

SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. This Section includes the following:
 - 1. Building wire and connectors.
 - 2. Supporting devices for electrical components.
 - 3. Electrical identification.
 - 4. Concrete equipment bases.
 - 5. Cutting and patching for electrical construction.
 - 6. Touchup painting.

1.2 SUBMITTALS

- A. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.3 QUALITY ASSURANCE

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

1.4 COORDINATION

- A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
 - 1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.
- B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
- C. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 8 Section "Access Doors."
- D. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.
- E. Where electrical identification markings and devices will be concealed by acoustical ceilings and similar finishes, coordinate installation of these items before ceiling installation.

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- A. Many pieces of equipment as listed in the Specifications are available in various model numbers from various equipment manufacturers.
- B. In order to show design criteria and equipment layouts, one of the acceptable manufacturers had to be chosen. Where differences in dimensions may be significant, the basis of design is indicated in the Specifications or on the Drawings.
- C. If the Contractor chooses to use any of the acceptable manufacturers other than the one indicated as the basis of design, he shall be responsible for any modifications including building, piping, steel, electrical, or mechanical modifications required by this manufacturer.
- D. Modifications shall be at **NO ADDITIONAL COSTS** to the Owner.

PART 2 - PRODUCTS**2.1 CONDUIT SYSTEMS**

- A. Rigid Metal Conduits: Fabricated of mild steel piping, galvanized inside and outside, and protected against corrosion by a dichromate rinse or a zinc chromate coating. Each conduit shall bear the UL label, be defect free, furnished in 10 ft. lengths minimum, and be of the following types:
 - 1. Electrical Metallic Tubing (EMT) and Fittings: Products meeting requirements of NEC Article 348 for materials and uses.
 - 2. Rigid Metal Conduit and Fittings: Products meeting requirements of NEC Article 346 for materials and uses.
 - 3. Intermediate Metal Conduit (IMC) and Fittings: Products meeting requirements of NEC Article 345 for materials and uses.
- B. Flexible Metal Conduit: NOT PERMITTED ON THIS PROJECT – Use Flexible Cord or Cable.
- C. Rigid Plastic Conduit: High impact PVC (polyvinyl chloride) Conduit and Fittings (conforming to NEMA Spec. TC-2, as "Listed" and "Labeled" by UL), and meeting the requirements of NEC Article 347 for PVC materials and uses. Additionally, PVC conduit shall have material strengths of 5500 psi tensile, 11,000 psi flexural and 8600 psi compression, all at 78°F. Use schedule 40 conduit and fittings except where schedule 80 is required by NEC.
- D. PVC Coated Rigid Thick Wall Metal Conduit and Fittings:
 - 1. Hot-dip galvanized conduit, circular in cross section, uniform wall thickness, meeting Federal Specification WW-C-581 E, ANSI C80.1 and UL #6.
 - 2. Exterior surfaces thoroughly cleaned and treated with an epoxy primer prior to application of PVC coating.
 - 3. Minimum exterior coating of 40 mil thick polyvinyl chloride (PVC).
 - 4. Minimum interior coating of 2 mil thick polyurethane.
 - 5. Conduit assembled with a tightly drawn up coupling.
 - 6. The thread opposite the coupling shall be covered with a thread protector.

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7. The bond between metal and plastic shall be equal to or greater than the tensile strength of the plastic coating.
8. Acceptable Manufacturers:
 - a) Robroy Industries - Plastibond Redhot.
 - b) Perma-Coat Industries - Supreme.
- E. PVC Coated Flexible Metal Conduit: NOT PERMITTED ON THIS PROJECT – Use Flexible Cord or Cable.
- F. Conduit Expansion Joints: Telescoping sleeve type designed for 4" maximum expansion; weatherproof, vaportight, with insulated bushings and packing.
- G. Conduit Seal Fittings: Seal fitting suitable for threaded connection with fill plug and galvanized. Fill with approved seal compound. Products meeting requirements of NEC Article 300-7 for materials and uses.
- H. Conduit Unions ("Erickson Couplings"): Use where necessary to complete a conduit run when neither end can be turned.

2.2 CONDUCTORS

- A. Conductors, No. 10 AWG and Smaller: Stranded copper.
- B. Conductors, Larger Than No. 10 AWG: Stranded copper.
- C. Insulation: Thermoplastic, rated at 75 deg C minimum.
- D. Wire Connectors and Splices: Units of size, ampacity rating, material, type, and class suitable for service indicated.
 1. Compression Butt Splices:
 - a) Connection of all control conductors shall be performed with UL Listed, compression butt splices or bolted ring tongue terminals utilizing a manufacturer approved crimp tool.
 2. Split Bolt Connectors:
 - a) All connections for power conductors larger than #10 AWG shall be performed with UL Listed, split bolt or compression type connectors.
 3. Provide companion preformed plastic insulating covers or tape insulation conforming to NEC requirements on all uninsulated connections.

2.3 MOUNTING HARDWARE

- A. Supporting Devices: Carbon steel angles, channels, and bars meeting material requirements of ASTM A36. Pre-engineered UL "Listed" supporting systems of electrogalvanized steel materials may be used in lieu of field fabricated support systems. PVC corrosion-resistant coating if used in corrosive area.
 1. Kindorf.
 2. Unistrut.
 3. B-Line Systems.
 4. Approved Equal.

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- B. Fasteners: Anchoring devices used to anchor conduit or raceway and "Supporting Devices" or pre-engineered supporting systems to the structure, shall be of the type made for the specific purpose of anchoring into structure materials at intended point of installation. WOOD OR FIBER PLUGS NOT PERMITTED.
1. Anchor Bolts (Pre-Set): Where anchor bolts are indicated or required as pre-set in cast-in-place concrete, provide anchor bolts of lug or bent shape design.
 - a) Galvanized Bolts: ASTM A 307 for bolts, nuts and washers; and ASTM B 454 or A 153 for galvanizing.
 - b) Stainless Steel Bolts: ASTM A 320, Grade B8, AISC Type 303 or 304.
 2. Drive (Deep-Pitch) Screws: Self-tapping type, Fed. Spec. FF-S-107C(2).
 3. Drilled-In Anchors and Fasteners: Fed. Spec. FF-S-107C(2).
 - a) Applications in Masonry (and Precast Concrete Hollow-Core Structural Elements):
 - 1) Anchors: Provide anchors designed to accept both machine bolts and/or threaded rods. Such anchors shall consist of an expansion shield and expander nut contained inside the shield. Expander nut fabricated and designed to climb the bolt or rod thread and simultaneously expand the shield as soon as the threaded item, while being tightened, reaches and bears against the shield bottom.
 - (a) Shield Body: Consisting of four legs, the inside of each tapered toward shield bottom (or **nut** end). The end of one leg is elongated and turned across shield bottom. Outer surface of shield body ribbed for grip-action.
 - (b) Expander Nut: Square design with sides tapered inward from bottom to top.
 - (c) Material: Die cast Zamac No. 3 zinc alloy of 43,000 psi minimum tensile strength.
 - 2) Fasteners: Machine bolts conforming to S.A.E. Grade 2, for use with above anchors; nuts and washers conforming to ASTM A 563.
 - 3) Acceptable Manufacturers:
 - (a) U.S.E. Diamond, Inc.; FORWAY System.
 - (b) Or Equal.
 - b) Applications in Cast-in-Place Concrete (and Solid Precast Concrete Structural Elements):
 - 1) Anchor/Fastener: UL Listed and one-piece stud (bolt) with integral expansion wedges, nut and washer, and meeting physical requirements of Fed. Spec. FF-S-325, Group II, Type 4, Class 1.
 - 2) Stainless Steel Anchor/Fastener: UL Listed one-piece stud (bolt) with integral expansion wedges, nut and washer, and meeting physical requirements of Fed. Spec. FF-S-325, Group II, Type 4, Class 1. Stud of AISI Type 303 or 304 stainless and nut and washer of AISI Type 316 stainless.
 - 3) Acceptable Manufacturers:
 - (a) U.S.E. Diamond, Inc.; SUP-R-STUD.
 - (b) Hilti Fastening Systems; KWIK-BOLT.
 - (c) Molly Fastener Group; PARABOLT.

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- (d) Phillips; RED HEAD Wedge-Anchor.
- (e) Or Equal.
- c) Applications in Existing Horizontal (Floor Mounted) Surfaces for Adhesive Anchors: Composed of an anchor rod assembly and an anchor rod adhesive cartridge.
 - 1) Anchor Rod Assembly: Chamfered and threaded stud rod of ASTM A 307 steel with nut and washer of ASTM A 563 steel.
 - 2) Stainless Steel Anchor Rod Assembly: Chamfered and threaded stud rod of AISI Type 304 stainless with nut and washer of AISI Type 316 stainless.
 - 3) Adhesive Cartridge: Sealed capsule containing pre-measured amounts of resin, quartz sand aggregate, and a hardener contained in a separate vial within the capsule. Capsule ingredients activated by the insertion procedure of the anchor rod assembly.
 - 4) Acceptable Manufacturers:
 - (a) U.S.E. Diamond, Inc.; SUP-R-SET.
 - (b) Hilti Fastening Systems; HVA.
 - (c) Molly Fastener Group; PARABOND.
 - (d) Or Equal.

Note: Hammer drive-type explosive charge drive-type anchors and fastener systems not acceptable. Lead shields, plastic-inserts, fiber-inserts, and drilled-in plastic sleeve/nail drive systems also not acceptable.

2.4 WALL PENETRATIONS

- A. Wall Seal (Below Grade): Hydrostatic seal designed to seal opening between conduit and a through structure opening. Provide Link-Seal by Thunderline Corp., or equal. Caulking, mastic sealants, lead/oakum; not equal.
- B. Fire Seals: Provide approved Fire Seals where conduit penetrates fire rated walls, floors, partitions and ceilings to ensure that the fire rating is maintained.
 - 1. For fire rating 2 hours or less, provide fire seal compound or mechanical seal.
 - 2. For fire rating greater than 2 hours, provide mechanical seals.
 - 3. For multiple conduit penetrations, provide approved through-wall barriers.
 - 4. Acceptable Manufacturers:
 - a) Compound - Dow Corning, or approved equal.
 - b) Mechanical Seal - Thunderline Corporation, or approved equal.
 - c) Through-Wall Barrier - Crouse-Hinds

2.5 ELECTRICAL IDENTIFICATION

- A. Identification Devices: A single type of identification product for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.
- B. Raceway and Cable Labels: Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway and cable size.
 - 1. Type: Preprinted, flexible, self-adhesive, vinyl. Legend is over-laminated with a clear, weather- and chemical-resistant coating.

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2. Color: Black letters on orange background.
 3. Legend: Indicates voltage.
- C. Wiring Identification:
1. Power Wiring: Identify each feeder/conductor cable of every feeder originating in a main distribution panel, branch panel, motor control center, etc. with a nameplate, and in every panel, cabinet, and pull box through which such feeder passes, enters or leaves.
 - a) Contractor Option: To provide heavy duty vinyl cloth material tape, pressure sensitive labels or markers, which when applied to conductors are easily read, in lieu of the nameplates specified above. Tape and labels as manufactured by W.H. Brady Co., Len Products Inc., or Stanco Products, Inc.
 2. Control and Signal Wiring: All wiring shall be clearly labeled at each termination end with permanent labeling sleeves or adhesive labels as manufactured by W.H. Brady Co., Len Products Inc., or Stanco Products, Inc.
 - a) Each cable assembly shall be labeled at the point where the jacket is stripped out. The label shall indicate the panel or equipment to which the opposite end of the cable assembly terminates.
 - b) Each individual conductor that is not part of a cable assembly shall be labeled at the conductor endpoint. The label shall indicate the panel or equipment to which the opposite end of the cable assembly terminates.
 - c) Spare cables and conductors shall be separately labeled as "SPARE."
 - d) All conductor and cable numbers shall be unique and shall be clearly identified on the As Built wiring diagrams.
- D. Underground Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape with the following features:
1. 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 that indicates type of underground line.
- E. Color-Coding Cable Ties: Type 6/6 nylon, self-locking type. Colors to suit coding scheme.
- F. Engraved-Plastic Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched or drilled for mechanical fasteners 1/16-inch minimum thickness for signs up to 20 sq. in. and 1/8-inch minimum thickness for larger sizes. Provide beveled finish. Engraved legend in black letters on white background
- G. Provide nameplates for every Unit Substation, Switchboard, Transformer, Panelboard, Motor Control Center, and Disconnect Switch, titled as follows:
1. Disconnect Switches
 - a) Major Title: Name of equipment served
 - b) Minor Title: Source of power
 2. Transformers
 - a) Major Title: Name of Equipment
 - b) Minor Title #1: Source & Destination of Power

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- c) Minor Title #2: Operating Voltages
- 3. Unit Substation, Switchboards, Panelboards, MCCs
 - a) Major Title: Name of Equipment
 - b) Minor Title #1: Source of Power
 - c) Minor Title #2: Operating Voltage
- H. Interior Warning and Caution Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145. Preprinted, aluminum, baked-enamel-finish signs, punched or drilled for mechanical fasteners, with colors, legend, and size appropriate to the application.
- I. Exterior Warning and Caution Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145. Weather-resistant, non-fading, 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.
- J. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers.

2.6 CONCRETE BASES

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

2.7 EQUIPMENT BACKBOARDS:

- A. Provide equipment backboards where indicated on the Drawings and of dimensions indicated.
- B. Plywood, grade C-D PLUGGES, INT-APA, 3/4-inch thickness with beveled and sanded edges painted with two coats of white enamel.

2.8 TOUCHUP PAINT

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

PART 3 - EXECUTION**3.1 AREA CLASSIFICATION**

- A. Install electrical equipment according to the classifications of each area as given in the Area Classification Table on the Drawings.

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

3.3 RACEWAY APPLICATION

- A. Minimum Raceway Size: 3/4-inch trade size.
 - 1. Install raceways as designated in Area Classification Table.

3.4 RACEWAY AND CABLE INSTALLATION

- A. Conceal raceways and cables, unless otherwise indicated, within finished walls, ceilings, and floors.
- B. Install raceways and cables at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Locate horizontal raceway runs above water and steam piping.
- C. Use temporary raceway caps to prevent foreign matter from entering.
- D. Make conduit bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
- E. Use raceway and cable fittings compatible with raceways and cables and suitable for use and location.
- F. Install raceways embedded in slabs in middle third of slab thickness where practical, and leave at least 1-inch concrete cover.
 - 1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
 - 2. Space raceways laterally to prevent voids in concrete.
 - 3. Install conduit larger than 1-inch trade size parallel to or at right angles to main reinforcement. Where conduit is at right angles to reinforcement, place conduit close to slab support.
 - 4. Transition from nonmetallic tubing to Schedule 80 nonmetallic conduit, rigid steel conduit, or IMC before rising above floor.
 - 5. Make bends in exposed parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for exposed parallel raceways.

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- G. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of the pull wire.
- H. Install telephone and signal system raceways, 2-inch trade size and smaller, in maximum lengths of 150 feet and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements, in addition to requirements above.
- I. Connect motors and equipment subject to vibration, noise transmission, or movement with a maximum of 24-inch flexible cord or cable.
 - 1. Cord/cable shall include a dedicated equipment-grounding conductor.
 - 2. Provide compression cord fittings on each end of flexible cord/cable for cable strain relief.
 - 3. Contractor may provide cord/cable for entire length of circuit or install a splice box adjacent to equipment to be utilized in transitioning from individual conductor wiring to cord/cable.
- J. Floor-mounted equipment, such as Motor Control Centers, Substations, etc., shall be mounted on a 4" housekeeping pad. The pad shall be constructed to extend 2" beyond the outside dimensions of the equipment on the front and sides, unless the Drawings indicate additional space for future expansion.

3.5 WIRING METHODS FOR POWER, LIGHTING, AND CONTROL

- A. Feeders: Type THHN/THWN insulated conductors in raceway.
- B. Underground Feeders and Branch Circuits: Type THWN or single-wire, Type UF insulated conductors in raceway.
- C. Branch Circuits: Type THHN/THWN insulated conductors in raceway.
- D. Remote-Control Signaling and Power-Limited Circuits: Type THHN/THWN insulated conductors in raceway for Classes 1, 2, and 3, unless otherwise indicated.

3.6 WIRING INSTALLATION

- A. Install splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- B. Install wiring at outlets with at least 12 inches of slack conductor at each outlet.
- C. Connect outlet and component connections to wiring systems and to ground. 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.

3.7 ELECTRICAL SUPPORTING DEVICE APPLICATION

- A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components. Any field work to be cold-galvanized to match.
- B. Dry Locations: Steel materials. Paint to match adjacent building steel.

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- C. Food Processing and/or USDA-inspected Locations:
 - 1. No Uni-Strut or similar channel-based systems allowed.
 - 2. No Redi-bolt or other similar running-thread rod allowed.
 - 3. Minimize dirt-collecting horizontal surfaces.
 - 4. Use only approved corrosion-resistant materials. For example, use of cadmium-plated hardware is prohibited.
- D. Support Clamps for PVC Raceways: Click-type clamp system.
- E. Selection of Supports: Comply with manufacturer's written instructions.
- F. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four; minimum of 200-lb design load.

3.8 SUPPORT INSTALLATION

- A. Install support devices to securely and permanently fasten and support electrical components.
- B. 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.
- C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.
- D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.
- E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.
- F. Install 1/4-inch-diameter or larger threaded steel hanger rods, unless otherwise indicated.
- G. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.
- H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.
- I. Simultaneously install vertical conductor supports with conductors.
- J. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach 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.
- K. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.

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- L. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.

- M. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:
 - 1. Wood: Fasten with wood screws or screw-type nails.
 - 2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
 - 3. New Concrete: Concrete inserts with machine screws and bolts.
 - 4. Existing Concrete: Expansion bolts.
 - 5. Instead of expansion bolts, threaded studs driven by a powder charge and provided with lock washers may be used in existing concrete.
 - 6. Steel: Welded threaded studs or spring-tension clamps on steel.
 - a) Field Welding: Comply with AWS D1.1.
 - 7. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
 - 8. Light Steel: Sheet-metal screws.
 - 9. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

- N. 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.

3.9 ANCHOR AND FASTENER INSTALLATIONS

- A. Auxiliary Steel Fabrication: Insofar as possible, fit and shop assemble steel fabrications and make ready for field installation.
 - 1. Drill or punch holes as required for attachment of work and for bolted connections. Burned holes are not acceptable.
 - 2. Perform welding of assemblies in accordance with AWS D1.1. Dress welds smooth and free of sharp edges and corners.
 - 3. Perform painting of auxiliary steel to match adjacent surfaces and/or finishes.

- B. Threaded Bolts: Draw threaded bolted connections up tight using lock washers to prevent bolt or nut loosening.

- C. Drilled-In Expansion Anchor Installation:
 - 1. General: In general, install expansion anchors in strict accordance with manufacturer's instructions and in accordance with the following.
 - 2. Drilling Holes: Use rotary hammer type drill and make drill holes to the required diameter and depth as consistent with anchor manufacturer's instructions for size of anchors being installed.

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3. Minimum Embedment: Embed expansion anchors to four and one-half bolt diameters, unless otherwise indicated on Drawings.
- D. Drilled-In Adhesive Anchor Installation:
1. General: In general, install adhesive anchors in strict accordance with manufacturer's instructions and in accordance with the following.
 2. Drilling Holes: Use rotary hammer type drill and make drill holes to the required diameter and depth as consistent with anchor manufacturer's instructions for size of anchors being installed.
 - a) Prior to setting cartridge and anchor stud clean drilled holes free of loose material by vacuum process, finishing with a blast of compressed air, and cover hole until actual use.
 3. Anchor Rod Installation: Following cartridge installation in prepared drill holes, set anchor rod to the required depth. Set anchor rods truly perpendicular (normal) to the base plate of item being anchored.
 4. Minimum Embedment Table:

3.10 MOUNTING HEIGHTS

- A. Mounting Heights: Unless otherwise specifically instructed, locate mounting heights from finished floor to centerline of box or cabinet of devices or apparatus, as stated hereinafter. Those dimensions stated or indicated as "clear" are to the bottom of the device, apparatus, plate, or trim.
1. Lighting Control Switches: 3'-6" AFF on strike side of door, unless indicated otherwise on the Drawings. Mount switches in tandem where not possible to mount side-by-side with a common device plate.
 2. Duplex Convenience Outlets: 24" AFF, unless indicated otherwise on the Drawings. In concrete block walls locate outlets to fall centered on the top of second course.
 3. Single Special-Purpose Receptacles: 24" AFF, unless indicated otherwise on the Drawings. In concrete block walls locate outlets to fall centered on the top of second course.
 4. Unit Heater Receptacles: Same elevation as unit heater
 5. Motor Safety Disconnect Switches: 4'-6" AFF, unless indicated otherwise on the Drawings.
 6. Lighting Fixtures: Locate as indicated on the Drawings.
 7. Wall Mounted Telephone: 4'-0 AFF.
 8. The Engineer and the Owner shall have the option to require the Contractor to move outlets (outlets as defined in NEC) a distance of ten feet or less before roughing-in, without incurring additional expense to the Owner.
 9. Exceptions to mounting heights:
 - a) In violation of the code.
 - b) At junction of differing wall finishes.
 - c) At break in wall surface.

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- A. Install wires in raceway according to manufacturer's written instructions and NECA's "Standard of Installation."
- B. Provide individual conductor to serve as equipment grounding conductor. Do not rely on conduit or raceway system for grounding.
- C. Conductor Splices: Keep to the minimum and comply with the following:
 - 1. Install splices and taps that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.
 - 2. Use splice and tap connectors that are compatible with conductor material.
- D. Wiring at Outlets: Install with at least 12 inches of slack conductor at each outlet.
- E. Connect outlets and components to wiring systems 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 requirements specified in UL 486A.
- F. 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; "Fab-Lok" fasteners on insulated panels; 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.
- G. Install concrete pads and bases according to requirements of Division 3 Section "Cast-in-Place Concrete."

3.12 IDENTIFICATION MATERIALS AND DEVICES

- A. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

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- B. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.
- C. Self-Adhesive Identification Products: Clean surfaces before applying.
- D. Identify raceways and cables with color banding as follows:
 - 1. Bands: Pretensioned, snap-around, colored plastic sleeves or colored adhesive marking tape. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two-color
 - a) Band Locations: At changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
 - b) Colors: As follows:
 - 1) Fire Alarm System: Red.
 - 2) Security System: Blue and yellow.
 - 3) Telecommunication System: Green and yellow.
- E. Install continuous underground plastic markers during trench backfilling, for exterior underground power, control, signal, and communication lines located directly above power and communication lines. Locate 6 to 8 inches below finished grade. If width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches, overall, use a single line marker.
- F. Colorcode 208Y/120-V system secondary service, feeder, and branch-circuit conductors throughout the secondary electrical system as follows:
 - 1. Phase A: Black.
 - 2. Phase B: Red.
 - 3. Phase C: Blue.
 - 4. Neutral: White.
 - 5. Ground: Green.
- G. Color-code 480Y/277-V system secondary service, feeder, and branch-circuit conductors throughout the secondary electrical system as follows:
 - 1. Phase A: Yellow.
 - 2. Phase B: Brown.
 - 3. Phase C: Orange.
 - 4. Neutral: White with a colored stripe or gray.
 - 5. Ground: Green.
- H. Color-code 240-V system secondary service, feeder, and branch-circuit conductors throughout the secondary electrical system as follows:
 - 1. Phase A: Yellow with Red stripe
 - 2. Phase B: Brown with Red stripe
 - 3. Phase C: Orange with Red stripe
 - 4. Ground: Green.

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- I. Color-code 120-240-V single-phase system secondary service, feeder, and branch-circuit conductors throughout the secondary electrical system as follows:
 - 1. Phase A: Black.
 - 2. Phase B: Red.
 - 3. Neutral: White
 - 4. Ground: Green
- J. Install warning, caution, and instruction signs where required to comply with 29 CFR, Chapter XVII, Part 1910.145, and where needed 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 are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
- K. Install engraved-laminated emergency-operating signs with white letters on red background with minimum 3/8-inch-high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
- L. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

3.13 FIRESTOPPING

- A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping."

3.14 CONCRETE BASES

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

3.15 FLOOR AND WALL PENETRATIONS

- A. Masonry Walls and Concrete Floors Penetrations:
 - 1. Place all sleeves necessary for the electrical installation and advise the General Building Contractor of all openings necessary for the installation of electrical work.
 - 2. Where sleeves are installed, they shall pass evenly through the floor, wall, ceiling, or partition. Sleeves in walls or partitions shall be finished flush on both sides, and sleeves in floors shall be 2" above finished floor level. Appropriately sized schedule 40 steel pipe or 1/4" thick rolled steel plate shall be used for sleeves through floors. 20 gauge sheet metal, plastic, or fiber material may be used for sleeves through walls, ceilings and partitions.
 - 3. All conduit penetrations through floors shall be sealed to prevent transfer of water, heat and smoke to other floors. Use grout mixture if through concrete or seal with Duxseal if passed through a sleeve. If floor or wall through which the sleeve passes is part of a fire-rated barrier system, sleeve shall be sealed with a rated and approved fire-stop material, installed per the manufacturer's installation instructions, (See below.)

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- B. 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.
1. Contractor shall coordinate all openings in walls and floors that exceed 5-Inches in diameter with the Engineer prior to performing any modifications to the structure. This is essential to prevent potential weakening of loading bearing structures.
- C. Wiring to Roof Mounted Equipment: Provide and install conduit and power to roof mounted equipment both as installed by this Contractor and as installed by others.
1. Conduit flashing and roof restoration work involved with conduits passing through the roof (if any) to roof mounted equipment shall be performed as part of the Work of the Roofing Contractor.
 2. Coordinate the time of roof penetration of conduits with the roof work to permit simultaneous roof restoration work.
 3. Run wiring to roof mounted equipment and interconnecting wiring between roof mounted and interior equipment through wiring channels in roof curbs when such are provided for the roof mounted equipment installed by other Trades.
 4. In the event that penetrations are not coordinated within ample time for the Roofing Contractor to provide for the penetrations during initial construction, additional costs will be borne by this Contractor.
- D. Thermal breaks: Provide a thermal break in the conduit system where practical by using a section of conduit of a material having low thermal conductivity, such as stainless steel or PVC, when passing from a region at one temperature to a region differing by more than twenty degrees Fahrenheit.
- E. Vapor barriers: Provide a vapor barrier within and around the conduit system when passing from a region at one temperature to a region differing by more than twenty degrees Fahrenheit, or from an interior to an exterior space or as indicated on the Drawings. The vapor seal shall be on the warm side and shall be a removable sealant such as silicone sealant or duct-seal installed in seal-offs or conduit bodies after the conductors have been installed.
- F. Wall Seal: Hydrostatic seal designed to seal opening between conduit and a through structure opening. Provide Link-Seal by Thunderline Corp., or equal. Caulking, mastic sealants, lead/oakum; not equal.
- G. Fire Wall Penetrations:
1. Fire-stopping: Apply to cable and raceway penetrations of fire-rated floor and wall assemblies. Perform fire-stopping as specified in Division 7 Section "Firestopping" to reestablish the original fire-resistance rating of the assembly at the penetration.
 2. All sleeves shall be grouted around with mortar.
 3. Penetrations shall be sleeved with steel pipe during the construction of the wall.
 4. Penetrations made after the construction of the wall shall be made with a masonry drill.
 5. After the conduits are installed, seal the penetration with mortar.

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- A. Underground Systems: Install underground conduit systems in accordance with Article 300-5 of the NEC, in accordance with previous requirements of this Section, and the following requirements exceeding NEC:
1. Earthwork: Perform earthwork for buried conduit as specified elsewhere.
 2. Provide "Concrete Encasement" for underground conduits and ducts as required by the general notes on the Symbols Legend drawing. Perform installation per the Typical Trench Detail shown on the drawings. Use 3000 psi concrete where encasement is required.
 3. Bank conduits away from buildings and secure same in place with approved separators installed at 5' intervals. Separators shall have sufficient strength to prevent displacement of conduits when placing backfill or pouring concrete encasement.
 4. Where conduits are not encased in concrete coat with two coats of bitumastic paint such as Carbolite Company Kop-Coat Bituplastic No. 33, or Approved Equal. Not required on PVC conduit.
 5. Where conduit lines run to underground structures, grade conduits to drain to such.
 6. Construct underground conduit lines to be absolutely watertight. Stagger conduit couplings in banks of conduits.
 7. Where conduits change direction or turn up use long sweep steel elbows.
 8. Provide two feet minimum cover over conduit or concrete encasement of conduit for systems 600 volts and less, and three feet minimum cover over conduit or concrete encasement of conduit for systems over 600 volts, unless indicated otherwise on the Drawings.
 9. Where underground conduits enter a building below finished grade such as in a basement area, seal between the conduit and the wall with a waterproof non-shrink grout. Such penetrations shall be made absolutely watertight. Where same conduits enter directly into a junction box or cabinet which is below grade, a cable sealing bushing shall be placed in each conduit which is entering from underground. This seal bushing shall be approved for the purpose and shall be O-Z Gedney, or Approved Equal.

3.17 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of the trades involved.
- B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.18 FIELD QUALITY CONTROL

- A. Inspect installed components for damage and faulty work, including the following:
1. Raceways.
 2. Building wire and connectors.
 3. Supporting devices for electrical components.

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4. Electrical identification.
5. Concrete bases.
6. Cutting and patching for electrical construction.
7. Touchup painting.

3.19 REFINISHING AND TOUCHUP PAINTING

- A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 9 Section "Painting."
 1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
 2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
 3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.20 CLEANING AND PROTECTION

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.
- B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

3.21 TESTING

- A. General: Unless waived in writing by the Engineer, tests and trials shall be made in the presence of a duly authorized representative of the Engineer. When the presence of such representative is so waived, sworn statements, in duplicate, of the tests made and the results thereof, shall be furnished to the Engineer by the Contractor.
- B. Inspection: The Contractor shall have the work inspected by the State or local agency having jurisdiction for compliance with National Electrical Code and shall obtain certificates of approval, acceptance, and compliance with code regulations. Work shall not be deemed complete until such certificates have been delivered to the Owner and the Engineer.
- C. Testing: Test materials shall be supplied. All parts and assemblies thereof, entering into the Work, shall be in conformity with the best modern and approved methods for the particular type and class of work.
 1. Include costs of tests and trials in the Contract Price.

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2. The entire installation shall be free from short circuits and improper grounds. The insulation resistance of all distribution feeders shall be individually tested. The distribution system feeders shall consist of all feeders shown on the single-line diagram, as well as all conductors #2/0 or larger in size. In no case, shall the insulation resistance be less than one Megohms. Any device (TVSS, circuit breaker, metering equipment, etc.) that has a lower voltage rating than that voltage to be applied during the test shall be removed from the circuit and safely isolated from the applied voltage. The Electrical Contractor shall follow approved lock-out and tag-out procedures when working with energized equipment and shall observe all safety precautions provided by the test equipment manufacturer.
3. Correct failures in a manner satisfactory to the Engineer or his authorized representative.

END OF SECTION 16050