

## SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS

## PART 1 - GENERAL

## 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

## 1.02 SUMMARY

- A. This Section includes the following:
  - 1. Raceways, boxes and fittings.
  - 2. Conductors, cables and associated connectors.
  - 3. Electrical identification.
  - 4. Wiring devices.
  - 5. Supporting devices for electrical components.
  - 6. Grounding and bonding.
  - 7. Equipment for Utility Company's electrical metering.

## 1.03 SUBMITTALS

- A. Submit manufacturer's product data for all electrical materials furnished under this section of the specifications.

## 1.04 QUALITY ASSURANCE

- A. Provide electrical devices and equipment specified in this section that are UL listed and labeled.
- B. Comply with NFPA 70.

## PART 2 - PRODUCTS

## 2.01 RACEWAYS, BOXES AND FITTINGS

- A. Manufacturers:
  - 1. Subject to compliance with requirements, provide products by one of the following manufacturers:
    - a. Metal Conduit and Tubing:
      - (1) Regal Manufacturing Co.
      - (2) Triangle PWC, Inc.
      - (3) Republic Steel
      - (4) Wheatland Tube Co.
    - b. Nonmetallic Conduit and Tubing:
      - (1) Certainteed Corp.; Pipe & Plastics Group.
      - (2) Hubbell, Inc.
      - (3) Carlon Electrical Products.
      - (4) Thomas & Betts Corp.
    - c. Conduit Bodies and Fittings:
      - (1) American Electric.
      - (2) Crouse-Hinds.
      - (3) Appleton Electric Co.
      - (4) Killark Electric Manufacturing Co.
      - (5) Carlon Electrical Products.

- (6) O-Z/Gedney.
  - d. Metal Wireways:
    - (1) Square D Co.
    - (2) Cuttler-Hammer.
    - (3) Hoffman Engineering Co.
  - e. Surface Metal Raceways:
    - (1) American Electric.
    - (2) Butler Manufacturing Co.; Walker Division.
    - (3) Wiremold Co.
  - f. Boxes, Enclosures, and Cabinets:
    - (1) American Electric.
    - (2) Butler Manufacturing Co.; Walker Division.
    - (3) Crouse-Hinds.
    - (4) Erickson Electrical Equipment Co.
    - (5) Hoffman Engineering Co.
    - (6) Killark Electric Manufacturing Co.
    - (7) Racor, Inc.
    - (8) Carlon Electrical Products.
    - (9) O-Z/Gedney.
    - (10) Adalet-PLM.
    - (11) Thomas & Betts Corp.
    - (12) Daniel Woodhead Co.
- B. Metal Conduit and Tubing
  - 1. Rigid Steel Conduit: ANSI C80.1.
  - 2. Rigid Aluminum Conduit: ANSI C80.5.
  - 3. IMC: ANSI C80.6.
  - 4. Plastic-Coated Steel Conduit and Fittings: NEMA RN 1.
  - 5. EMT and Fittings: ANSI C80.3.
    - a. Fittings: Set-screw or compression type.
  - 6. Flexible Metal Conduit: Aluminum or zinc-coated steel.
  - 7. Liquidtight Flexible Metal Conduit: Flexible steel conduit with PVC jacket.
  - 8. Fittings: NEMA FB 1; compatible with conduit/tubing materials.
- C. Nonmetallic Conduit
  - 1. Rigid Nonmetallic Conduit: NEMA TC 2, Schedule 40 PVC.
  - 2. Rigid Nonmetallic Fittings: Match conduit type and material.
- D. Metal Wireways
  - 1. Metal Wireways shall be manufactured from sheet metal. Type shall be as indicated on the drawings.
  - 2. Wireways shall include all required fittings and accessories including couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.
  - 3. The complete wireway system shall comply with NFPA 70.
  - 4. Wireway covers shall be the hinged type unless otherwise indicated on the drawings.
  - 5. Wireway finish shall be the manufacturer's standard gray enamel unless otherwise indicated on the drawings.
- E. Surface Raceways
  - 1. Surface metal raceways and finish shall be as indicated on the drawings.
  - 2. Furnish types and sizes as indicated for each application, with fittings that match and mate with the raceways.

- F. Outlet and Device Boxes
  - 1. Sheet Metal Boxes: NEMA OS 1.
  - 2. Cast-Metal Boxes: NEMA FB 1, Type FD, cast box with gasketed cover.
- G. Floor Boxes
  - 1. Floor Boxes shall be cast metal, fully adjustable, rectangular.
- H. Pull and Junction Boxes
  - 1. Pull boxes and junction boxes used indoors in dry locations shall be sheet metal, NEMA OS 1.
  - 2. Cast-metal boxes shall conform to NEMA FB 1, and shall have gasketed covers.
- I. Enclosures and Cabinets
  - 1. Hinged-cover enclosures shall conform to NEMA 250, Type 1, with continuous hinge cover and flush latch, unless otherwise indicated on the drawings. Enclosures shall be steel with manufacturer's standard enamel finish, unless otherwise indicated on the drawings.

## 2.02 CONDUCTORS, CABLES AND CONNECTORS

- A. Manufacturers:
  - 1. Subject to compliance with requirements, provide products by one of the following manufacturers:
    - a. Wires and Cables:
      - (1) American Insulated Wire Corp.
      - (2) Carol Cable Co., Inc.
      - (3) Southwire Company.
    - b. Connectors for Wires and Cables:
      - (1) AMP Incorporated
      - (2) General Signal
      - (3) Square D Co.; Anderson.
      - (4) 3M Company; Electrical Products Division.
- B. Conductors and Cables:
  - 1. Conductors and cables for general building wiring shall be UL type THHN/THWN, stranded copper, #12 AWG minimum. Aluminum wiring shall not be used.
  - 2. Conductors for control wiring shall be stranded copper, and shall be as recommended by the associated equipment manufacturer, and installed in raceway. Minimum control power conductors shall be #14 AWG, THHN/THWN/MTW, stranded copper.
  - 3. Thermoplastic insulation material shall comply with NEMA WC 5.
  - 4. Cross-linked polyethylene insulation material shall Comply with NEMA WC 7.
  - 5. "MC" cable is approved only for connection to lighting fixtures located in lay-in ceilings, in lengths of 6'-0" maximum. "MC" cable is not approved for any other use.
- C. Conductors for Fire Alarm circuits shall be as recommended by the Fire Alarm system manufacturer, and shall be installed in conduit unless otherwise indicated on the drawings.
- D. Connectors and Splices
  - 1. Furnish and install UL-listed, factory-fabricated wiring connectors of size, ampacity rating, material, type, and class for application and service indicated. Comply with Project's installation requirements and as specified in Part 3.

## 2.03 ELECTRICAL IDENTIFICATION

- A. General:
  - 1. Pretensioned wraparound plastic sleeves shall be flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the cable it identifies and arranged to stay in place by pretensioned gripping action when placed in position.
  - 2. Colored adhesive tape shall be self-adhesive vinyl not less than 3 mils thick by 1 inch wide (0.08 mm thick by 25 mm wide).
  - 3. Underground-line warning tape shall be permanent, bright-colored, continuous-printed, vinyl as follows:
    - a. Not less than 6 inches wide by 4 mils thick (152 mm wide by 0.102 mm thick).
    - b. Compounded for permanent direct-burial service.
    - c. Embedded continuous metallic strip or core.
    - d. Printed legend indicating type of underground line.
  - 4. Tape markers shall be vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.
- B. Nameplates
  - 1. Engraved plastic nameplates shall be constructed of melamine plastic laminate, minimum 1/16 inch (1.6 mm) thick for nameplates up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes. Nameplates shall be engraved with black letters on a white face, and shall be punched for mechanical fasteners.
  - 2. Fasteners for nameplates shall be self-tapping, stainless-steel screws.

## 2.04 WIRING DEVICES

- A. Manufacturers:
  - 1. Subject to compliance with requirements, provide products by one of the following manufacturers:
    - a. Wiring Devices:
      - (1) Bryant Electric, Inc.
      - (2) Eagle Electric Manufacturing Co., Inc.
      - (3) GE Company; GE Wiring Devices.
      - (4) Hubbell, Inc.; Wiring Devices Div.
      - (5) Killark Electric Manufacturing Co.
      - (6) Leviton Manufacturing Co., Inc.
      - (7) Pass & Seymour/Legrand; Wiring Devices Div.
      - (8) Pyle-National, Inc.; an Amphenol Co.
    - b. Multioutlet Assemblies:
      - (1) Airey-Thompson Co.
      - (2) Wiremold.
    - c. Poke-through, Floor Service Outlets and Telephone/Power Poles:
      - (1) American Electric.
      - (2) Hubbell, Inc.; Wiring Devices Div.
      - (3) Pass & Seymour/Legrand; Wiring Devices Div.
      - (4) Square D Co.
      - (5) Wiremold.
- B. Receptacles
  - 1. Straight-blade and locking type receptacles shall be heavy-duty grade.
  - 2. GFCI receptacles shall be feed-through type, with integral NEMA WD 6, configuration 5-20R duplex receptacle arranged to protect connected downstream receptacles on same circuit. GFCI units shall be designed for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter.
  - 3. Color for receptacles shall be ivory.

- C. Cord and Plug Sets
  - 1. Cord and plug sets shall match the voltage and current ratings and number of conductors to requirements of equipment being connected. Cord and plug sets shall only be used where specifically indicated on the drawings.
    - a. Cord shall be rubber-insulated, stranded-copper conductors, with type SOW-A jacket. Cord shall contain a green-insulated grounding conductor, and have an equipment-rating ampacity plus a minimum of 30 percent.
    - b. Plugs shall have a nylon body and integral cable-clamping jaws. Match cord and receptacle type for each connection.
- D. Switches
  - 1. Snap switches shall be heavy-duty, quiet type, 20 A, 120/277 V ac.
  - 2. Dimmer switches shall be the modular, full-wave, solid-state type units with integral, quiet on/off switches and audible and electromagnetic noise filters.
    - a. Control of dimmer switches shall be by a continuously adjustable slide, toggle, or rotary knob. Furnish single-pole or three-way switches to suit connections.
    - b. Rating of dimmer switches shall be sufficient to serve the load associated with the switch.
  - 3. Color for switches shall be ivory.
- E. Wall Plates
  - 1. Furnish single and combination type wall plates to match the corresponding wiring devices.
    - a. Plate-securing screws shall be metal with head color to match plate finish.
    - b. Material for wall plates in finished spaces shall be 0.04-inch- (1-mm-) thick, Type 302, satin-finished stainless steel unless otherwise indicated on the drawings.
    - c. Material for wall plates in unfinished spaces shall be galvanized steel.
- F. Floor Service Fittings
  - 1. Type shall be modular, flush-type, dual-service units suitable for wiring method used.
  - 2. Floor service fittings shall be furnished with barriered compartments to separate power and signal wiring.
  - 3. Floor service fittings shall be constructed of die-cast aluminum with a satin finished, unless otherwise indicated on the drawings.
  - 4. Power receptacles for floor service fittings shall comply with NEMA WD 6, Configuration 5-20R, unless otherwise indicated. Color for receptacles in floor service fittings shall be ivory.
  - 5. Furnish signal outlet in floor service fittings with a blank cover with bushed cable opening, unless otherwise indicated on the drawings.
- G. Poke-Through Assemblies
  - 1. Poke-through assemblies shall be factory-fabricated and wired assembly of below-floor junction box unit with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
    - a. Size shall be selected to fit nominal 3-inch (75-mm) cored holes in floor and matched to floor thickness.
    - b. The poke-through assembly shall be UL listed and labeled for the fire rating of the floor-ceiling assembly.

- c. Closure plugs, where indicated on the drawings, shall be arranged to close unused 3-inch (75-mm) cored openings and reestablish fire rating of floor.
- H. Multioutlet Assemblies
  - 1. Multioutlet assemblies shall consist of products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
  - 2. Raceway material shall be as indicated on the drawings. Raceway covers shall be of the same material as the raceway.
- I. Telephone/Power Service Poles
  - 1. Telephone/power service poles shall be factory-assembled units to extend power, telephone, and data service from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
    - a. Poles shall be a nominal 2.5-inch- (65-mm-) square cross section with height adequate to extend from floor to at least 6 inches (150 mm) above ceiling, and separate channels for power and signal wiring.
    - b. Furnish poles with ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports, and pole foot with carpet pad attachment.
    - c. Pole finishes shall be as indicated on the drawings.
    - d. Furnish each pole with two single; 20-A; heavy-duty; NEMA WD 6, Configuration 5-20R receptacles, unless otherwise noted on the drawings.
    - e. Furnish each pole with two signal outlets with blank inserts and bushed cable openings.

## 2.05 SUPPORTING DEVICES

- A. General:
  - 1. Support devices shall be manufactured from cold-formed steel, with corrosion-resistant coating.
  - 2. Metal support devices used outdoors and in damp or wet locations shall be hot-dip galvanized steel.
  - 3. Metal strut shall be sized as required to safely and adequately support the load served in accordance with the strut manufacturer's recommendations, but minimum size shall be 1 5/8" square 12 gauge steel, Unistrut #P-1000, or approved equal.
  - 4. Nonmetallic strut and angle supports, where indicated on the drawings, shall be structural-grade, factory-formed, glass-fiber-resin channels and angles.
    - a. Nonmetallic fittings and accessories shall be of the same manufacturer as channels and angles.
    - b. Fittings and accessory materials shall be stainless steel.
  - 5. Raceway and cable supports shall be approved clevis hangers, riser clamps, threaded C-clamps with retainers, trapeze hangers and wall brackets.
  - 6. Pipe sleeves shall be ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.
  - 7. Cable supports for vertical conduits shall be factory-fabricated assemblies 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.
  - 8. Expansion anchors shall be carbon-steel wedge or sleeve type.
  - 9. Toggle bolts shall be all-steel springhead type.

## 2.06 GROUNDING AND BONDING

- A. Manufacturers:
  - 1. Subject to compliance with requirements, provide products by one of the following manufacturers for grounding conductors, cables, connectors, and rods:
    - a. Apache Grounding/Erco Inc.
    - b. Chance/Hubbell.
    - c. Copperweld Corp.
    - d. Erco Inc.; Electrical Products Group.
    - e. Burndy Electrical.
    - f. Heary Brothers Lightning Protection Co.
    - g. Ideal Industries, Inc.
    - h. ILSCO.
    - i. Kearney/Cooper Power Systems.
    - j. O-Z/Gedney Co.
- B. Grounding Conductors
  - 1. Insulated grounding conductors shall comply with the requirements of conductors and cables specified in this Division of the Specifications.
  - 2. Material for grounding conductors shall be stranded copper.
  - 3. Equipment grounding conductors shall have green-colored insulation.
  - 4. Underground grounding conductors shall be bare, tinned, stranded, No. 2/0 AWG minimum.
  - 5. Bare copper conductors shall comply with the following:
    - a. Solid conductors: ASTM B 3.
    - b. Assembly of stranded conductors: ASTM B 8.
    - c. Tinned conductors: ASTM B 33.
  - 6. Furnish and install bonding jumpers at all conduit expansion joints, and where otherwise required to maintain electrical continuity.
- C. Connector Products
  - 1. Connectors shall comply with IEEE 837 and UL 467. Grounding products shall be UL listed for use for specific types, sizes, and combinations of conductors and connected items.
  - 2. Bolted connectors shall be bolted-pressure-type, or compression type.
  - 3. Welded connectors shall be exothermic-welded type, in kit form, and selected in accordance with manufacturer's written instructions.
- D. Grounding Electrodes
  - 1. Ground rods shall be copper-clad steel.
    - a. Minimum size of ground rods shall be 3/4 by 120 inches (19 by 3000 mm).
  - 2. Provide grounding test well handhole at main electrical service entrances.

## 2.07 EQUIPMENT FOR UTILITY COMPANY'S ELECTRICITY METERING

- A. General:
  - 1. Furnish current transformer cabinets, meter sockets, conduits, weatherheads, supports, and other Utility required devices in accordance with the requirements of the local Utility Company. Coordinate metering equipment requirements with the local Utility Company.

## PART 3 - EXECUTION

## 3.01 RACEWAY APPLICATIONS

- A. Outdoors: The following wiring methods only shall be allowed outdoors:
  - 1. Exposed above grade : Rigid steel or IMC.
  - 2. Underground: Rigid nonmetallic conduit.
  - 3. Connection to Vibrating Equipment : Liquidtight flexible metal conduit.
  - 4. Boxes and Enclosures: NEMA 250, Type 3R unless otherwise noted on the drawings.
- B. Indoors: The following wiring methods only shall be allowed indoors:
  - 1. Exposed (where not subject to physical damage): EMT up to and including 3" trade size. Rigid steel or IMC for sizes above 3".
  - 2. Exposed (where subject to physical damage): Rigid galvanized steel conduit with cast boxes and fittings.
  - 3. Concealed in dry locations: EMT up to and including 3" trade size. Rigid steel or IMC for sizes above 3".
  - 4. Connection to Vibrating Equipment (Including transformers and motors): Flexible metal conduit in dry locations, liquidtight flexible metal conduit in damp or wet locations.
  - 5. Damp or Wet Locations: Rigid galvanized steel conduit with cast boxes and fittings.
  - 6. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
    - a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel.

### 3.02 RACEWAYS, BOXES AND FITTINGS

- A. Installation:
  - 1. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.
  - 2. The minimum raceway size for use above grade shall be 1/2-inch trade size. The minimum raceway size for use underground in lengths of 150 feet and shorter shall be 1 inch trade size, and for lengths longer than 150 feet shall be 1 1/4" trade size minimum.
  - 3. In finished areas and where indicated on the drawings, conceal conduit within finished walls and above ceilings.
  - 4. Keep raceways at least 24 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
  - 5. Install raceways level, square and in general, as high as possible. Provide adequate headroom.
  - 6. Support raceways adequately from the building structure.
  - 7. Use temporary closures to prevent foreign matter from entering raceways.
  - 8. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so that curved portion of bends are not visible above the finished slab.
  - 9. Use raceway fittings compatible with raceways and suitable for use and location. For rigid steel and intermediate steel conduit, use threaded rigid steel conduit fittings.
  - 10. Raceways embedded in concrete slabs shall be installed in middle third of slab thickness where practical, with at least 1-inch (25-mm) of concrete cover.
    - a. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
    - b. Space raceways apart laterally to prevent voids in concrete.
    - c. Install conduit larger than 1-inch trade size parallel to or at right angles to main reinforcement.
    - d. PVC conduits shall be transitioned to rigid steel or IMC conduit before rising above floor slab.



11. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
  - a. Run parallel or banked raceways together, on common supports where practical.
12. Join raceways with fittings designed and approved for the purpose.
  - a. Make raceway terminations tight. Use bonding bushings at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
  - b. Use insulating grounding bushings with locknuts at all conduit terminations.
  - c. Install conduit expansion fittings with bonding jumpers in all conduits that cross building expansion joints, and where otherwise required for conduit expansion.
13. Install pull cords in all empty raceways. Pullcords shall be monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of the pull cord.
14. Install raceway sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
  - a. Where conduits pass from warm to cold locations, such as the boundaries of refrigerated spaces.
  - b. Where otherwise required by NFPA 70.
15. Where indicated on the drawings, extend conduits through concrete floor for connection to freestanding equipment. Install conduit stub-ups with an adjustable top or coupling threaded inside for plugs set flush with the finished floor.
16. Flexible connections to lighting fixtures in lay-in type ceilings shall use a maximum of 6 feet (1830 mm) of flexible conduit. Provide flexible connections for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across all flexible connections.
17. PVC externally coated, rigid steel conduits shall use PVC coated fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits.
18. Install a separate, green grounding conductor in all surface mounted raceways, from the junction box supplying the raceways to the receptacle or fixture grounding terminals.
19. Set floor boxes level and trim after installation to fit flush to finished floor surface.
20. Install a minimum of (4) 1" spare conduits at each panelboard that is installed flush in wall. Conduits shall extend from the panelboard enclosure to the space above the ceiling, or to the joist space in areas where no ceiling is installed.
21. Conduits shall be supported at not more than 10'-0" on center, and shall be securely fastened within (3) feet of each conduit termination at equipment, junction boxes, etc.
22. Flexible metal conduit and liquid-tight conduit shall not be used in lengths greater than 4'-0".
23. Junction boxes for receptacles and telephone/data outlets shall be installed 18 inches above the finished floor to centerline of the box, unless otherwise noted on the drawings.
24. Junction boxes for lighting switches, pushbuttons, shall be installed 48 inches above the finished floor to centerline of the box, unless otherwise noted on the drawings. Lighting switch junction boxes shall be installed on the strike side of the door, unless otherwise indicated on the drawings.

25. Junction boxes for receptacles at countertops shall be installed 44 inches above the finished floor to centerline of the box, or 6 inches above top of countertop to centerline of box, whichever is higher, unless otherwise noted on the drawings.
26. Junction boxes for fire alarm manual pull stations shall be installed 48 inches above the finished floor to centerline of the box.
27. Junction boxes for fire alarm horns, strobes, or combination horn/strobes shall be installed 80 inches above the finished floor to centerline of the box, or 6 inches below the ceiling, whichever is lower.
28. Mounting height of junction boxes for connection to automatic flush valves shall be coordinated with the Division specifying valves.

B. Protection

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

3.03 CONDUCTOR AND CABLE

A. Installation:

1. Install wires and cables as indicated, according to manufacturer's written instructions. All wires and cables shall be installed in raceways.
2. Use UL and conductor manufacturer-approved pulling compound where necessary. Compound shall not deteriorate conductor or insulation. Manufacturer's recommended maximum pulling tensions and sidewall pressure values shall not be exceeded in the process of installing conductors.
3. Use pulling means that will not damage cables or raceway.
4. Identify wires and cables according to "ELECTRICAL IDENTIFICATION" in this section of the specifications.

B. Connections:

1. Conductor splices shall be used indoors only in dry locations unless otherwise noted on the drawings. Conductors shall be installed in a manner that minimizes splices. Conductors shall be installed unspliced where noted on the drawings.
2. Install splices and tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
3. Use splice and tap connectors compatible with conductor material.
4. Install 12 inches (300 mm) of slack in conductors at each outlet.
5. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer.
6. 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.

C. Field Quality Control

1. Testing all wires and cables before electrical circuitry has been energized.
2. Replace defective conductors and cables and retest to demonstrate compliance.

3.04 ELECTRICAL IDENTIFICATION

A. Installation:

1. Install electrical identification materials and devices at locations for most convenient viewing, and without interference with operation and maintenance of equipment.
2. Install continuous underground plastic tape marker located directly above underground ductbanks at 12 inches (305 mm) below finished grade. Install two runs of tape evenly spaced across the ductbank where the concrete envelope exceeds 16 inches (400 mm).
3. Secondary service, feeder, and branch-circuit conductors shall be color-coded throughout the electrical system. Conductor color coding shall be applied in panelboards and other enclosures in the sequence A-B-C from left to right and from top to bottom as viewed from the front of the enclosure.
  - a. Color-code 208Y/120-V system as follows:
    - (1) Phase A: Black.
    - (2) Phase B: Red.
    - (3) Phase C: Blue.
    - (4) Neutral: White.
    - (5) Ground: Green.
    - (6) Isolated Ground: Green with orange stripe.
  - b. Color-code 480Y/277-V system as follows:
    - (1) Phase A: Brown.
    - (2) Phase B: Orange.
    - (3) Phase C: Yellow.
    - (4) Neutral: Gray.
    - (5) Ground: Green.
    - (6) Isolated Ground: Green with orange stripe.
  - c. Conductor insulation shall be color coded along the entire length of conductors for sizes #8 AWG and smaller. For conductors larger than #8 AWG, use colored tape at all termination points, and in boxes where splices or connections are made. Use 1-inch- (25-mm-) wide tape in colors specified.

### 3.05 ELECTRICAL SUPPORTING DEVICES

- A. Application:
  1. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.
  2. Dry Locations: Painted steel materials.
  3. Support devices shall be sized to adequately and safely support the associated load, shall include a safety factor of at least four, and shall be designed to carry a minimum of 200-lb (90-kg) load.
- B. Installation:
  1. Install support devices to securely and permanently fasten and support electrical components. Securely fasten all electrical items and their supports to the building structure.
  2. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.
  3. Support parallel runs of horizontal raceways together on trapeze type hangers.
  4. Size supports for multiple raceway installations 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. The minimum size of threaded steel hanger rods shall be 1/2-inch- (13-mm-) diameter.

7. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-inch (25.4-mm) and smaller raceways.
8. Install vertical conductor supports in all multi-floor vertical conduit runs.
9. Separately support all metal boxes and enclosures independently of the conduit system. Support sheet-metal pullboxes directly from the building structure or by bar hangers.
10. Install metal strut racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural building steel members. Sheet metal is not considered a structural building member under these specifications.
11. Install sleeves for cable and raceway penetrations of concrete slabs and walls, and for penetration of all fire-rated walls. Sleeves installed in floor slabs shall extend 2" above the top of the slab.

### 3.06 WIRING DEVICES

#### A. Installation:

1. Install devices and assemblies plumb and secure.
2. Protect wiring devices during sheetrock mudding and painting. Install wall plates after final painting is complete.
3. Ganged wall mounted dimmer switches shall have their junction boxes spaced with nipples sufficiently to allow installation of switches without breaking off heat sink fins.
4. The neutral conductor shall not be shared on the load side of dimmer switches.
5. Unless otherwise indicated on the drawings, install all wiring devices with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under a single multigang wall plate. Ganged wall boxes for lighting switches shall have barriers installed between each switch.
6. Adjust locations of telephone/power service poles to suit arrangement of partitions and furnishings.
7. The mounting heights for junction boxes for wiring devices shall be as specified in paragraph 3.2 "RACEWAYS, BOXES AND FITTINGS", Part A "Installation", in this specification section.

#### B. Connections:

1. Connect wiring device grounding terminal to branch-circuit equipment grounding conductor.
2. All connections to wiring devices shall use screw-type connections. Push-in type connections to wiring devices is not allowed. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B.

#### C. Field Quality Control

1. Test wiring devices for proper polarity and ground continuity.
2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
3. Replace damaged or defective components.

#### D. Cleaning

1. Clean devices, device outlet boxes, and enclosures. Replace damaged or unintentionally painted wall plates and devices.

### 3.07 GROUNDING

- A. Application:
1. Grounding conductors used above grade shall be insulated.
  2. Exothermic-welded connections shall be used for connections to structural steel and for underground connections, with the exception of underground connections at test wells, which shall be bolted pressure clamp-type connection.
  3. Equipment grounding conductor terminations shall be made using lugs and connectors that are UL approved for use as a grounding connector, and approved for the specific use.
  4. Underground grounding conductors shall be buried at least 24 inches (600 mm) below grade or buried 6 inches (152 mm) above duct bank when installed as part of a duct bank.
- B. Conductors:
1. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or additional conductors than required by NFPA 70 are indicated on the drawings.
  2. Install equipment grounding conductors in all feeders and branch circuits.
  3. Provide a grounding electrode and grounding conductor at each metal pole supporting outdoor lighting fixtures, in addition to a separate equipment grounding conductor with the supply branch circuit conductors.
  4. Where a lightning protection system is present or is furnished as part of the building construction, bond the electrical power system service entrance grounding electrode directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode using a bonding conductor of the same size as the system grounding electrode conductor.
- C. Installation:
1. Install at one ground rod at each service entrance rated 1600 amperes and less, and three ground rods for each service entrance rated above 1600 amperes.
    - a. Drive ground rods until tops are 12 inches (50 mm) below final grade, unless otherwise indicated. Verify all existing underground utilities prior to driving ground rods.
    - b. For installations with multiple ground rods, interconnect ground rods with conductors of the same size as the service entrance grounding electrode conductor.
  2. Install grounding conductors along shortest possible route, unless otherwise indicated. Grounding conductors installed in earth shall be snaked in trench to prevent strain. All grounding conductors located above grade shall be installed in conduit.
  3. Install bonding jumpers at all conduit expansion joints.
  4. Install one test well for each service at the ground rod electrically closest to the service entrance. Set top of well flush with finished grade.
- D. Connections:
1. Select grounding connectors, hardware, conductors, and connection methods to insure that metal-to-metal connections are galvanically compatible.
  2. Exothermic-welded connections shall comply with manufacturer's written instructions.
  3. Equipment grounding conductor terminations shall use pressure-type lugs which are UL approved for use in grounding applications.
  4. Connections at test wells shall be the compression-type connectors on the conductors, and bolted-type connections between conductors and ground rods.
  5. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values.

- 6. Compression-type connections shall be made using hydraulic compression tools approved by the connector manufacturer.
- E. Quality Control
  - 1. Perform the following field quality-control testing:
    - a. After installing grounding system but before permanent electrical circuitry has been energized, test the grounding system.

### 3.08 UTILITY COMPANY ELECTRICITY-METERING EQUIPMENT

- A. Install equipment according to utility company's written requirements. Provide grounding, meter sockets, empty conduits and miscellaneous materials and equipment as required by utility company serving the facility.

END OF SECTION 16050