges as indicated.

CLEANING

- A. **After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, and abrasions.**

MOTOR CONTROLLERS

GENERAL

SUMMARY

- A. This Section includes ac motor-control devices rated 600 V and less that are supplied as enclosed units.
- B. Related Sections include the following:
 - 1. Division 16 Section "Basic Electrical Materials and Methods" for general materials and installation methods.
 - 2. Division 16 Section "Electrical Identification" for labeling materials.
 - 3. Division 16 Section "Fuses."

QUALITY ASSURANCE

- A. Source Limitations: Obtain similar motor-control devices through one source from a single manufacturer.
- B. Comply with NFPA 70.
- C. Listing and Labeling: Provide motor controllers specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

COORDINATION

- A. Coordinate features of controllers and accessory devices with pilot devices and control circuits to which they connect.
- B. Coordinate features, accessories, and functions of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, and the duty cycle of the motor and load.

WARRANTY

- A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
- B. Special Warranty for Variable Frequency Controllers: Submit a written warranty signed by installer and manufacturer, agreeing to replace or repair items that do not require or that deteriorate as defined in this Section within the specified warranty period.

PRODUCTS

MANUFACTURERS

- A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
1. ABB Power Distribution, Inc.; ABE Control, Inc. Subsidiary.
 2. Allen-Bradley Co.; Industrial Control Group.
 3. Crouse-Hinds ECM.; Cooper Industries, Inc. Div.
 4. Eaton Corp.; Cutler-Hammer Products.
 5. General Electric Co.; Electrical Distribution & Control Div.
 6. Square D Co.
 7. Reliance Electric

MANUAL MOTOR CONTROLLERS

- A. **Description:** NEMA ICS 2, general purpose, Class A with toggle action and overload element.

ENCLOSURES

- A. **Description:** Flush or surface-mounted cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to meet environmental conditions at installed location.
1. **Outdoor Locations:** NEMA 250, Type 3R.

ACCESSORIES

- A. **Devices** are factory installed in controller enclosure, unless otherwise indicated.

EXECUTION

APPLICATIONS

- A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.
- C. Use fractional-horsepower manual controllers for single-phase motors, unless otherwise indicated.
- D. Use manual controllers for 3-phase motors up to 5 hp where indicated and not requiring automatic or remote control.
- E. **Hand-Off-Automatic Selector Switches:** In covers of manual and magnetic controllers of motors started and stopped by automatic controls or interlocks with other equipment.

INSTALLATION

- A. Install independently mounted motor-control devices according to manufacturer's written instructions.
- B. **Location:** Locate controllers within sight of motors controlled, unless otherwise indicated.
- C. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks conforming to Division 16 Section "Basic Electrical Materials and Methods."
- D. **Motor-Controller Fuses:** Install indicated fuses in each fusible switch.

IDENTIFICATION

- A. Identify motor-control components and control wiring according to Division 16 Section "Electrical Identification."

CONTROL WIRING INSTALLATION

- A. Install wiring between motor-control devices according to Division 16 Section "Wires and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic control devices where available.
 - 1. Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the hand position.
 - 2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

CONNECTIONS

- A. Tighten connectors, terminals, bus joints, and mountings. Tighten field-connected connectors and terminals, including screws and bolts, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

FIELD QUALITY CONTROL

- A. Testing: After installing motor controllers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.
 - 2. Remove and replace malfunctioning units with new units, and retest.

CLEANING

- A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally, using methods and materials recommended by manufacturer.

TRANSFER SWITCHES

GENERAL

SUMMARY

A. This Section includes transfer switches rated 600 V and less and the following items:

1. Automatic transfer switch.

SUBMITTALS

- A. **Product Data:** For each switch specified. Include dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and materials lists.
- B. **Wiring Diagrams:** Details of wiring for transfer switches and differentiating between manufacturer-installed and field-installed wiring. Show both power and control wiring.
- C. **Maintenance Data:** For each type of product to include in the maintenance manuals specified in Division 1. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay-setting and calibration instructions.

QUALITY ASSURANCE

- A. **Emergency Service:** Manufacturer maintains a service center capable of providing emergency maintenance and repairs at Project site with an 8-hour maximum response time.
- B. **Source Limitations:** Obtain automatic transfer switch, bypass/isolation switch, nonautomatic transfer switch, and control panels from a single manufacturer who assumes responsibility for all components.
- C. **Listing and Labeling:** Provide transfer switches specified in this Section that are listed and labeled for emergency service under UL 1008.
 1. **The Terms "Listed" and "Labeled":** As defined in the National Electrical Code, Article 100.
- D. Comply with NFPA 70.
- E. Comply with NFPA 110.
- F. Comply with NEMA ICS 1.
- G. **UL Compliance:** Comply with UL 1008, "Automatic Transfer Switches," unless requirements of these Specifications are stricter.

PRODUCTS

MANUFACTURERS

- A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
1. Emerson Electric Co.; Automatic Switch Co. Subsidiary.
 2. Generac Corp.
 3. Kohler Co.; Generator Division.
 4. Onan Corp.; Electrical Products Division.
 5. Zenith Controls, Inc.

GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. **Units Smaller than 600 A:** Listed without derating for all classes and all mixtures of classes of loads, including 100 percent tungsten filament lamp or 100 percent inductive load.
- B. **Tested Fault-Current Closing and Withstand Ratings:** Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated based on testing according to UL 1008.
1. **Where External Circuit Breaker or Fuses Protect Transfer Switch:** Products are listed for use with the actual devices providing the fault-current protection at each location for Project.
- C. **Solid-State Controls:** Repetitive accuracy of all settings is plus or minus 2 percent or better over an operating temperature range of minus 20 deg C to 70 deg C.
- D. **Resistance to Damage by Voltage Transients:** Components meet or exceed voltage-surge withstand capability requirements when tested according to ANSI C37.90.1. Components meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. **Neutral Terminal:** Where 2- or 3-pole switches are indicated, provide fully rated, solid, unswitched neutral terminal, unless otherwise indicated.
- F. **Enclosures:** General-purpose NEMA 250, Type 1, complying with NEMA ICS 6; UL 508, unless otherwise indicated or required to meet environmental conditions. Outdoor locations: Type 3R.
- G. **Factory Wiring:** Train and bundle factory wiring and label consistent with Shop Drawings, either by color code or by numbered or lettered wire and cable tape markers at terminations.
1. **Designated Terminals:** Pressure type suitable for types and sizes of field wiring indicated.
 2. **Power-Terminal Arrangement and Field-Wiring Space:** Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 3. **Control Wiring:** Equipped with lugs suitable for connection to terminal strips.
- H. **Electrical Operation:** Accomplish by a nonfused, momentarily energized solenoid or electric motor-operated mechanism, mechanically and electrically interlocked in both directions.
- I. **Switch Characteristics:** Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. **Limitation:** Switches using molded-case switch or insulated-case circuit-breaker components and switches using contactors not designed for continuous-duty repetitive switching between active power sources are not acceptable.
 2. **Switch Action:** Double throw; mechanically held in both directions.

3. **Switch Contacts:** Silver composition for load current switching. Conventional automatic transfer-switch units rated 225 A and greater have separate arcing contacts.

AUTOMATIC TRANSFER SWITCH

- A. **Comply with Level 1 equipment according to NFPA 110.**
- B. **Switching Arrangement:** Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. **Manual Switch Operation:** Manually operated under load, with the door closed, and with either or both sources energized. Transfer time is the same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

AUTOMATIC TRANSFER-SWITCH FEATURES

- A. **Voltage sensing for each phase of normal source.** Pickup voltage is adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
- B. **Time delay for override of normal-source voltage sensing delays transfer and engine start signals.** Adjustable 0 to 6 seconds and factory set at 1 second.
- C. **Voltage/Frequency Lockout Relay:** Prevents premature transfer to an emergency generator set. Pickup voltage is adjustable from 85 to 100 percent of nominal. Factory set to pickup at 90 percent. Pickup frequency is adjustable from 90 to 100 percent of nominal. Factory set to pickup at 95 percent.
- D. **Time Delay for Retransfer to Normal Source:** Adjustable from 0 to 30 minutes and factory set at 10 minutes. Provides automatic defeat of the delay on loss of voltage or sustained undervoltage of the emergency source, provided normal supply has been restored.
- E. **Test Switch:** Simulates normal-source failure.
- F. **Switch-Position Pilot Lights:** Indicate source to which load is connected.
- G. **Source-Available Indicating Lights:** Supervise sources via the transfer-switch, normal- and emergency-source sensing circuits.
 1. **Normal Power Supervision:** Green light with nameplate engraved "Normal Source Available."
 2. **Emergency Power Supervision:** Red light with nameplate engraved "Emergency Source Available."
- H. **Unassigned Auxiliary Contacts:** 2 normally open single-pole, double-throw contacts for each switch position, rated 10 A at 240 V, ac.
- I. **Transfer Override Switch:** Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of the condition of the normal source. A pilot light indicates override status.
- J. **Engine Starting Contacts:** One isolated, normally closed and one isolated, normally open. Contacts are gold flashed or gold plated and rated 10 A at 32 V, dc minimum.
- K. **Engine Shutdown Contacts:** Time delay adjustable from 0 to 5 minutes; factory set at 5 minutes. Initiates shutdown at remote engine-generator controls after retransfer of load to normal source.
- L. **Engine-Generator Exerciser:** Solid-state, programmable-time switch starts engine-generator set and transfers load to it from normal source for a preset time, then retransfers and shuts

down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory-set periods are for 7 days, 20 minutes, and 5 minutes, respectively. Exerciser features include the following:

1. **Exerciser Transfer Selector Switch:** Permits selection between exercise with and without load transfer.
2. **Push-button programming control with digital display of settings.**
3. **Integral battery operation of time switch when normal control power is not available.**

FINISHES

- A. **Enclosures:** Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

SOURCE QUALITY CONTROL

- A. **Factory Test Components, Assembled Switches, and Associated Equipment:** Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

EXECUTION

INSTALLATION

- A. **Wall Mounting of Switches:** Plumb and rigid without distortion of enclosures.
- B. **Identify components according to Division 16 Section "Electrical Identification."**

CONNECTIONS

- A. **Ground equipment as indicated and required by National Electrical Code.**
 1. **Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.**

FIELD QUALITY CONTROL

- A. **Preliminary Tests:** Perform electrical tests as recommended by manufacturer and as follows:
 1. **Measure phase-to-phase and phase-to-ground insulation resistance levels with insulation resistance tester. Include external annunciator and control circuits. Use test voltages and procedure recommended by manufacturer. Meet manufacturer's specified minimum resistance.**
 2. **Check for electrical continuity of circuits and for short circuits.**
- B. **Coordinate tests with tests of generator plant and run them concurrently.**
- C. **Tests:** As recommended by manufacturer and as follows:
 1. **Contact Resistance Test:** Measure resistance of power contacts for automatic transfer switches, nonautomatic transfer switches, and bypass/isolation switches. Resolve values in excess of 500 micro-ohms and differences between adjacent poles exceeding 50 percent.

2. **Operational Tests: Demonstrate interlocking sequence and operational function for each switch at least three times.**
 - a. **Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.**
 - b. **Simulate low phase-to-ground voltage for each phase of normal source to automatic transfer switches.**
 - c. **Verify time-delay settings and pickup and dropout voltages.**
- D. **Test Failures: Correct deficiencies identified by tests and prepare for retest. Verify that equipment meets specified requirements.**
- E. **Reports: Maintain a written record of observations and tests. Report defective materials and workmanship and retest corrected items. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.**

- INTERIOR LIGHTING

GENERAL

SUMMARY

- A. This Section includes interior lighting fixtures, lighting fixtures mounted on exterior building surfaces, lamps, ballasts, emergency lighting units, and accessories.
- B. Related Sections include the following:
 - 1. Division 16 Section "Lighting Control Equipment" for programmable lighting control systems, time switches, additional photoelectric relays, power relays, and contactors.

SUBMITTALS

- A. Product Data: For each type of lighting fixture indicated, arranged in order of fixture designation. Include data on features, accessories, and the following:
 - 1. Dimensions of fixtures.
 - 2. Manufacturer's catalog data sheets.
- B. Shop Drawings: Show details of nonstandard or custom fixtures. Indicate dimensions, weights, method of field assembly, components, features, and accessories.
 - 1. Wiring Diagrams: Detail wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.
- C. Coordination Drawings: Reflected ceiling plans and sections drawn to scale and coordinating fixture installation with ceiling grid, ceiling-mounted items, and other components in the vicinity. Include work of all trades that is to be installed near lighting equipment.
- D. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Division 1.

QUALITY ASSURANCE

- A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- B. Comply with NFPA 70.
- C. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

COORDINATION

- A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

WARRANTY

- A. **General Warranty:** Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

PRODUCTS

MANUFACTURERS

- A. **Available Products:** Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products indicated in the Lighting Fixture Schedule on the drawings.

FIXTURES AND FIXTURE COMPONENTS, GENERAL

- A. **Metal Parts:** Free from burrs, sharp corners, and edges.
- B. **Sheet Metal Components:** Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- C. **Doors, Frames, and Other Internal Access:** Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.
- D. **Reflecting Surfaces:** Minimum reflectance as follows, unless otherwise indicated:
1. **White Surfaces:** 85 percent.
 2. **Specular Surfaces:** 83 percent.
 3. **Diffusing Specular Surfaces:** 75 percent.
 4. **Laminated Silver Metallized Film:** 90 percent.
- E. **Lenses, Diffusers, Covers, and Globes:** 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.
1. **Plastic:** High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
 2. **Lens Thickness:** 0.125 inch minimum, unless greater thickness is indicated.

FLUORESCENT LAMP BALLASTS

- A. **General Requirements:** Unless otherwise indicated, features include the following:
1. **Designed for type and quantity of lamps indicated at full light output.**
 2. **Total Harmonic Distortion Rating:** Less than 20 percent.
 3. **Sound Rating:** A.
- B. **Electronic Ballasts for Linear Lamps:** Unless otherwise indicated, features include the following, besides those in "General Requirements" Paragraph above:
1. **Certified Ballast Manufacturer Certification:** Indicated by label.
 2. **Encapsulation:** Without voids in potting compound.
 3. **Parallel Lamp Circuits:** Multiple lamp ballasts connected to maintain full light output on surviving lamps if one or more lamps fail.
- C. **Ballasts for Compact Lamps in Fixtures:** Unless otherwise indicated, additional features include the following:

1. Type: Electronic or electromagnetic, fully encapsulated in potting compound.
2. Power Factor: 90 percent, minimum.
3. Operating Frequency: 20 kHz or higher.
4. Flicker: Less than 5 percent.
5. Lamp Current Crest Factor: Less than 1.7.
6. Transient Protection: Comply with IEEE C62.41 for Category A1 locations.
7. Lamp end of life shutdown for prevention of socket over-heating.

HIGH-INTENSITY-DISCHARGE LAMP BALLASTS

- A. General: Comply with ANSI C82.4. Unless otherwise indicated, features include the following:
 1. Type: Constant wattage autotransformer or regulating high-power-factor type, unless otherwise indicated.
 2. Operating Voltage: Match system voltage.
 3. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single lamp ballasts.
 4. Normal Ambient Operating Temperature: 104 deg F (40 deg C).
 5. Open-circuit operation that will not reduce average life.
 6. Auxiliary, Instant-on, Quartz System: Automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. Automatically turns quartz lamp off when high-intensity-discharge lamp reaches approximately 60 percent light output.
- B. Encapsulation: Manufacturer's standard epoxy-encapsulated model designed to minimize audible fixture noise, where noted on drawings.
- C. High-Pressure Sodium Ballasts: Equip with a solid-state igniter/starter having an average life in pulsing mode of 10,000 hours at an igniter/starter case temperature of 90 deg C.

EXIT SIGNS

- A. General Requirements: Comply with UL 924 and the following:
 1. Sign Colors and Lettering Size: Comply with authorities having jurisdiction.
- B. Internally Lighted Signs: As follows:
 1. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum rated lamp life.

LAMPS

- A. Fluorescent Color Temperature and Minimum Color-Rendering Index: 4100 K and 85 CRI, unless otherwise indicated.
- B. Noncompact Fluorescent Lamp Life: Rated average is 20,000 hours at 3 hours per start when used on rapid-start circuits.

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 steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.

- D. **Rod Hangers:** 3/16-inch- (5-mm-) minimum diameter, cadmium-plated, threaded steel rod.
- E. **Hook Hangers:** Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- F. **Aircraft Cable Support:** Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

FINISHES

- A. **Fixtures:** Manufacturer's standard, unless otherwise indicated.
 - 1. **Paint Finish:** Applied over corrosion-resistant treatment or primer, free of defects.
 - 2. **Metallic Finish:** Corrosion resistant.

EXECUTION

INSTALLATION

- A. **Fixtures:** Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.
- B. **Support for Fixtures in or on Grid-Type Suspended Ceilings:** Use grid for support.
 - 1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from fixture corners.
 - 2. **Support Clips:** Fasten to fixtures and to ceiling grid members at or near each fixture corner.
 - 3. **Fixtures of Sizes Less Than Ceiling Grid:** Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
- C. **Suspended Fixture Support:** As follows:
 - 1. **Pendants and Rods:** Where longer than 48 inches, 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 installed according to fixture manufacturer's written instructions and details on Drawings.

CONNECTIONS

- A. **Ground equipment.**
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

FIELD QUALITY CONTROL

- A. **Inspect each installed fixture for damage. Replace damaged fixtures and components.**

B. Tests: As follows:

1. **Verify normal operation of each fixture after installation.**
2. **Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.**

C. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

D. Corrosive Fixtures: Replace during warranty period.

CLEANING AND ADJUSTING

A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.

B. Adjust aimable fixtures to provide required light intensities.

EXTERIOR LIGHTING

GENERAL

SUMMARY

- A. This Section includes exterior lighting units with luminaires, lamps, ballasts, poles/ support structures, and accessories.
- B. Related Sections include the following:
 - 1. Division 16 Section "Interior Lighting" for interior fixtures, lamps, ballasts, emergency lighting units, and accessories; and for exterior luminaires normally mounted on buildings.
 - 2. Division 16 Section "Lighting Control Equipment" for programmable lighting control systems, time switches, additional photoelectric relays, power relays, and contactors.

DEFINITIONS

- A. Lighting Unit: A luminaire or an assembly of luminaires complete with a common support, including pole, post, or other structure, and mounting and support accessories.
- B. Luminaire (Light Fixture): A complete lighting device consisting of lamp(s) and ballast(s), when applicable, together with parts designed to distribute light, to position and protect lamps, and to connect lamps to power supply.

SUBMITTALS

- A. Product Data: For each type of lighting unit indicated, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
 - 1. Materials and dimensions of luminaires and poles.
 - 2. High-intensity-discharge luminaire ballasts.
- B. Shop Drawings: Structural foundations keyed to specific poles and certified by professional structural engineer.
- C. Maintenance Data: For lighting units to include in maintenance manuals specified in Division 1.

QUALITY ASSURANCE

- A. Luminaires and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for their indicated use, location, and installation conditions by a testing agency acceptable to authorities having jurisdiction
- B. Comply with ANSI C2.
- C. Comply with NFPA 70.

DELIVERY, STORAGE, AND HANDLING OF POLES

- A. Package aluminum poles for shipping according to ASTM B 660.

- B. Store poles on decay-resistant treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Retain factory-applied pole wrappings on metal poles until just before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

WARRANTY

- A. **General Warranty:** Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. **Special Warranty:** Written warranty, signed by manufacturer and Installer agreeing to replace external parts of luminaires and poles exhibiting a failure of finish as specified below. This warranty is in addition to, and not a limitation of, other rights and remedies Owner may have under requirements of the Contract Documents.

PRODUCTS

MANUFACTURERS

- A. **Products:** Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule on the drawings.

LUMINAIRES

- A. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- B. **Metal Parts:** Free from burrs, sharp corners, and edges.
- C. **Sheet Metal Components:** Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- D. **Housings:** Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- E. **Doors, Frames, and Other Internal Access:** Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange to disconnect ballast when door opens.
- F. **Exposed Hardware Material:** Stainless steel.
- G. **Plastic Parts:** High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
- H. **Reflecting Surfaces:** Minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- I. **Lenses and Refractors:** Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor in luminaire doors.

- J. **High-Intensity-Discharge Ballasts:** Comply with ANSI C82.4. Constant wattage autotransformer or regulating high-power-factor type, unless otherwise indicated.
 - 1. **Single-Lamp Ballasts:** Minimum starting temperature of minus 40 deg C.
 - 2. **Open-circuit operation will not reduce average life.**
 - 3. **High-Pressure Sodium Ballasts:** Equip with a solid-state igniter/starter having an average life in pulsing mode of 10,000 hours at an igniter/starter case temperature of 90 deg C.
 - 4. **Noise:** Uniformly quiet operation, with a noise rating of B or better.
- K. **Lamps:** Comply with the standard of the ANSI C78 series that is applicable to each type of lamp. Provide luminaires with indicated lamps of designated type, characteristics, and wattage. Where a lamp is not indicated for a luminaire, provide medium wattage lamp recommended by manufacturer for luminaire.

LUMINAIRE SUPPORT COMPONENTS

- A. **Description:** Comply with AASHTO LTS-3 for pole or other support structures, brackets, arms, appurtenances, base, and anchorage and foundation.
- B. **Wind-Load Strength of Total Support Assembly:** Adequate to carry support assembly plus luminaires at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 100 mph (160 km/h) with a gust factor of 1.3. Support assembly includes pole or other support structures, brackets, arms, appurtenances, base, and anchorage and foundation.
 - 1. **Strength Analysis:** For each pole type and luminaire combination, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis
- C. **Finish:** Match finish of pole/support structure for arm, bracket, and tenon mount materials.
- D. **Mountings, Fasteners, and Appurtenances:** Corrosion-resistant items compatible with support components.
 - 1. **Materials:** Will not cause galvanic action at contact points.
 - 2. **Mountings:** Correctly position luminaire to provide indicated light distribution.
 - 3. **Anchor Bolts, Nuts, and Washers:** Hot-dip galvanized after fabrication unless stainless-steel items are indicated.
 - 4. **Anchor-Bolt Template:** Plywood or steel.
- E. **Pole/Support Structure Bases:** Anchor type with hold-down or anchor bolts, leveling nuts, and bolt covers.
- F. **Steel Poles:** Tubing complying with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet in length with access handhole in pole wall.
- G. **Steel Mast Arms:** Fabricated from NPS 2 (DN50) black steel pipe, continuously welded to pole attachment plate with span and rise as indicated.
- H. **Metal Pole Brackets:** Match pole metal. Provide cantilever brackets without underbrace, in sizes and styles indicated, with straight tubular end section to accommodate luminaire.
- I. **Pole-Top Tenons:** Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- J. **Concrete for Pole Foundations:** Comply with Division 3 Section "Cast-in-Place Concrete."

1. Design Strength: 3000-psig (20.7-MPa), 28-day compressive strength.

FINISHES

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Steel: Grind welds and polish surfaces to a smooth, even finish.
 1. Galvanized Finish: Hot-dip galvanize after fabrication to comply with ASTM A 123.

EXECUTION

INSTALLATION

- A. Concrete Foundations: Construct according to Division 3 Section "Cast-in-Place Concrete."
 1. Comply with details for reinforcement and for anchor bolts, nuts, and washers. Verify anchor-bolt templates by comparing with actual pole bases furnished.
 2. Finish for Parts Exposed to View: Trowel and rub smooth. Comply with Division 3 Section "Cast-in-Place Concrete" for exposed finish.
- B. Install poles as follows:
 1. Use web fabric slings (not chain or cable) to raise and set poles.
 2. Mount pole to foundation with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
 3. Secure poles level, plumb, and square.
 4. Grout void between pole base and foundation. Use nonshrinking or expanding concrete grout firmly packed in entire void space.
- C. Luminaire Attachment: Fasten to indicated structural supports.
- D. Luminaire Attachment with Adjustable Features or Aiming: Attach luminaires and supports to allow aiming for indicated light distribution.
- E. Lamp luminaires with indicated lamps according to manufacturer's written instructions. Replace malfunctioning lamps.

CONNECTIONS

- A. Ground equipment.
 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Ground metal poles/support structures according to Division 16 Section "Grounding."

FIELD QUALITY CONTROL

- A. Inspect each installed unit for damage. Replace damaged units.
- B. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

CLEANING AND ADJUSTING

- A. Clean units after installation. Use methods and materials recommended by manufacturer.**
- B. Adjust amiable luminaires and luminaires with adjustable lamp position to provide required light distributions and intensities.**

GROUND-FAULT PROTECTION SYSTEMS

1 GENERAL

SUMMARY

- A. This Section includes ground-fault sensing, relaying, tripping, and alarm devices for installation in distribution switchboards and panelboards rated 600 volts and less.

SYSTEM DESCRIPTION

- A. Sensing Method: Protect main disconnecting means using outgoing-circuit sensing method.
- B. Feeders: Protect as indicated using outgoing-circuit sensing method.
1. Selectivity: Time-current-band method with 0.2-second minimum difference between upstream and downstream device settings.
- C. Design ground-fault system that cannot be left in an inactive, or off state.

SUBMITTALS

- A. General: Submit the following according to Conditions of Contract and Division 1 Specification Sections.
1. Product data for each component.
 2. Wiring diagrams detailing power and control wiring and differentiating clearly between manufacturer-installed wiring and field-installed wiring.
 3. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include list of completed projects with project names, addresses, names of Architects and Owners, and other information specified.
 4. Field test reports indicating and interpreting test results relative to compliance with performance requirements of ground-fault protection system.
 5. Maintenance data for ground-fault relay, for inclusion in Operating and Maintenance Manual specified in Division 1.

QUALITY ASSURANCE

- A. Testing Firm Qualifications: In addition to the requirements specified in Division 1 Section "Quality Control Services," an independent testing firm shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or shall be a full member company of the International Electrical Testing Association.
1. Testing Firm's Field Supervision: Use persons currently certified by the International Electrical Testing Association or National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.
- B. Comply with NFPA 70, "National Electrical Code," for components and installation.

- C. **Listing and Labeling:** Provide products specified in this Section that are listed and labeled.
1. **The Terms "Listed and Labeled":** As defined in the "National Electrical Code," Article 100.

PRODUCTS

MANUFACTURERS

- A. **Manufacturers:** Subject to compliance with requirements, provide ground-fault protection components by one of the following:
1. **Challenger Electrical Equipment Corp.**
 2. **Electrical Distribution & Control; General Electric Company.**
 3. **Allen-Bradley Company; Rockwell International Corp.**
 4. **Distribution Equipment Div; Square D Co.**
 5. **Industrial Electrical Products; Westinghouse Electric Corp.**

GROUND-FAULT SENSING DEVICES

- A. **Outgoing-Circuit Current Sensors:** Current transformer with rectangular windows for circuits requiring outgoing-circuit sensing method. Use single transformer per circuit, or multiple transformers with identical ratios, to measure vectorial sum of currents in all conductors, including neutral, of a circuit.
- B. **Ground-Return Current Sensors:** Current transformer suitable for encircling main bonding jumper connection between system neutral and grounding electrode conductor.
- C. **Short-Circuit Rating:** 200,000 amperes rms symmetrical.
- D. **Outputs:** Compatible with relay inputs.
- E. **Split-Core Construction:** Construct sensor to allow installation and removal without disturbing the electrical conductors being encircled.
- F. **Provide test windings in sensor for testing the operation of ground-fault protection unit, including sensor pick-up, relay, and circuit-protection devices.**

GROUND-FAULT RELAYS AND MONITORS

- A. **Ground-Fault Relay:** Solid-state type that requires no external source of electrical power for relay operation, drawing control power from output of current sensor.
1. **Testing and Tripping Voltage:** 120 volts AC, from external source.
 2. **Pick-up Current Sensitivity:** Adjustable range from 100 to 1200 amperes, with calibrated dial to show pick-up point settings.
 3. **Time Delay:** Field adjustable from instantaneous to 1 second, and designed to prevent tampering with setting.
 4. **Component Classification:** UL 1053, Class II.
 5. **Output Circuit:** Compatible with ratings of disconnect tripping coils.
- B. **Monitor Panels:** Include ground-fault indicators, control-power indicators, and test and reset buttons. Arrange to allow testing with and without tripping.

EXECUTION

INSTALLATION

- A. Install ground-fault sensing windows symmetrically encircling power conductor bus bars or cables. Maintain clearances between conductors and ground-fault sensor body as recommended by device manufacturer.
- B. Provide grounding connections for ground-fault protection systems and components as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.

FIELD QUALITY CONTROL

- A. Testing Firm: Provide the services of a qualified independent testing firm to perform field quality control testing.
- B. Testing: Upon completion of installation of ground-fault protection system and after electrical circuitry has been energized, demonstrate capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA Standard ATS, Section 7.14. Certify compliance with test parameters.
- C. Correct malfunctioning units at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

ADJUSTING

- A. Set field-adjustable pick-up and time-sensitivity ranges as indicated.
- B. Perform short-circuit analysis and coordination study. Set field-adjustable pick-up and time-sensitivity ranges accordingly.

FIRE ALARM SYSTEMS - Addressable

1 GENERAL

SUMMARY

- A. This Section includes fire alarm systems, including manual stations, detectors, signal equipment, controls, and devices.

DEFINITION

- A. FACP: Fire Alarm Control Panel.

SYSTEM DESCRIPTION

- A. General: Zoned, noncoded, addressable, microprocessor-based fire-detection and alarm system with manual and automatic alarm initiation.
- B. Signal Transmission: Multiplex signal transmission dedicated for fire alarm service only.
- C. Audible Alarm Indication: By sounding of horns and bells or by tone signals on loudspeakers.
- D. Audible Alarm Indication: by sounding of horns and bells for alarm zones indicated and by voice alarm messages and tone signals on loudspeakers for remaining zones.
- E. Visual Alarm Indication: By xenon-strobe-type units.
- F. System connections for alarm-initiating and alarm-indicating circuits. Class A wiring.

SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product Data for each type of system component specified including dimensioned plans and elevations showing minimum clearances and installed features and devices. Include list of materials and listing data.
- C. Wiring diagrams from manufacturer differentiating clearly between factory- and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified. Make all diagrams specific to this Project and distinguish between field and factory wiring.
- D. Floor Plans: Indicate final outlet locations and routings of raceway connections.
- E. Device Address List: Coordinate with final system programming.
- F. System operation description covering this specific Project, including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are unacceptable.
- G. Operating instructions for mounting at the FACP.

- H. **Product certificates signed by manufacturers of fire alarm system components certifying that their products comply with specified requirements.**
- I. **Maintenance data for fire alarm systems to include in the operation and maintenance manual specified in Division 1. Include data for each type of product, including all features and operating sequences, both automatic and manual. Include recommendations for spare parts to be stocked at the site. Provide the names, addresses, and telephone numbers of service organizations that carry stock of repair parts for the system to be furnished.**
- J. **Submission to Authorities Having Jurisdiction: In addition to routine submission of the above material, make an identical submission to the authorities having jurisdiction. Include copies of annotated Contract Drawings as needed to depict component locations to facilitate review. Upon receipt of comments from the authorities having jurisdiction, submit them for review. Resubmit if required to make clarifications or revisions to obtain approval.**

QUALITY ASSURANCE

- A. **Installer Qualifications: Engage an experienced factory-authorized Installer to perform work of this Section.**
- B. **Single-Source Responsibility: Obtain fire alarm components from a single source who assumes responsibility for compatibility of system components.**
- C. **Compliance with Local Requirements: Comply with the applicable building code, local ordinances, and regulations, and the requirements of the authorities having jurisdiction.**
- D. **Comply with NFPA 70.**
- E. **Comply with NFPA 72.**
- F. **Listing and Labeling: Provide systems and equipment specified in this Section that are listed and labeled.**
 - 1. **The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.**
- G. **Comply with ADA.**

PRODUCTS

MANUFACTURERS

- A. **Manufacturers: Subject to compliance with requirements, provide products by one of the following:**
 - 1. **Edwards Systems Technology; General Signal Unit.**
 - 2. **Notifier; Pitway Corp. Div.**
 - 3. **Simplex Time Recorder Co.**

FUNCTIONAL DESCRIPTION OF SYSTEM

- A. **Include the following system functions and operating features plus those additional functions and features required by the authorities having jurisdiction:**
 - 1. **Priority of Signals: Accomplish automatic response functions by the first zone initiated. Alarm functions resulting from initiation by the first zone are not altered by subsequent alarms. The highest priority is an alarm signal. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even though the lower-priority condition occurred first. Annunciate all alarm signals regardless of priority or order received.**

2. **Noninterfering:** Zone, power, wire, and supervise the system so a signal on one zone does not prevent the receipt of signals from any other zone. All zones are manually resettable from the FACP after the initiating device or devices are restored to normal. Systems that require batteries or battery back-up for the programming function are unacceptable.
3. **Fire Alarm Control Panel (FACP) Response:** The manual or automatic operation of an alarm-initiating or supervisory-operating device causes the FACP to transmit an appropriate signal including the following:
 - a. General alarm.
 - b. Smoke or heat detector alarm.
 - c. System trouble.
 - d. Fan shutdown.
 - e. Smoke-control initiation.
4. **Silencing at the FACP:** Switches provide capability for acknowledgment of alarm, supervisory, trouble, and other specified signals at the FACP; and capability to silence the local audible signal and light a light-emitting diode (LED). Subsequent zone alarms cause the audible signal to sound again until silenced by switch operation. Restoring alarm, supervisory, and trouble conditions to normal extinguishes the associated LED and causes the audible signal to sound again until restoration is acknowledged by switch operation.
5. **Loss of primary power** sounds a trouble signal at the FACP. The FACP indicates when the fire alarm system is operating on an alternate power supply.
6. **Annunciation:** Manual and automatic operation of alarm- and supervisory-initiating devices is annunciated both on the FACP and on the annunciator, indicating location and type of device.
7. **FACP Alphanumeric Display:** Displays plain-English-language descriptions and addresses of initiating devices, alarms, trouble signals, supervisory signals, monitoring actions, system and component status, and system commands.
8. **General Alarm:** A system general alarm includes the following:
 - a. Indicating the general alarm condition at the FACP and the annunciator.
 - b. Identifying the device that is the source of the alarm (or its zone) at the FACP and the annunciator.
 - c. Initiating audible and visible alarm signals throughout the building.
 - d. Stopping supply and return fans serving zone where alarm is initiated.
 - e. Closing smoke dampers on system serving zone where alarm is initiated.
 - f. Initiating transmission of alarm signal to remote central station.
9. **Manual station alarm operation** initiates a general alarm.
10. **Smoke detection** initiates a general alarm.

ADDRESSABLE DEVICES

- A. **Alarm-Initiating Devices:** Classified as addressable devices according to NFPA 72.
 1. **Communication Transmitter and Receiver:** Integral to device. Provides each device with a unique identification and capability for status reporting to the FACP.

2. **External Addressable Interface Unit:** May be used where specified devices are not manufactured and labeled with integral multiplex transmitter and receiver. Arrange to monitor status of each device individually.

MANUAL PULL STATIONS

- A. **Description:** Double-action type, fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.
 1. **Station Reset:** Key or wrench operated, double pole, double throw, switch rated for the voltage and current at which it operates. Stations have screw terminals for connections.

SMOKE DETECTORS

- A. **General:** Comply with UL 268. Include the following features:
 1. **Factory Nameplate:** Serial number and type identification.
 2. **Operating Voltage:** 24-V dc, nominal.
 3. **Self-Restoring:** Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 4. **Plug-in Arrangement:** Detector and associated encapsulated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. The plug connection requires no springs for secure mounting and contact maintenance. Terminals in the fixed base accept building wiring.
 5. **Integral Visual Indicating Light:** Connect to indicate detector has operated.
 6. **Remote Controllability:** Individually monitor detectors at the FACP for calibration, sensitivity, and alarm condition, and individually adjust for sensitivity from the FACP.
- B. **Photoelectric Smoke Detectors:** Include the following features:
 1. **Detector Sensitivity:** Between 2.5- and 3.5-percent-per-foot smoke obscuration when tested according to UL 268.
 2. **Sensor:** An infrared detector light source with matching silicon-cell receiver.
- C. **Duct Smoke Detector:** Ionization type.
 1. **Sampling Tube:** Design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied.
 2. **Relay Fan Shutdown:** Rated to interrupt fan motor-control circuit.

OTHER DETECTORS

- A. **Thermal Detector:** Combination fixed-temperature and rate-of-rise unit with mounting plate arranged for outlet box mounting; 135 deg F fixed-temperature setting, except as indicated.

ALARM-INDICATING DEVICES

- A. **General:** Equip alarm-indicating devices for mounting as indicated. Provide terminal blocks for system connections.
- B. **Horns:** Electric-vibrating-polarized type, operating on 24-V dc, with provision for housing the operating mechanism behind a grille. Horns produce a sound-pressure level of 90 dB, measured 10 feet from the source.

- C. **Visual Alarm Devices:** Xenon strobe lights with clear or nominal white polycarbonate lens. Mount lenses on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch high letters on the lens.
 - 1. Devices have a minimum light output of 115 candela.
 - 2. Devices have a minimum light output as indicated on the Drawings.
 - 3. Strobe Leads: Factory connected to screw terminals.
 - 4. Combination devices consist of factory-combined, audible and visual alarm units in a single mounting assembly.
- D. **Remote Alarm Indicator:** LED type, mounted flush in a single gang wall plate.
 - 1. Connected to indicate the alarm operation of a single detector or other device.
 - 2. Legend: "Alarm."

CENTRAL FIRE ALARM CONTROL PANEL (FACP)

- A. **General:** Comply with UL 864.
- B. **Cabinet:** Lockable steel enclosure. Arrange panel so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control panel, provide exactly matching modular unit enclosures. Accommodate all components and allow ample gutter space for interconnection of panels and field wiring. Identify each enclosure by an engraved, red, laminated, phenolic-resin nameplate. Lettering on the enclosure's nameplate shall not be less than 1 inch high. Identify individual components and modules within the cabinets with permanent labels.
- C. **Systems:** Alarm and supervisory systems are separate and independent in the FACP. The alarm-initiating zone boards in the FACP consist of plug-in cards. Construction requiring removal of field wiring for module replacement is unacceptable.
- D. **Control Modules:** Types and capacities required to perform all functions of the fire alarm systems. Local, visible, and audible signals announce alarm, supervisory, and trouble conditions. Each type of audible alarm has a different sound.
- E. **Zones:** Provide for all alarm and supervisory zones indicated.
- F. **Alphanumeric Display and System Controls:** Arrange to provide the basic interface between human operator at the FACP and addressable system components, including annunciation and supervision. A display with a minimum of 32 characters shows alarm, supervisory, and component status messages. Arrange keypad for use in entering and executing control commands.
- G. **Alphanumeric Display and System Controls:** Arrange to provide the basic interface between human operator at the FACP and addressable system components, including annunciation, supervision, and control. A display with a minimum of 32 characters shows alarm, supervisory, and component status messages and indicates control commands to be entered into the system for control of smoke detector sensitivity and other parameters. Arrange keypad for use in entering and executing control commands.

EMERGENCY POWER SUPPLY

- A. **General:** Components include nickel-cadmium-type battery, charger, and an automatic transfer switch. Battery nominal life expectancy is 20 years, minimum.
- B. **Battery capacity** is adequate to operate the complete alarm system in normal or supervisory (nonalarm) mode for a period of 24 hours. At the end of this period, the battery has sufficient

capacity to operate the system, including alarm-indicating devices in either alarm or supervisory mode, for a period of 15 minutes.

- C. **Battery Charger:** Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining the batteries at full charge. In the event batteries are fully discharged, the charger recharges them completely within 4 hours. Charger output is supervised as part of system power supply supervision.
- D. **Integral Automatic Transfer Switch:** Transfers the load to the battery without loss of signals or status indications when normal power fails.

WIRE

- A. **Wire:** Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 - 1. **Low-Voltage Circuits:** No. 16 AWG, minimum.
 - 2. **Line-Voltage Circuits:** No. 12 AWG, minimum.

EXECUTION

INSTALLATION, GENERAL

- A. Install system according to NFPA standards referenced in Parts 1 and 2 of this Section.
- B. **Fire Alarm Power Supply Disconnect:** Paint red and label "FIRE ALARM." Provide with lockable handle or cover.

EQUIPMENT INSTALLATION

- A. **Manual Pull Stations:** Mount semiflush in recessed back boxes with operating handles 48 inches above the finished floor or lower as indicated.
- B. **Smoke Detectors:** Install ceiling-mounted detectors not less than 4 inches from a side wall to the near edge. Install detectors located on the wall at least 4 inches, but not more than 12 inches, below the ceiling. For exposed solid-joint construction, mount detectors on the bottom of the joists. On smooth ceilings, install detectors not over 30 feet apart in any direction. Install detectors no closer than 60 inches from air registers.
- C. **Audible Alarm-Indicating Devices:** Install not less than 80 inches above the finished floor nor less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille or as indicated. Combine audible and visual alarms at the same location into a single unit.
- D. **Visual Alarm-Indicating Devices:** Install adjacent to each alarm bell or alarm horn and not more than 80 inches above the finished floor and at least 6 inches below the ceiling.
- E. **Device Location-Indicating Lights:** Locate in public space near the device they monitor.
- F. **FACP:** Surface mount with tops of cabinets not more than 72 inches above the finished floor.

WIRING INSTALLATION

- A. **Wiring Method:** Install wiring in metal raceway according to Division 16 Section "Raceways, Boxes, and Cabinets." Conceal raceway except in unfinished spaces and as indicated.
- B. **Wiring within Enclosures:** Install conductors parallel with or at right angles to the sides and back of the enclosure. Bundle, lace, and train the conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring

diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

- C. **Cable Taps:** Use numbered terminal strips in junction, pull or outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- D. **Color Coding:** Color-code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and a different color code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visual alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

IDENTIFICATION

- A. **Identify system components, wiring, cabling, and terminals according to Division 16 Section "Electrical Identification."**

GROUNDING

- A. **Ground cable shields and equipment according to system manufacturer's instructions to eliminate shock hazard and to minimize, to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments.**
- B. **Signal Ground Terminal:** Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding.
- C. **Install grounding electrodes of type, size, location, and quantity as indicated. Comply with installation requirements of Division 16 Section "Grounding."**
- D. **Ground equipment and conductor and cable shields. For audio circuits, minimize, to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.**

FIELD QUALITY CONTROL

- A. **Manufacturer's Field Service:** Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.
- B. **Pretesting:** After installation, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
- C. **Final Test Notice:** Provide a 10-day minimum notice in writing when the system is ready for final acceptance testing. Coordinate with authorities having jurisdiction.
- D. **Minimum System Tests:** Test the system according to the procedures outlined in NFPA 72. Minimum required tests are as follows:
 - 1. **Verify the absence of unwanted voltages between circuit conductors and ground.**
 - 2. **Test all conductors for short circuits using an insulation-testing device.**
 - 3. **Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.**
 - 4. **Observe proper signal transmission according to class of wiring used.**

5. **Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.**
 6. **Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.**
- E. **Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.**

CLEANING AND ADJUSTING

- A. **Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.**

TELEPHONE RACEWAY SYSTEMS

GENERAL

SUMMARY

- A. This Section includes telephone distribution systems, including a provision for service by the telephone utility organization. It includes the raceway, cabinets, junction boxes and terminal boards for installation of wiring and equipment by others.
- B. Related Sections: The following Division 16 Sections contain requirements that relate to this Section:
 - 1. "Raceways, Boxes and Cabinets" for telephone raceways, including conduit, tubing, wireways, and surface raceways.

SUBMITTALS

- A. General: Submit the following according to Conditions of the Contract and Division 1 Specification Sections.
- B. Product Data.

QUALITY ASSURANCE

- A. Comply with NFPA 70, "National Electrical Code."
- B. "Nationally Recognized Testing Laboratory" (NRTL) Listing: Provide materials that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
- C. Coordination of Work: Coordinate the Work of this Section with the requirements of the Owner's telephone system supplier and of the telephone utility organization.
 - 1. Meet jointly with the representatives of the above organization and the Owner's representative to exchange information and agree on details of installation interfaces.
 - 2. Record agreements reached in the meeting and distribute the record to the other participants.

PRODUCTS

CABLE AND WIRING COMPONENTS

- A. Raceways, Boxes, and Cabinets: Comply with Division 16 Section "Raceways, Boxes, and Cabinets." Cabinets are equipped with backboard.
- B. Backboard: 3/4-inch interior grade plywood. Where installed in wire closet, height and width must cover entire wall up to 8 feet above floor, except as otherwise indicated.

EXECUTION

INSTALLATION, GENERAL

- A. **Telephone Service:** Comply with telephone utility organization requirements as to details of the telephone service.
- B. **Raceway Distribution System:** Install completely so system will be fully operational when telephone instruments and switching equipment are connected.
- C. **Raceway:** Install telephone service and distribution raceway where indicated as specified in Division 16 Section "Raceways, Boxes, and Cabinets."

INSTALLATION

- A. **Wiring Method:** Install boxes at outlets. Install raceway concealed in wall where walls are solid or filled with insulation. Terminate raceway with a bushing in ceiling space above outlet except as otherwise indicated.

GROUNDING

- A. Install ground terminal at service location and connect in accordance with Division 16 Section "Grounding."

IDENTIFICATION

- A. Identify telephone system backboards and cabinets with the legend "Telephone." Identify terminals of terminal strip and jack outlets and pull and junction boxes with approved designations. Perform all identification in accordance with Division 16 Section "Electrical Identification."

LIGHTING CONTROL EQUIPMENT

GENERAL

SUMMARY

- A. This Section includes the following types of lighting controls:
 - 1. Time switches.
 - 2. Photoelectric relays.
 - 3. Lighting relays and contactors.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 16 Section "Basic Electrical Materials and Methods" for general component identification and support requirements.

SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
 - 1. Submit Product Data for lighting control equipment and systems components, including dimensions and data on features and components. Include wiring diagrams and elevation views of front panels of control and indicating devices. Include data on ratings. For flush control panels, submit color and finish options for selection. Also include the following:
 - a. Lists of ballast and lamp combinations compatible with dimmer systems, by manufacturer and catalog number.
 - b. Sound data, including operational tests of dimming systems.
 - c. Operational documentation for software.
 - 2. Shop Drawings detailing assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
 - 3. Wiring diagrams detailing specific systems tailored to this Project and differentiating between factory-installed and field-installed wiring.
 - 4. Maintenance data for lighting control equipment and systems components to include in the operation and maintenance manual specified in Division 1.

QUALITY ASSURANCE

- A. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL where available.
- B. Comply with FCC Regulations of Part 15, Subpart J for Class A.
- C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. **The Terms "Listed" and "Labeled":** As defined in the "National Electrical Code," Article 100.

WARRANTY

- A. **General Warranty:** The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
- B. **Special Warranty:** Submit a written warranty signed by manufacturer and Installer agreeing to replace programmable lighting control system components that fail in materials or workmanship within the specified warranty period.
- C. **Warranty Period:** 2 years from date of Substantial Completion.

PRODUCTS

MANUFACTURERS

- A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 1. **Contactors and Relays:**
 - a. Automatic Switch Co.
 - b. Eaton Corporation, Cutler-Hammer Products.
 - c. GE Lighting Controls.
 - d. Square D Co.
 - e. Zenith Controls, Inc.
 2. **Time Switches:**
 - a. Intermatic, Inc.
 - b. Leviton Manufacturing Co., Inc.
 - c. Paragon Electric Co., Inc.
 - d. Zenith Controls, Inc.
 3. **Photoelectric Relays:**
 - a. Fisher Pierce.
 - b. Intermatic, Inc.
 - c. Paragon Electric Co, Inc.
 - d. SSAC, Inc.

CONTACTORS AND RELAYS

- A. **Comply with NEMA ICS 2.**
- B. **Description:** Devices are electrically operated and mechanically held. Number of poles and ratings are as indicated. Coordinate rating of each unit with type of load served, including tungsten filament and inductive-type loads.
- C. **Modular Single-Pole Relays:** Split-coil, momentary-pulsed type, knockout mounting.
 1. **Low-Voltage Leads:** 5-pin plug connector.
 2. **Pilot Contacts:** Single pole.
 3. **Rated Capacity:** 20 A, 125 VAC for tungsten filaments, and 20 A, 277 VAC for ballasts.
 4. **Endurance:** 50,000 cycles at rated capacity.

- D. **Modular Relay Panels:** Steel cabinets, preassembled with modular single-pole relays, transformer power supplies, and associated components.
 - 1. Barriers separate low-voltage and line-voltage components.
 - 2. Cover: Hinged, lockable type.
 - 3. Directory: Mounted on back of door. Identifies relays and loads controlled.

TIME SWITCHES

- A. **Time Switches:** Solid-state programmable units with alphanumeric display conforming to UL 917. Include the following features:
 - 1. Astronomic dial.
 - 2. Contacts: 2, rated 30 A at 277 VAC, except as otherwise indicated.
 - 3. Pilot-Duty Contacts: 2, rated 2 A at 240 V, except as otherwise indicated.
 - 4. Eight-Day Program: Uniquely programmable for each day of the week and holidays.
 - 5. Skip-day mode.

PHOTOELECTRIC RELAYS

- A. Conform to UL 773A.
- B. Type: Solid-state, with SPDT dry contacts rated to operate relay or contactor coils to which connected.
- C. Time delay prevents false operation.
- D. **Indoor Ceiling- or Wall-Mounted Units:** Semiflush, calibrated to detect adequacy of daylighting in perimeter locations and arranged to turn artificial illumination on and off to suit varying intensities of available daylighting. Units are adjustable for turn-on/turn-off levels.
- E. **Outdoor Sealed Units:** Weathertight housing, resistant to high temperatures and equipped with sun-glare shield and ice preventer.

EXECUTION

INSTALLATION

- A. Install equipment according to manufacturer's written instructions.
- B. Mount control equipment according to manufacturer's instructions and Division 16 Section "Basic Electrical Materials and Methods."
- C. Mounting heights indicated are to bottom of unit for suspended items and to center of unit for wall-mounted ones.

CONTROL WIRING INSTALLATION

- A. Install wiring between control devices as specified in Division 16 Sections "Wires and Cables" for low-voltage connections, and "Voice and Data Systems" for digital circuits.
- B. **Wiring Method:** Install all wiring in raceway as specified in Division 16 Section "Raceways, Boxes, and Cabinets."
- C. Bundle, train, and support wiring in enclosures.
- D. **Grounding:** Ground equipment. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

IDENTIFICATION

- A. Identify components and power and control wiring according to Division 16 Section "Electrical Identification."
- B. Label each system control module with a unique designation. Make designations on elevated components readable from floor.

FIELD QUALITY CONTROL

- A. **Manufacturer's Field Services:** Provide services of a factory-authorized service representative to test, adjust, and program lighting control systems.
- B. **Reports:** Prepare written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.
- C. **Test Labeling:** After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible organization and person.
- D. Schedule visual and mechanical inspections and electrical tests with at least 7 days advance notice.
- E. **Visual and Operational Inspections:** Include the following inspections:
 - 1. Inspect control components for defects and physical damage, NRTL labeling, and nameplate compliance with current Project Drawings.
 - 2. Check tightness of electrical connections with torque wrench calibrated within previous 6 months. Use manufacturer's recommended torque values.
 - 3. Verify settings of photoelectric devices with photometer calibrated to National Institute for Science and Technology (NIST) standards within past 6 months.
 - 4. Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's instructions for routine functional operation.
- F. **Electrical Tests:** Use particular caution when testing devices containing solid-state components. Perform the following tests according to manufacturer's instructions:
 - 1. Continuity tests of circuits.
 - 2. **Operational Tests:** Set and operate controls to demonstrate controls in a methodical sequence that cues and reproduces actual operating functions. Include testing of dimming equipment and ambient-light, programmable, and occupancy controls under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
- G. Correct deficiencies disclosed by inspections and tests, make necessary adjustments, and retest deficient items. Verify that specified requirements are met.

ADJUSTING AND CLEANING

- A. **Occupancy Adjustments:** Upon request within 1 year of date of Substantial Completion, make up to 3 on-site visits to Project site to assist in adjusting light levels, making program changes, and adjusting sensors and controls.
- B. Repair scratches and mars of finish to match original finish. Clean equipment and devices internally and externally using methods and materials recommended by manufacturers.

DEMONSTRATION

- A. **Training: Provide services of a factory-authorized service representative to demonstrate programmable lighting control system and to train Owner's maintenance personnel.**
 - 1. **Train Owner's personnel to operate, service, maintain, adjust, and program equipment and system components. Allow at least 4 hours to conduct training. Schedule training with at least 7 days advance notice. Use final approved operation and maintenance manual as a training aid throughout training. Use both classroom training and hands-on exercises.**

