

## **SECTION 16000**

### **BASIC ELECTRICAL REQUIREMENTS**

#### **PART 1 - GENERAL**

##### **1.01 DESCRIPTION**

- A. Section includes specifications for furnishing and installation of all electrical systems, including the checkout and startup of the systems.

##### **1.02 GENERAL**

- A. Provisions specified in this Section apply to all Division 16, Electrical.
- B. The types of systems covered by this Section include AC normal and emergency power supply equipment; railroad signals, train control, and communications; station lighting, communications, and amenities; fire alarm systems; and power supply to HVAC systems. Systems include electrically driven motors and pumps.
- C. The general extent of the electrical work includes furnishing and installing the following items:
  - 1. Raceways, conduit, junction boxes, wire, cable and connectors required to inter-connect and place all equipment in complete operation.
  - 2. Power distribution systems, overcurrent protection, load transfer switches, electrical panels and switchboards, fused and unfused disconnects, receptacle outlets, switching, and circuits as indicated on the Contract Drawings.
  - 3. Complete grounding systems.
  - 4. Site electrical service conduits, equipment pads, manholes, handholes, splice boxes, excavation, trenching, backfill, and compaction.
  - 5. Lighting including fixtures, lighting poles, outlets, switching, and circuits.

##### **1.03 REFERENCE STANDARDS**

- A. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. 81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

##### **1.04 DESIGN REQUIREMENTS**

- A. Design anchorage and secure electrical equipment in accordance with applicable code. In addition, design anchorage and secure equipment to withstand a lateral force of 0.6 times the weight of the equipment, if such requirement is more stringent.

- B. Size conduits, raceways, and junction boxes with minimum 20 percent spare or expansion capacity.
- C. Locate electrical equipment in a manner suited to the application and install per the original equipment manufacturers' (OEM) recommendations and applicable code.
- D. Provide circuit schedule for all lighting and power panel boards.
- E. Unless designed or rated for exterior use or provided with its own housing or enclosure, install electrical equipment in a manner such that it is adequately protected from the local environment (such as rain and dust). Provide temperature controls (ventilating fans or air conditioning) in the enclosed space if the temperature will exceed the OEM recommended operating temperatures.

### 1.05 SUBMITTALS

- A. Material List: Submit list of materials and equipment proposed for use in the work. Except as specified herein for "rough-in" materials, submit complete list at one time and include all proposed alternatives.
  - 1. Include name of manufacturer and where applicable, brand name, type and/or catalog number of each item. Do not list more than one manufacturer for any one item of equipment. Do not list items "as specified", without both make and model or type designation.
  - 2. "Rough-in" materials, such as conduit, fittings, junction boxes, 600V power conductors, and outlets, need not be included in the Material List, provided that these items are as specified and are listed by UL.
- B. Shop Drawings and Descriptive Data: As soon as practical after submission of Material List, submit shop drawings and descriptive data of equipment listed hereinafter, and the required wiring diagrams. Include copies of catalog cuts including complete description, information, and performance data.
- C. Panelboard Directories: Submit for approval.
- D. Calculations: Submit structural calculations showing that equipment anchorage will withstand applicable lateral force. Submit other calculations as specified in individual Sections. Calculations shall be signed and sealed by professional engineer licensed in the State of California.
- E. Manufacturer Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces according to applicable code and other Contract requirements, whichever is most stringent. Include the following:
  - 1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. The term "withstand" means the unit will remain in place without separation of internal and external parts during a seismic event and the unit will be fully operational after the event.
  3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- F. Qualifications: Submit evidence of qualifications of electrical field engineer.
- G. Test Procedures: Submit test procedures for testing electrical equipment installation and operation.
- H. Test Reports: Submit test reports within 30 days of completion of test.

#### **1.06 PROJECT RECORD DOCUMENTS**

- A. Refer to Section 01720, Contract Record Documents, for general requirements. Mark Project Record Documents daily to indicate all changes made in the field.
1. In addition, indicate on Contract Drawings any changes on equipment locations and ratings, trip sizes and settings on magnetic-only circuit breakers, alterations in raceway runs and sizes, changes in wire sizes, circuit designations, installation details, one-line diagrams, control diagrams and schedules.
  2. Accurately record on Contract Drawings the actual locations and exact routing of duct bank. Locate underground conduit stubbed-out for future use, underground feeder conduits, and feeder pull box locations using building lines.
  3. Show pull box number, conduit layout with number of bends, total number of cables and wires in each conduit, and indicate spare or empty conduits.
  4. Use same symbols as used on Contract Drawings.

#### **1.07 REGULATORY REQUIREMENTS**

- A. Comply with the following codes and regulatory requirements:
1. California Code of Regulations (CCR)
  2. California Public Utilities Commission (CPUC) General Orders and Regulations
  3. Institute of Electrical and Electronics Engineers (IEEE):  
IEEE C2            National Electrical Safety Code

4. National Fire Protection Association (NFPA):  
NFPA 70          National Electrical Code (NEC)

### **1.08 QUALITY ASSURANCE**

- A. Field Engineer: Provide a qualified field engineer with a minimum of 10 years of experience in the installation of electrical equipment and systems. The Field Engineer shall perform the following:
  1. Prepare detailed Shop Drawings. Review submittals prior to submitting to the Engineer.
  2. Inspect equipment for compliance with specified requirements and accepted Shop Drawings at worksite.
  3. Prepare field inquiries and work to resolve identified field issues related to installation of electrical equipment and systems.
  4. Prepare and coordinate approval with the Engineer any recommended field modifications to controls and equipment received at Worksite.
  5. Oversee and monitor electrical work installation, and design and installations of temporary electrical systems in accordance with NFPA 70.
  6. Perform or witness specified field tests.
  7. Interpret Contract Documents for subordinates.
  8. Witness vendor equipment performance tests and inspection.
  9. Identify and track work non-conformances and assist with corrective action to remove non-conforming work.
- B. Equipment shall be standard products of manufacturers regularly engaged in the production of such equipment and material. In addition to the requirements for an "equal" specified under the General Provisions, for a standard product to be considered an equal to equipment specified, such products shall have been proven in commercial service for a period of at least two years.

### **1.09 COORDINATION WITH OTHER WORK AND UTILITIES**

- A. Review civil, architectural, and structural Contract Documents. Plan work to conform to conditions shown and specified to provide the best assembly of the combined work.
- B. Work out "tight" conditions in advance.
- C. Where the work of several trades is involved, coordinate all related work to provide each system in complete and proper operating order.

- D. Coordinate electrical service with utility company, including design and installation of load transfer equipment. Verify with the utility company the available fault current at the incoming service connection point and provide appropriately rated service equipment and overcurrent protection devices.
- E. Verify with the phone company their requirements and identify interface points prior to start of work.

## **PART 2 - PRODUCTS**

### **2.01 NAMEPLATES**

- A. Equipment Labels and Nameplates:
  - 1. Construction: Laminated phenolic plastic, black front and back, white core, with lettering etched through outer covering. Use 3/16 inch high lettering at push button stations, thermal overload switches, receptacles, wall switches, and similar devices, where nameplate is attached to device plate. Use 1/4 inch high lettering at all other locations, unless otherwise specified or detailed. Engraving directly on device plates with black enamel filled lettering is acceptable in lieu of separate plastic nameplates. Motor nameplates may be of nonferrous metal, 0.03-inch thick minimum, die stamped.
  - 2. Inscription: If detailed on the Contract Drawings, use inscription exactly as shown; otherwise, describe adequately function or use of equipment involved.
    - a. For Panelboards and Switchboards: Include panel designation, voltage and phase of supply, e.g., "Panel A, 480/277 V, 3 ph."
  - 3. Provide nameplates on the following equipment:
    - a. Metered service pedestal, meter/main service boxes, service switchboards, panelboards, push button stations, control panels, time switches, disconnect switches, thermal overload switches.
    - b. Circuit breakers, contactors, or relays in separate enclosures.
  - 4. Fasteners for Nameplates: No. 4 Phillips round head, cadmium plated steel, self-tapping screws, or nickel-plated brass bolts.
- B. Circuit Panelboard Directories: Create directory after balancing panel board loads. Provide neatly typed schedule (odd numbered circuits on left side, even on right side) under plastic jacket or protective cover to protect the schedule from damage or dirt. Securely mount on inside face of panelboard door. Briefly and accurately define nature of connected load. Do not use sequentially numbered schedules.
- C. One-Line Diagram: Provide approved "one line" for the "As-Built" distribution system.

- D. Empty Conduits: Provide tags with typed description of purpose and location of opposite end, wired to each end of conduits.

### **PART 3 - EXECUTION**

#### **3.01 GENERAL**

- A. Fasten nameplates securely to equipment.
- B. Provide pull rope in all conduits, including spare conduits.

#### **3.02 VOLTAGE CHECK**

- A. At completion of job, check voltage at several points of utilization on the system that has been installed under this Contract. During test, energize all loads installed.
- B. Set taps on transformers to give proper voltage, which is 118 to 122 volts for 120-volt nominal systems and proportionately equivalent for higher voltage systems.
- C. If proper voltage cannot be obtained, inform the Engineer.

#### **3.03 FIELD QUALITY CONTROL**

- A. Perform tests, in accordance with approved procedures, to prove installation is in accordance with contract requirements. Perform tests in presence of the Engineer, and furnish test equipment, facilities, and technical personnel.
- B. Request for Tests: Notify the Engineer a minimum of 24 hours in advance of tests. In the event the Engineer does not witness the test, certify in writing that all specified tests have been made in accordance with the specifications.
- C. Deficiencies: Immediately correct deficiencies, which are evidenced during the tests and repeat tests until system is approved. Do not cover or conceal electrical installations until satisfactory tests are made and approved.
- D. Tests:
  - 1. Test panel and circuits for grounds and shorts with mains disconnected from feeder, branch circuits connected, circuit breakers closed, all fixtures in place and permanently connected, without lamps, and all switches closed.
  - 2. Test each individual circuit at the panel with equipment connected for proper operation.
  - 3. Ground tests:
    - a. Ground tests shall meet requirements of CCR, Title 24.

- b. Perform fall-of-potential test or alternative in accord with IEEE 81 on the main ground electrode or system.
  - c. Perform point-to-point tests to determine resistance between main ground system and all major electrical equipment frames, system neutral, and/or derived neutral points.
  - d. Test Values: Resistance between main ground electrode and ground shall be no greater than 25 ohms. Additional rods shall be installed and bonded to grounding system and driven to a depth of 50 ft. or refusal, whichever comes first. Investigate point-to-point resistance values that exceed 0.5 ohm.
  - e. Record all test values and submit certified copies to the Engineer.
4. Cables:
- a. Make insulation resistance tests on all power cables, using a self-contained instrument such as the direct-indicating ohmmeter of the generator type, or "megger" such as manufactured by J.G. Biddle Company or equal. Insulation resistance values shall be at least 75 percent of shop test records.
  - b. Apply the following test voltages for one (1) minute, except where specified otherwise herein, in accord with procedure recommended by manufacturer of test equipment and as specified herein.

Rated Circuit Voltage	Megger Voltage (DC)	Min. Megger Reading
600 Volts	500 Volts	600 Kilo-ohms

- c. Record all test values and submit certified copies to the Engineer.
- d. Replace cables not meeting specified resistance values.

**3.04 CLEANING**

- A. After other work such as sanding, painting, and similar work has been completed, clean lighting fixtures, panelboards, switchboards, and other electrical equipment to remove dust, dirt, grease, or other marks, and leave work in clean condition.

**END OF SECTION**





## **SECTION 16060**

### **GROUNDING AND BONDING**

#### **PART 1 – GENERAL**

##### **1.01 DESCRIPTION**

- A. Section includes requirements for an electrical grounding system, including electrodes, grounding rods, connectors, insulators, equipment grounding and bonding conductors, and wire and cable grounding conducts and joints.

##### **1.02 REFERENCE STANDARDS**

- A. American National Standards Institute (ANSI):
  - 1. J-STD-607 A Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
- B. American Society of Testing and Materials (ASTM International):
  - 1. B3 Standard Specification for Soft or Annealed Copper Wire
  - 2. B187 Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes
- C. California Code of Regulations (CCR):
  - 1. Title 24, Part 3, California Electrical Code
- D. National Fire Protection Association (NFPA):
  - 1. NFPA 70 National Electrical Code (NEC)
- E. Underwriters Laboratories Inc. (UL):
  - 1. UL 467 Grounding and Bonding Equipment

##### **1.03 SUBMITTALS**

- A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
- B. Submit shop drawings showing locations of ground rods, grounding connections, and embedded and buried grounding conductors.
- C. Submit product data including manufacturer's catalog cuts showing all specified items.
- D. Submit test procedures. Include description of method of measuring grounding resistance. Include plan showing locations of test points to measure grounding resistance items.

- E. Submit report of test results of grounding resistance.

## **PART 2 – PRODUCTS**

### **2.01 GROUNDING AND BONDING EQUIPMENT**

- A. Equipment: Conform to UL 467, with additional requirements as specified herein.

### **2.02 GROUNDING CONDUCTORS**

- A. Grounding conductors shall comply with NEC Articles 250.118, 250.119 and 250.122.

### **2.03 GROUND RODS**

- A. Material: ASTM B187, medium carbon steel core, copper-clad by the molten weld casting process.
- B. Size: 3/4 inch diameter; 10 feet long

### **2.04 MECHANICAL CONNECTORS**

- A. Material: Bronze

### **2.05 COMPRESSION CONNECTORS**

- A. Material: High conductivity electrolytic copper tubing, heavy wall
- B. Manufacturer: Burndy Electrical, Thomas & Betts, or Engineer approved equal

### **2.06 EXOTHERMIC CONNECTIONS**

- A. Manufacturer: Cadweld, Division of Erico, or Engineer approved equal.

### **2.07 WIRE**

- A. Material: ASTM B3, bare soft drawn stranded copper
- B. Grounding Electrode Conductor: Size to meet NFPA 70 requirements and the requirements of Section 16100, Wiring Methods.
- C. Insulated general wiring: Type THHN/THWN for grounds routed in conduit with feeders. Size as noted on the Contract Drawings. Insulation: Green in color or taped ends as allowed by code.

### **2.08 BARE CONDUCTORS**

- A. Bare Conductors: ASTM B3, Class B stranded annealed copper conductor unless otherwise indicated.
- B. Bare Copper Cables for Direct Burial in Earth: No smaller than No. 2 AWG, having stranding no smaller than No. 12 AWG.

- C. Bare Copper Cables for Use for Concrete Encased Grounds: No smaller than No. 2 AWG, having stranding no smaller than No. 14 AWG.
- D. Flexible copper braid, minimum cross-sectional area 24,000 cir. Mils (No. 6 AWG), minimum strand size No. 30 AWG.
- E. Copper ground bus assembly, minimum 1/4 inch x 3 inches x 12 inches drilled and tapped every 2 inches on center for two-hole lugs.
- F. Bus bar insulators shall be fibrous glass reinforced polyester.
- G. Terminals, two-hole lug, compression type.
- H. Counterpoised Grounding Electrode Conductor: #4/0 AWG bare soft drawn stranded copper.

## **2.09 JUMPERS**

- A. Tin-plated copper, braided, flexible jumper.

## **2.10 SINGLE CONDUCTOR INSULATED WIRE**

- A. As specified in Section 16100, Wiring Methods.

## **PART 3 – EXECUTION**

### **3.01 GENERAL REQUIREMENTS**

- A. Install products as indicated on the Contract Drawings.
- B. Provide grounding and bonding to meet NEC and ANSI/J-STD-607 A requirements.
- C. Use continuous ground conductor without splices.
- D. Install counterpoised grounding electrode system for OCS (Overhead Catenary System) system and bond to platform reinforcement as indicated on the Contract Drawings.

### **3.02 GROUND CONNECTIONS**

- A. Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.
- B. For above ground connections, install compression type terminal lugs or mechanical bolted connectors.
- C. Exothermic weld buried and embedded ground connections: Make welds in accordance with manufacturer's requirements.
- D. Make connections to ground bus assembly in the following manner:

1. Bond cable to two-hole lug using exothermic welding process
2. Bolt two-hole lug to ground bus assembly

### **3.03 GROUND RODS**

- A. Install rod electrodes for electrical service panel and in handholes as indicated. Install and tie-in additional rods as required to achieve the resistance to ground specified under "Field Quality Control" in this Section.
- B. Verify that final grading has been completed before driving rod electrodes. Coordinate with the work performed under Section 02300, Earthwork.
- C. Bury ground rods vertically with rod top a minimum two feet below grade or with rod top exposed a minimum of 3 inches in handholes. Use ground rod for main grounding system. If extensive rock formation is encountered, relocate ground rods as approved by the Engineer.

### **3.04 SERVICE EQUIPMENT**

- A. Ground neutral bus to ground bus and ground bus to ground rod.
- B. Run insulated ground conductor in conduit with all feeder and branch circuits.

### **3.05 EQUIPMENT GROUNDING**

- A. Ground stationary equipment enclosures as required by the applicable codes.
- B. Ground metallic conduits, raceways, boxes, cabinets, cable trays, panelboards, disconnect switches, exposed expansion joints, receptacles, and lighting fixtures in accordance with NEC.
- C. Ground outdoor light poles as indicated on the Contract Drawings.
- D. Ground frames of motors by ground conductor carried in power conduit. Provide ground conductor sized in accordance with NEC.
- E. Bond all conduits that are used for parallel feeders.
- F. Feeders: Install ground conductor for the feeder rating in each conduit.
- G. All metallic structures, including station shelters, station lighting poles, metallic equipment cabinets, metal benches, railings, metal fences, and other metallic structures within a 10 ft distance to the centerline of an OCS line or supporting structure, shall be bonded to the OCS system counterpoise ground with a #2 AWG bare copper wire.

### **3.06 FIELD QUALITY CONTROL**

- A. Refer to Section 16000, Basic Electrical Requirements, for basic test procedures, as augmented by test procedures submitted under this Section.

- B. Perform tests in accordance with approved test procedures in coordination with the Field Engineer.
- C. In the presence of the Engineer, test the grounding system by the fall-of-potential method to demonstrate that total ground resistance does not exceed the value specified in the Contract Documents. If necessary, install additional ground rods to meet this resistance requirement.
- D. Test equipment enclosures, conduit, raceways and lighting fixtures for continuity to the ground system.
- E. Test counterpoise grounding electrode system resistance to remote ground using the 3-point fall of potential method. Counterpoise grounding electrode resistance shall not exceed 5 ohms.

**END OF SECTION**



## **SECTION 16100 WIRING METHODS**

### **PART 1 - GENERAL**

#### **1.01 DESCRIPTION**

- A. Section includes requirements for wire and cable of 600 volts or less.

#### **1.02 REFERENCE STANDARDS**

- A. California Code of Regulations (CCR):
  - 1. Title 24, Part 3, California Electrical Code
- B. National Fire Protection Association (NFPA):
  - 1. NFPA 70 National Electrical Code (NEC)
- C. Underwriters Laboratories Inc. (UL):
  - 1. UL 83 Thermoplastic-Insulated Wires and Cables
  - 2. UL 969 Marking and Labeling Systems
  - 3. UL 1569 Metal-Clad Cables
  - 4. UL 1581 Reference Standard for Electrical Wire, Cable and Flexible Cord

#### **1.03 SUBMITTALS**

- A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
- B. Submit manufacturer's product data for wires and cables, wire connectors, insulating tape, wire markers, and miscellaneous wiring materials.
- C. Submit test procedures for verification of circuit operation.
- D. Submit results of tests and verification of testing of all electrical systems and circuits.

### **PART 2 – PRODUCTS**

#### **2.01 LABELING AND MARKERS**

- A. Conductors shall be delivered to the job site plainly marked on 24-inch centers. Markings on cables shall be white lettering with black jacketing for conductor sizes of No. 6 and larger. Indentations for lettering are not acceptable. Markings shall be as follows:

1. Per UL 969
  2. Gauge
  3. Voltage
  4. Kind of Insulation
  5. Name of Manufacturer
  6. Trade Name
- B. Conductor labels shall be with PVC tubing with machine printed black marking. Tubing shall be sized to fit conductor insulation. Adhesive strips are not acceptable.
- C. Power and Control Conductors Markers or Labels: Plastic-coated, self sticking markers such as Thomas & Betts E-Z Code or Brady "Perma Code", or field-marked labels such as manufactured by Panduit. Label shall be permanent and non-handwritten.

## 2.02 CONDUCTORS

- A. Conductors shall be sized according to American Wire Gauge (AWG). Stranding, insulation, rating, and geometrical dimensions shall conform to UL Specifications and bear the label of a nationally recognized testing laboratory.
- B. Wire and cable for secondary power, lighting and control circuits shall be rated for 600 V. Use wire with following types of insulation at the specified locations:
1. Dry Locations: Type THHN/THWN or XHHW
  2. Wet locations: Type XHHW-2
  3. Branch Circuits within 3 inches of Fluorescent Lamp Ballasts: Type XHHW or Type THHN (Applies to fixtures where circuit wiring is in same compartment with ballasts).
  4. Minimum 75 degrees C temperature rated insulation on conductors, except minimum 90 degrees C temperature rated insulation on conductors in conduits exposed on roof or wet locations.
  5. Conductors for general wiring: Thermoplastic insulation rated for 600V manufactured in accordance with UL 83. Copper conductors, 3/4 hard drawn. Cable sizes No. 8 AWG or larger shall be stranded conductors.
  6. At Motors and Other Applications Where Subject to Vibration: Stranded conductors.



**2.03 600 VOLT METAL CLAD CABLE (MC)**

- A. Lightweight, interlocked steel galvanized armor sheath applied over the cable core in accordance with UL 1569 and NEC Article 330.
- B. Cable shall have the required number of conductors and shall include a separate, internal ground conductor, no smaller than indicated on the Drawings. Ground conductor shall meet NEC requirements for equipment grounding conductor.
- C. MC cable assembly shall be rated for 90 Degrees Celcius in wet and dry locations.
- D. Color coding for conductors shall be as specified in paragraph 3.01 below.

**2.04 600 VOLT SERVICE DROP CABLE**

- A. Service drop cable shall be triplexed, aluminum conductor, 600 volt rated, with 75 Degrees Celcius polyethylene insulation. Messenger wire shall be all aluminum conductor (AAC). Conductor sizes shall be as indicated on the Contract Drawings.

**2.05 PULLING LUBRICANT**

- A. Wire pulling lubricant shall be a wire pulling compound approved by a nationally recognized testing laboratory.
  - 1. Aqua Gel II, as manufactured by Ideal Industries, Sycamore, IL, or Engineer approved equal.

**2.06 WIRING MATERIALS**

- A. Connectors for Copper Conductors No. 10 AWG and Smaller:
  - 1. Pre-insulated Spring Pressure Type: Scotchlok Types Y, R, G and B; Ideal "Wing Nut"; T & B Series PT, or equal.
  - 2. Splice Cap Type: Un-insulated metal cap applied with proper indenter tool which provides deformation of cap in 2 directions at right angles to each other, Buchanan, or Engineer approved equal.
- B. Connectors for Fixture Leads: Pre-insulated spring pressure type as specified above for conductors; or set screw type, Marr, Ideal, or Engineer approved equal.
- C. Connectors and Lugs for Copper Conductors No. 8 AWG and Larger: Compression type, Burndy, Dossert, T & B, or Engineer approved equal.
- D. Watertight Splice Kits: Epoxy resin type, suitable for the type, size and number of conductors being spliced.
- E. Splicing and Insulating Electrical Tape (600 V and Below): General purpose electrical tape shall be suitable for temperatures from 18 deg C to 105 deg C and

shall be black, ultraviolet proof, self extinguishing, 7 mil thick vinyl.

- F. Washers:
  - 1. Flat washer: Mild steel, tin plated, and slightly larger than Belleville washer.
  - 2. Belleville washer: Either hardened or tempered steel or stainless steel.

**PART 3 – EXECUTION**

**3.01 WIRING METHODS**

- A. General Requirements:
  - 1. Use No. 12 AWG or larger wire for light and power circuits and No. 14 AWG or larger wire for control circuits, unless smaller wire is specified or shown.
  - 2. Unless otherwise specified or shown, leave at least 9 inches of free conductors at each unconnected outlet. Tape free ends of conductors and coil neatly in outlet box.
  - 3. All cable conductors of 3-phase circuits of single-phase shall be of the same type. Mixing stranded conductors for some phases with others as solid is not acceptable.
- B. Splicing and Termination of Conductors:
  - 1. Conductors No. 10 AWG and Smaller:
    - a. Twist conductors together to be electrically and mechanically secure by means of pre-insulated spring pressure connectors or un-insulated splice caps applied with proper indenter tool designed for the specific type of cap used. Twist conductors together before applying splice caps.
    - b. Insulate splices, joints and free ends of conductors with insulation equivalent to that of conductors by taping with rubber and friction tapes, or with high dielectric strength plastic tape.
    - c. If splice caps are used, plastic insulating caps may be used. After applying splice caps, use insulating caps rated for the temperatures to which they may be subjected, and install as recommended by the manufacturer.
  - 2. Conductors No. 8 AWG and Larger:
    - a. Splice and terminate conductors by means of compression connectors and compression terminal lugs.
    - b. Do not use split bolt type connectors.

- c. After initial set has been taken, retighten all pressure type connectors and lugs.
  - d. Insulate all splices, joints, and free ends of conductors as specified on this Section.
  - e. Where aluminum lug is bolted with steel or copper bolt, use Belleville spring washer and flat washer.
3. Underground Splices: Conductor and cable splices installed underground in manholes, pull boxes and similar locations, shall be made watertight. Splices for lead-sheathed cables shall be wiped lead joints. Approved splice kits may be used for conductors and cables other than lead-sheathed.
- C. Color Coding:
1. Color code for general wiring as follows:
    - a. For 240/120V, 1-phase system:  
Phase A: Black  
Phase B: Red  
Neutral: White
    - b. For 240/120V and 208/120V, 3-phase system:  
Phase A: Black  
Phase B: Red  
Phase C: Blue  
Neutral: White
    - c. For 480/277V, 3-phase system:  
Phase A: Brown  
Phase B: Orange  
Phase C: Yellow  
Neutral: Gray
    - d. Ground conductors:
      - i. Bare copper conductor may be used for equipment ground only.
      - ii. Insulated ground conductors:  
Ground conductor: Green  
Isolated ground conductor: Green with white stripe
  2. Use green color for any conductor intended solely for equipment grounding, unless it is bare.
  3. Use wire with insulation of required color. For other types of wire, which may not be available in specified colors, use self-adhesive wrap-around cloth type markers of solid colors to color code conductors.

4. Where wire markers are used for color coding, mark each conductor at all accessible locations (panelboards, junction boxes, handholes, auxiliary gutters, outlets, switches, control centers and similar devices).
- D. Conductor Identification:
1. Feeders: Identify with the corresponding circuit designation at overcurrent device and load ends, at all splices, and in pull boxes.
  2. Branch circuits: Identify with corresponding circuit designation at overcurrent device and at all splices.
  3. If more than one white (neutral) conductor is present, mark each with all related circuit numbers.
  4. Control Wires: Identify with indicated number and or letter designation at all terminal points and connections, including manufacturer pre-wired control sections and cabinets.
  5. Alarm and Detection Wires: Identify with indicated wire and mnemonics numbers at all connections, terminal points, and coiled conductors within cabinets.
  6. Identify power and control conductors using markers or field-marked labels.

### 3.02 INSTALLATION

- A. Use approved specified wire pulling lubricant. Do not use oil, grease, or similar indiscriminate substances to facilitate the pulling in of conductors.
- B. Pull wire into conduits with care and prevent damage to insulation. Use basket pulling grips to avoid slipping of insulation on conductors.
- C. Do not use blocks, tackle, or other mechanical means to pull wires No. 8 AWG, or smaller.
- D. When pulling conductors, do not exceed manufacturer's recommended pull tension values.
- E. Dress harness all wire and cable to prevent mechanical stress on electrical connections. No wire and cable shall be supported by a connection point.
- F. Correct the following conditions: Deformed, brittle, or cracked insulation; insulation shrunk or stripped further than 1/8 inches away from the actual point of connection; cold solder joints, flux joints, and solder splatter; ungrommated, unattached or uninsulated wire or cable entries; and deformation of improper rading of wire or cable, especially coaxial cable.
- G. Install cable with a bend radius not less than that recommended by cable manufacturer. Provide a box loop for all wire and cable routed through junction boxes or distribution panels.

- H. Remove debris and moisture from raceways, boxes, and cabinets before installing wire or cable.
- I. Install MC cable at locations indicated on the Contract Drawings or at other locations approved by the Engineer.
- J. Service drop cable shall be used only for temporary lighting installation and at other temporary installations as approved by the Engineer.

**3.03 FIELD QUALITY CONTROL**

- A. Prior to operating test, the Field Engineer shall verify that all wiring and connections are done, all circuits are active and working properly, motor phases are wired properly, electrical switches are in the right direction, and that overall the system is ready for application of power and testing.
- B. Operating Test: After installation has been completed, conduct an operating test. Demonstrate that equipment operates in accordance with the requirements of this Section. Furnish necessary instruments and personnel required for test.

**END OF SECTION**



## **SECTION 16130 CONDUIT AND FITTINGS**

### **PART 1 – GENERAL**

#### **1.01 DESCRIPTION**

- A. Section includes requirements for conduit and conduit fittings. Conduit types shall be as shown on the Contract Drawings and as specified herein.

#### **1.02 REFERENCE STANDARDS**

- A. American National Standards Institute (ANSI):
  - 1. C80.1 Electrical Rigid Steel Conduit (ERCS)
- B. ASTM International (ASTM):
  - 1. A153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
  - 2. D2564 Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems
- C. American Welding Society (AWS):
  - 1. D1.1 Structural Welding Code - Steel
- D. California Code of Regulations (CCR):
  - 1. Title 24, Part 3, California Electrical Code
- E. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. IEEE C2 National Electrical Safety Code (NESC)
- F. National Electrical Manufacturers Association (NEMA):
  - 1. TC2 Electrical Polyvinyl Chloride (PVC) Conduit
  - 2. TC3 Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing
- G. National Fire Protection Association (NFPA):
  - 1. NFPA 70 National Electrical Code (NEC)
- H. Underwriters Laboratories Inc. (UL):
  - 1. UL 6 Electrical Rigid Metal Conduit - Steel

2. UL 651 Schedule 40 and 80 Rigid PVC Conduit and Fittings

### **1.03 DESIGN REQUIREMENTS**

- A. In addition to requirements specified in Section 16000, Basic Electrical Requirements, design supports to support the following loads.
  1. Support load equal to sum of weights of conduits and wires, and weight of hanger plus 200 pounds.
  2. Stress at root of thread of hanger rods: Not more than 9475 psi at design load.
  3. Size horizontal member to limit maximum stress of not more than 12,650 psi at design load.

### **1.04 SUBMITTALS**

- A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
- B. Submit manufacturer's product data for all types of conduit and fittings to be used.
- C. Shop drawing information may be combined on a single drawing. Identify each drawing by a number and descriptive title.
- D. Submit records of grout quantity installed in casings.
- E. Submit test reports.

### **1.05 DELIVERY, STORAGE AND HANDLING**

- A. Install thread protectors both ends of galvanized rigid steel conduits for shipment and handling.
- B. Package couplings separately.

## **PART 2 - PRODUCTS**

### **2.01 GENERAL**

- A. Conduit and conduit fittings shall be standard types and sizes as manufactured by a nationally recognized manufacturer of this type of materials, and be in conformity with standards.

### **2.02 RIGID GALVANIZED STEEL CONDUIT (RGS)**

- A. Provide conduit, couplings, elbows, bends, sealing fittings, and nipples conforming to ANSI C80.1 and UL 6, with each length bearing manufacturer's stamp and UL label.
- B. Couplings, locknuts, and all other fittings shall be galvanized, waterproof, and threaded type only.



- C. Bushings shall be nylon insulated metallic and grounding type.
- D. Furnish conduit straps, clamps and clamp backs made of galvanized malleable iron.

### **2.03 POLYVINYLCHLORIDE (PVC) CONDUIT**

- A. Schedule 40 and schedule 80 rigid polyvinyl chloride electrical conduit conforming to the requirements of EPC-40-PVC and EPC-80-PVC conduit of NEMA TC 2 and fittings for EPC-40-PVC and EPC-80-PVC conduit of NEMA TC 3 and listed by UL for direct underground burial, manufactured from high impact, non-conducting, self-extinguishing material.
- B. Couplings, Adapters, Expansion Fittings: Conform to same requirements as rigid PVC conduit. Use solvent cement for PVC joints, as recommended by conduit manufacturer.
- C. Bends: Factory made PVC bends.
- D. PVC conduits shall be Schedule 40 throughout the Work, except at rail crossing, which shall be PVC Schedule 80.
- E. UL 651 listed and in accordance with NEC Article 352 for underground use.
- F. Solvent for welding PVC shall comply with ASTM D 2564 or approved equal.
- G. Minimum 10 foot assembled from factory section, 25 foot assembled from factory section preferred.

### **2.04 PULL CORD**

- A. Pull Cord or Rope: Twisted or braided nylon cordage, 1/4 inch diameter, with a minimum tensile strength of 1000 pounds. Pull cord shall be combination footage measuring tape and pull line.

### **2.05 MANDRELS**

- A. High-strength aluminum alloy with steel center rod and cast iron eyes.
- B. Use solid cylindrical type mandrels, minimum 12 inches long and 1/4 inch less than diameter of duct at center, tapering to 1/2 inch less than duct size at ends.

### **2.06 CONDUIT SUPPORTS**

- A. Steel shapes, angles and channels: 1 1/2 by 1 1/2 or 1 5/8 by 1 5/8 inches, 12 gauge, cold-formed, lipped channel; designed to accept special spring-held hardened steel nuts for securing hanger rods and other attachments.
- B. Single Conduit Hangers: Steel City No. C-149, Unistrut No. J1205 through J1260, or Engineer approved equal, with 3/8 inch minimum diameter steel rod.

- C. Riser Supports: Steel City No. C-210, or Engineer approved equal.

## **2.07 REINFORCED PLASTIC MORTAR SPACERS (RPM)**

- A. Duct Spacers: Refer to Section 02500, Underground Ductwork and Structures.
- B. Bore spacers shall be made from high density polyethylene (not less than 0.96 specific gravity), as manufactured by Formex Manufacturing, Inc., Underground Devices Inc. make, or Engineer approved equal.
- C. Steel Bands and Polypropylene Straps for Securing Ducts in Bore Spacers: Provide means of securing conduits to bore spacers in accordance the bore spacers manufacturer's written instructions. At minimum provide one of the following means:
  - 1. 5/8 inch by 0.30 inch galvanized steel bands and buckles having a minimum breaking strength of 1405 lbs.
  - 2. 3/4inch wide polypropylene strapping having a 1400 lb breaking strength, 7 percent maximum stretch, and steel seals.

## **2.08 UTILITY MARKER TAPE**

- A. Tracer Tape: As specified in Section 02300, Earthwork. Use in trenches containing electric and power circuit. Tape shall have printed warning that an electric circuit is located below the tape.

## **2.09 CONDUIT EXPANSION FITTINGS**

- A. Fabricate from material similar to type conduit with which used.
- B. Include factory installed packing ring and pressure ring; prevent entrance of moisture.
- C. Include grounding ring or grounding strap for metallic expansion couplings.

## **2.10 INSERTS**

- A. Channel Inserts:
  - 1. Fabricate from cold-formed steel channels 12 gauge or thicker; overall size 1 1/2 inches by 1 1/2 inches or 1 5/8 inches by 1 5/8 inches; lengths as indicated. Hot-dip galvanize after fabrication in accordance with ASTM A153.
  - 2. For Embedding in Concrete:
    - a. Fabricate from channels having a solid base
    - b. Weld concrete anchors to channel during fabrication and before coating
    - c. Clean and galvanize after fabrication

- d. Provide assemblies with minimum pull-out load rating of 4500 pounds per linear foot uniformly distributed.
- e. Furnish channel inserts for embedded installation in concrete with channel interior completely filled with Styrofoam.
- 3. For Surface Mounting:
  - a. Fabricate from channel with 3/8 inch by 3 inches slots on 4 inches centers in base.
  - b. Galvanize inserts for surface mounting on concrete surfaces, and for installation in damp or wet areas in accordance with ASTM A153.
  - c. Use galvanized expansion shield type anchor bolts.
- B. Spot Inserts for Embedding in Concrete:
  - 1. Steel, galvanized after fabrication in accordance with ASTM A 153.
  - 2. Design for maximum loading of 800 pounds with safety factor of three.
  - 3. Knockout openings: Designed to accommodate square or rectangular nuts.

### **2.11 FILLING MATERIALS**

- A. Furnish fire-resistive filling material for openings similar to the material of the floor, wall or ceiling being penetrated, and finish to prevent passage of water, smoke and fumes.
- B. Where conduits passing through openings are exposed in finished rooms, use filling material that matches the adjoining finished floor, ceiling, or wall.

### **2.12 END CAPS**

- A. Provide end caps at both ends of all empty conduits.

### **2.13 CASINGS**

- A. Casing to receive bore spacers and ducts shall be a minimum of 0.375 inch thick steel wall and shall be straight and true.

## **PART 3 – EXECUTION**

### **3.01 GENERAL REQUIREMENTS**

- A. All exposed conduit, conduit embedded in concrete walls and embedded in concrete floor, and conduit from handhole to shelter equipment shall be threaded rigid galvanized steel, except as follows:

1. Rigid PVC conduit may be used:
  - a. For direct earth burial outside of building foundations, only where specifically shown on Contract Drawings and if buried not less than 24 inches below the surface.
  - b. PVC Schedule 80 conduit shall be used at rail crossings. Conduit shall be buried not less than 42" from the top of the rail tie.
- B. For system higher than 150 volts to ground, maintain continuity of equipment ground across flexible conduit connection to motor outlet by installing bonding wire inside conduit and connecting each end of wire to outlet or junction boxes by separate bolt, or use liquid tight flexible conduit approved for this purpose.
- C. For PVC conduits, maintain continuity of conduit system ground by installing copper grounding wire inside PVC conduit, per CCR, Title 24. Ground this wire at each accessible location (manhole, pullbox, cabinet, outlet and junction box, and similar locations) and at each termination.
- D. Check embedded items for correct location and detail before concrete is placed.
- E. Control erection tolerance requirements; do not impair strength, safety, serviceability, or appearance of installations. Determine exact locations of conduit.
- F. Install trade size, type, and general routing and location of conduits, raceways, and boxes as indicated or specified.
- G. When exposed or buried conduit passes through expansion or contraction joint in structure, install conduit at right angles to joint; provide approved conduit expansion fitting at joint.
- H. Provide expansion fittings in conduit runs as required to compensate for thermal expansion.
- I. Conduits exposed to different temperatures: Seal to prevent condensation and passage of air from one area to the other.
- J. When field cutting of conduit is required, remove rough edges. Where conduit enters box or other fitting, provide bushing to protect wire from abrasion.
- K. Provide a minimum slope of three inches to each 100 feet away from buildings and towards manholes or pull boxes; run in straight lines between indicated changes in direction.
- L. Perform welding in accordance with AWS D1.1.

### **3.02 EXCAVATION, TRENCHING, AND BACKFILL**

- A. As specified in Section 02300, Earthwork, and as indicated in the Contract Documents.

### 3.03 REINFORCED PLASTIC MORTAR SPACERS (RPM)

- A. Duct Spacers: Refer to Section 02500, Underground Ductwork and Structures.
- B. Bore Spacers (For ducts installed inside casing):
  - 1. Use one double wall bore spacer for every 5 feet of duct bank.
  - 2. Construct a trough or feeder bridge at the leading end of the casing to support sections of duct bank as they are assembled and pulled into the casing.
  - 3. Use "Off Center Weight Technique" or "Stabilization Cables" to prevent rotating of the duct bank (corkscrew) as it is pulled through the casing.
  - 4. Hold bore spacers in place relative to the conduit to avoid excessive temporary thrust load on each bore spacer while grout is pump into the casing.
  - 5. Hold duct bank in position at both ends to accommodate possible uneven thrust loads that may be generated during the grouting operation.
  - 6. Do not exceed the hydraulic collapse pressure of the conduits during grouting operation.
  - 7. Measure and record actual quantity of grout used.
  - 8. Secure conduits to bore spacers by installing on each side of each bore steel bands and buckles or polypropylene strapping and steel seals.

### 3.04 UNDERGROUND CONDUITS

- A. Refer to 02300, Earthwork, for provisions for trenching, backfilling, and tracer tape.
- B. Verify conduit is continuous and not damaged by pulling mandrel through embedded conduit within five days after concrete placement.
- C. Cap or plug ends of conduit with permanent cap or plug. Do not use duct tape to temporarily seal conduit. Prevent concrete and other materials from entering and obstructing conduit. Do not install bell end fittings on conduits in ungrounded pull boxes.
- D. Sandpaper joints in PVC conduit; remove burrs, clean and dry joints, and brush with solvent cement recommended by manufacturer.
- E. Heating or any other method shall not be used to produce a larger bend. A sweep radius shall never be less than 15 feet in any given section.
- G. Install duct runs straight and true between pull boxes. Do not use bends except where shown on the Contract Drawings. For alignment curves, do not use more than 5 degree segments for each standard straight length.

- H. Conduits smaller than three inches: Make horizontal and vertical changes in direction exceeding 10 degrees by long sweep bends; having minimum radius of 25 feet. Manufactured bends may be used at ends of short runs of 100 feet or less, but only at or within five feet of end of run. Sweep bends may be made up of curved or straight sections, or combinations. Manufactured bends: bend radius to centerline of all conduits not less than 10 times nominal diameter of conduit for ducts of three inches in diameter and larger.
- I. Place underground raceways at minimum depth of 24 inches to top of sand encasement, or to top of conduit (as applicable), unless specifically indicated otherwise.
- J. Plug all ends of unused ducts and conduits in pull boxes/manholes. Use plugs manufactured for the purpose.
- K. Unless otherwise shown on the Contract Drawings, install an expansion joint with minimum range of 5 inches in every 100-foot length of PVC type conduit. Make all joints in PVC conduit with solvent cement, as recommended by conduit manufacturer.
- L. During non-work hours, and at locations where installation of ducts is temporarily suspended or terminated, close ends of ducts with caps or plugs fitted to prevent entry of water or debris. Use caps or plugs designed for purpose by conduit manufacturer.
- M. Inspect ducts and couplings to ensure only clean and undamaged units are incorporated in Work.
- N. Refer to Article entitled Mandrel.
- O. Provide flared bell ends on conduit and ducts entering manholes, handholes, and pull boxes.
- P. Conduit runs shall have no more than three (3) 90 degree bends between pull boxes, between manholes, and from point to point from the last pullbox.

### **3.05 UNDERGROUND CONDUITS FOR COMMUNICATIONS**

- A. Conduit bends shall be in accordance with NEC and the California Electrical Code, with not more than 120 degrees in bend. Where more bends are required in a particular run, install pull boxes as required to facilitate pulling conductors. For straight conduit runs, maximum length without a pull box/manhole shall not exceed 500 feet. For conduit runs with some bends, maximum length without a pull box/manhole shall not exceed 400 feet.
- B. Conduit stacks shall begin sweeps a minimum of 10 feet from exterior pull box face, leaving 10 feet of straight conduit perpendicular to cored entrance holes of pull box.

- C. When conduit stack enter or exit in a straight line to a pull box face, conduit stack shall separate from common trench at a minimum distance of 30 feet from entrance to pull box.
- D. When conduit stack enter or exit from sweep to a manhole, conduit stack shall separate from common trench at a minimum distance of 35 feet perpendicular to entrance of pull box.
- E. Communication conduit stack shall contain a minimum of 4 - four inch conduits.
- F. All conduits shall be 15-foot minimum radius in any given section of the 90 degrees conduit sweep. 90 degrees conduit sweep shall be manufacturer-supplied bends of 20 foot length. Determine the total sweep radius by the maximum natural bending capability of each twenty-foot section.
- G. Terminate underground conduit stubs with coupling and threaded plug.

### **3.06 EXPOSED CONDUITS**

- A. Use galvanized rigid steel (GRS) for exposed conduits.
- B. Install conduits straight and true with respect to each other and adjacent construction.
- C. Exposed conduits on Public Areas shall be painted to match surrounding areas.
- D. Route exposed conduits in such a manner as to obtain the least visibility from public view, along columns and beams, and similar features. Verify routing with the Engineer.
- E. Provide separable watertight hub fittings with gasket, separate nylon insulated throat and case hardened locknut.

### **3.07 SUPPORTS**

- A. Support conduits in vertical runs not to exceed 5-foot intervals. Use riser supports with clamps for vertical conduit risers.
- B. For single conduit runs, use pipe straps with single conduit hangers. Single hole malleable iron clamps may be used for horizontal runs on vertical surfaces. Perforated strap (plumber's tape) is not acceptable.
- C. Multiple Pipe Hangers (Trapeze Type):
  - 1. Fabricate two or more steel hanger rods, a steel horizontal member and U-bolts, clamps, and/or other attachments necessary for securing hanger rods, cable trays and conduits.
  - 2. Hanger Rod – Not smaller than 1/4 inch diameter, threaded full length.

3. Horizontal Member: Steel angles, and channels. Two or more channels may be welded together to form horizontal members of greater strength.

### **3.08 MANDREL**

- A. As each section of conduit and duct line is completed between manholes, handholes, and pull boxes, pull mandrel and swab through conduit or duct to remove foreign matter.
- B. Draw mandrel through completed conduit run manually without mechanical assistance. If obstructions are encountered which cannot be removed or if conduits do not pass the "usable capacity" mandrel, correct or replace conduit.
- C. Correct or replace conduits which have a consistent "hard spot" (indicating possible separation), conduits where joints may damage cable sheaths, or conduits with misaligned junctions or poor conduit joints.
- D. During construction, protect partially completed duct lines from entrance of debris by means of suitable caps or plugs.

### **3.09 PULL CORDS**

- A. Install pull line in empty (unused/future) conduits. Make pull-line continuous from outlet to outlet, with two (2) feet of slack at each outlet.
- B. After conduits are cleaned and mandrelled, install rope and securely seal both ends of conduit with caps.
- C. Do not splice pull cords. Leave ample slack length at each end of pull cords.

### **3.10 FILLING OF OPENINGS**

- A. Wherever slots, sleeves or other openings are provided in floors or walls for the passage of raceways, including bus ducts, fill such openings as follows:
  1. Install fire-resistive filling material to prevent passage of water, smoke and fumes.
  2. Where conduits passing through openings are exposed in finished rooms, use filling material that matches, and is flush with, the adjoining finished floor, ceiling or wall.

### **3.11 CASINGS**

- A. Install casing in which bore spacers and ductwork will be installed so that inside walls are smooth and free from ridges, projections and seams that might impede the rolling of wheels of bore spacers.

### **3.12 FIELD QUALITY CONTROL**

- A. Notify the Engineer for inspection and sign-off of the following installations:



1. Conduits to be direct buried: Notify the Engineer prior to covering.
  2. Completed underground installations: Obtain the Engineer's inspection and acceptance before installation of cable and equipment.
  3. Conduits to be embedded in concrete: Obtain the Engineer's inspection and acceptance before issuing concrete pouring permit.
  4. Mandrelling and swabbing (to be witnessed by the Engineer).
  5. Installation of pull cords (to be witnessed by the Engineer).
- B. Document each mandrelled or swabbed conduit and submit test report.

**END OF SECTION**



## **SECTION 16135**

### **OUTLET, JUNCTION, AND PULL BOXES**

#### **PART 1 - GENERAL**

##### **1.01 DESCRIPTION**

- A. Section includes requirements for outlet boxes for use with wiring devices and lighting fixture outlets.

##### **1.02 REFERENCE STANDARDS**

- A. California Code of Regulations (CCR):
  - 1. Title 24, Part 3, California Electrical Code
- B. National Electrical Manufacturers Association (NEMA):
  - 1. NEMA FB-1 Fittings, Cast Metal Boxes, Conduit Bodies for conduit, Electrical Metallic Tubing (EMT) and Cable
  - 2. NEMA OS-1 Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
  - 3. NEMA 250 Enclosures for Electrical Equipment (1000 Volts max)
- C. National Fire Protection Association (NFPA):
  - 1. NFPA 70 National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
  - 1. UL 514A Metallic Outlet Boxes

##### **1.03 SUBMITTALS**

- A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
- B. Submit manufacturer's product data on outlet boxes to be used.

#### **PART 2 – PRODUCTS**

##### **2.01 GENERAL**

- A. Furnish electrical boxes of material, finish, type and size indicated and required for location, kind of service, number of wires, and function.
- B. Boxes shall have appropriate means to secure covers. Provide boxes complete with accessible covers designed for quick removal and suitable for purpose used;

- equip boxes, in which or on which no devices or fixtures are to be installed with flat or raised blank covers as required.
- C. Provide neoprene gaskets 1/8 inch thick for boxes subjected to weather.
  - D. Provide fire resistant gaskets 1/8 inch thick for boxes in tunnels and cross-passages.
  - E. Furnish necessary adapter plate for mounting devices on light fixtures, brackets, supports, hangers, fittings, bonding jumpers and other accessories required.
  - F. Concealed and Embedded Junction Boxes: Zinc-coated inside and out.

## **2.02 STANDARD SHEET METAL BOXES**

- A. Standard Sheet Metal Boxes: Conform to NEMA OS-1 standard, hot dipped galvanized, one piece drawn steel.
- B. Outlet Boxes shall be 4 inch minimum true size and 1-1/2 inches minimum depth unless otherwise specified for the installation. For 1-inch conduit, use boxes 4-11/16-inch minimum trade size. Sectional boxes assembled by means of screws are not acceptable.
- C. Use standard galvanized covers, rings and fittings of appropriate type for box or device to be installed. Same thickness as sheet steel boxes.
- D. Provide products of commercial quality best suited for purpose indicated or specified.
- E. Luminaire and equipment supporting boxes shall be rated for weight of equipment supported.
- F. Manufacturer: Appleton, Bowers, Raco, Steel City, or Engineer approved equal.

## **2.03 CAST BOXES**

- A. Cast Boxes: Conform to NEMA FB-1. Boxes for exposed switches and receptacles: Cast metal, FS and FD Types.
- B. Boxes shall be cast metal type with threaded hubs. Steel or ferrous alloy, with compatible conduit fittings.
- C. Use cast metal boxes in moist locations where surface mounted rigid conduit system is used (e.g. storm water lift station sump, above ground prefabricated service booth on interior and exterior surfaces, and for surface mounted weatherproof outlets or devices, regardless of location)
- D. Surface Mounted Cast Metal Box: NEMA 250, Type 4, 4X or 6, flat flanged, galvanized cast iron. Furnish cover with ground flange, neoprene gasket, and stainless steel cover screws.
- E. Recessed Mounted Cast Metal Box: NEMA 250, Type 3S, heavy duty, galvanized cast iron, recessed cover with neoprene gasket suitable for concrete wall

embedment. Cover shall be provided with stainless steel tamper proof screws. Box shall be drilled and tapped for the number and size of conduits indicated on the Contract Drawings. Use box in tunnels and pedestrian underpasses.

- E. In-Ground Cast Metal Box: NEMA 250, Type 6, inside flanged, recessed cover for flush mounting. Galvanized cast iron. Non-skid cover with neoprene gasket and stainless steel screws.
- F. Cover Legend: "ELECTRIC"
- G. Manufacturer: Appleton, Crouse-Hinds, or Engineer approved equal.

### **PART 3 - EXECUTION**

#### **3.01 OUTLET BOXES**

- A. Outlet boxes
  - 1. Securely fasten outlet boxes in position and support independent of the conduit system.
  - 2. Install boxes true to the building lines and at equal heights in conformity with mounting heights per NEC and as indicated in the Contract Documents.
  - 3. Boxes shall have only the holes necessary to accommodate the conduits at point of installation.
  - 4. Rigidly secure boxes in position. Set boxes so that the front edge of the box is flush with the finished wall or ceiling line, or not more than 1/8 inch back of same.
  - 5. Offset back-to-back outlets so that a minimum of 6 inches separation.
  - 6. All boxes shall be accessible. Mount boxes with long axis of devices vertical unless otherwise indicated.
  - 7. Locate boxes and box knockouts without interference with reinforcing steel.
- B. Lighting Outlet Boxes
  - 1. Exposed installation: Cast metal, not smaller than 4 inches round or square by 2 1/8 inches deep.
  - 2. Embedded and concealed installation: Standard sheet steel boxes approved for intended purpose.
  - 3. Locate outlet boxes to allow luminaries positioned as shown on reflected ceiling plan.

- C Support fixture outlet boxes installed in suspended ceilings supporting acoustical tiles or panels, directly from the structure above, wherever pendent mounted lighting fixtures are installed on the box. Mount boxes independent of ceiling suspension system.
- D. Install necessary adapter plate for mounting devices on light fixtures, brackets, supports, hangers, fittings, bonding jumpers and other accessories.
- E. Install specified gaskets.
- F. Grounding: As specified in Section 16060, Grounding and Bonding. Install grounding jumpers.

### 3.02 JUNCTION AND PULL BOXES

- A. Junction and pull boxes less than 100 cubic inches in size: Cast metal for exposed installation and sheet steel for embedded installation.
- B. Junction and pull boxes more than 100 cubic inches in size: Conform to requirements for cabinets, except use recessed cast metal boxes with gasketed covers in tunnels; interface pull boxes at ends of tunnels.
- C. Support boxes independently of conduit.
- D Use gang boxes where more than one device is mounted together. Do not use sectional box.
- E. Install covers readily accessible after completion of installation.
- F. Outlet boxes used as junction boxes: Not smaller than four inches square by 1 1/2 inches deep. Provide flat blank covers.
- G. Covers:
  - 1. Same thickness as sheet steel boxes; secured in position by No. 10-24 stainless steel machine screws. Arrange covers to be vandal resistant.
  - 2. Cover for four-inch square box: Provide opening at one side for switch or receptacle; blank at other side.
- H. Concealed and Embedded Junction Boxes:
  - 1. Concealed or embedded switch or receptacle boxes: Sheet steel, four inches by 1 1/2 inches deep minimum size.
  - 2. Boxes Set in Concrete:
    - a. Support boxes to prevent movement during placement of concrete.
    - b. Plug and mask unused nailing holes and other holes in side or bottom of boxes.

**3.03 CLEAN UP**

- A. After installation, clean boxes placed in concrete.

**END OF SECTION**





## **SECTION 16140**

### **CONCRETE HANDHOLES AND PULL BOXES**

#### **PART 1 – GENERAL**

##### **1.01 DESCRIPTION**

- A. Section includes requirements for handholes and pull boxes. Handholes and pull boxes are both referred to in this Section as handholes.

##### **1.02 REFERENCE STANDARDS**

- A. American Association of State Highway and Transportation Officials (AASHTO):
  - 1. M199 Specification for Precast Reinforced Concrete Manhole Sections
- B. California State Department of Transportation (Caltrans) Standard Plans:
  - 1. ES-8 Pull Box Details
- C. California Public Utilities Commission (CPUC) General Orders (G.O.):
  - 1. G.O. No. 128. Rules for Construction of Underground Electric Supply and Communication Systems
- D. National Fire Protection Association (NFPA):
  - 1. NFPA 70 National Electrical Code (NEC)

##### **1.03 SUBMITTALS**

- A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
- B. Submit manufacturer's product data for supports, covers, grounding, pullboxes and handholes, joint sealing compound, and other materials. Include concrete mix design.
- C. Submit shop drawings for fabrication and installation of concrete structures.
- D. Submit precast manufacturer's Certification of Compliance.

##### **1.04 QUALITY ASSURANCE**

- A. Regulatory Requirements: Comply with NEC and PUC GO No. 128

## **PART 2 – PRODUCTS**

### **2.01 PRECAST CONCRETE HANDHOLES**

- A. Unless otherwise indicated, precast concrete handholes shall conform to Caltrans Standard Plan ES-8, No. 3-1/2T, No. 5T, and No. 6T, for H-20 loading, and AASHTO M199.
- B. Pullbox No. 3-1/2T shall be "Christy" B1017 or Engineer approved equal, with minimum inside dimensions of 10-5/8 inch wide x 17-1/4 inch long x 24 inches deep. Pullbox shall be provided with bolt down checkered steel lid identified as "ELECTRICAL" or "COMMUNICATIONS", as required.
- C. Pullbox No. 5T shall be "Christy" B1324 or Engineer approved equal, with minimum inside dimensions of 13-1/4 inch wide x 24 inch long x 24 inches deep. Pullbox shall be provided with bolt down checkered steel lid identified as "ELECTRICAL" or "COMMUNICATIONS", as required.
- D. Pullbox No. 6T shall be "Christy" B1730 or Engineer approved equal, with minimum inside dimensions of 17 inch wide x 30 inch long x 24 inches deep. Pullbox shall be provided with bolt down checkered steel lid identified as "ELECTRICAL" or "COMMUNICATIONS", as required.
- E. Where indicated on the Plans provide pullbox "Christy" B2436 or Engineer approved equal, with minimum inside dimensions of 24 inch wide x 36 inch long x 24 inches deep. Pullbox shall be provided with two (2) piece bolt down checkered steel lids, with one of the leads identified as "ELECTRICAL" or "COMMUNICATIONS", as required.
- F. Where indicated on the Plans provide pullbox "Christy" B3048 or Engineer approved equal, with minimum inside dimensions of 30-1/4 inch wide x 48-1/4 inch long x 24 inches deep. Pullbox shall be provided with three (3) piece bolt down checkered steel lids, with center lid identified as "ELECTRICAL" or "COMMUNICATIONS", as required.

## **PART 3 – EXECUTION**

### **3.01 CONCRETE HANDHOLES**

- A. Install handholes flush with concrete platform surface, or flush with sidewalks, curbs, paved areas and other concrete surfaces. Install top of handholes 2 inches above grade in landscaped areas. Seal unused openings with mortar.
- B. Install no more than equivalent of three 90 degree bends between pull points.
- C. Plug all ends of unused ducts and conduits in handholes. Use plugs manufactured for the purpose.

### **3.02 HANDHOLE INSTALLATION**

- A. Excavation and backfill shall be in accordance with Section 02300, Earthwork.

- B. Install handhole structures in accordance with the requirements established for precast concrete drainage structures as specified under Section 02630, Storm Drainage System.
- C. Set precast handholes on well-compacted soil with minimum of six inches of crushed stone base. Where duct lines enter handholes, sections of duct may be cast in concrete or may enter through square or rectangular opening of suitable dimensions.
- D. Review location of handholes and obtain the Engineer's acceptance before installation of handhole is started.
- E. Unless otherwise indicated, install ground rod at each pullbox. Provide grounding braid and grounding accessories for grounding the pullbox cover(s) to the ground rod.

**3.03 FIELD QUALITY CONTROL**

- A. Notify the Engineer for inspection and obtain Engineer's acceptance of handholes and pull boxes prior to installation of cable and equipment. Make corrections required.

**END OF SECTION**



## **SECTION 16250 WIRING DEVICES**

### **PART 1 – GENERAL**

#### **1.01 DESCRIPTION**

- A. Section includes requirements for line voltage wiring devices.

#### **1.02 REFERENCE STANDARDS**

- A. National Electric Manufacturers Association (NEMA):
  - 1. NEMA WD 1 General Color Requirements for Wiring Devices
  - 2. NEMA WD 6 Wiring Devices – Dimensional Specifications
- B. National Fire Protection Association (NFPA):
  - 1. NFPA 70 National Electrical Code (NEC)
- C. Underwriters Laboratories Inc. (UL):
  - 1. UL 20 General-Use Snap Switches
  - 2. UL 50 Enclosures for Electrical Equipment, Non-Environmental Considerations
  - 3. UL 94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
  - 4. UL 486A&B Wire Connectors
  - 5. UL 498 Attachment Plugs and Receptacles
  - 6. UL 514A Metallic Outlet Boxes
  - 7. UL 514B Conduit, Tubing, and Cable Fittings
  - 8. UL 943 Ground-Fault Circuit-Interrupters

#### **1.03 SUBMITTALS**

- A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
- B. Submit shop drawings.
- C. Submit manufacturer product data for all types of wiring devices to be used.

**PART 2 – PRODUCTS**

**2.01 DEVICES**

- A. Provide wiring devices conforming to the following UL Standards: 20, 50, 94, 486A-486B, 498, 514A, 514B and 943. Wiring devices shall also conform to NEMA WD 1 and WD 6.
- B. Provide wiring devices indicated. Provide all similar devices of same manufacturer. Provide devices and device plates of the color and finish specified in the Contract Documents.

**2.02 SWITCHES, FLUSH TUMBLER TYPE**

- A. General Requirements:
  - 1. Unless otherwise specified or shown, use quiet type switches with ivory handles, rated 120/277 Volts ac and conforming to NEMA WD 1. Wiring methods shall be as specified in Section 16100, Wiring Methods.
  - 2. Do not load switches more than 80 percent of their current rating.
  - 3. Equip switches with metal mounting yoke with plaster ears, insulated from mechanism and fastened to switch body using bolts, screws, rivets or other substantial means to meet test requirements.
  - 4. Provide green-colored equipment grounding screw on yoke. Switches shall be back or side wired with terminals of screw or combination screw-clamp type. Terminal screws shall be No. 8 or larger, captive or terminal type with access hole for back wiring. Wiring terminals shall be able to receive and hold proper wire size.
- B. Standard Type Switches:
  - 1. Tumbler type, totally enclosed, heavy duty. Catalog numbers listed below are for 120/277 Volt, 20 Amps, with ivory handles. Provide different color if specified in the Contract Documents. Where required, furnish 2 pole, 3 way and 4 way switches, and lock switches of comparable grade. Provide one key for each lock switch.

	<b>SPST</b>	<b>DPST</b>	<b>3-WAY</b>	<b>SPST-KEY</b>	<b>4-WAY</b>
Arrow-Hart	1991-I	1992-I	1993-I	1991-L	1994-I
Bryant	4901-I	4902-I	4903-I	4901-L	4904-I
Hubbell	1221-I	1222-I	1223-I	1221-L	1224-I
P & S	20AC1-I	20AC2-I	20AC3-I	20AC1-L	20AC4-I

or Engineer approved equal.

- C. Weatherproof Switches:
  - 1. Provide switch in cast metal box: Appleton or Crouse-Hinds Type FS or FD, or Engineer approved equal.
  - 2. Cover and gasket: Appleton #FSK-1V, Crouse-Hinds #DS-181, or Engineer approved equal combination.

### 2.03 RECEPTACLES

- A. Power receptacles and switches for general purpose circuits shall be manufactured per NEMA Specifications, rated as follows:
  - 1. General purpose receptacles: NEMA 5-15R or 5-20R
  - 2. Dedicated Receptacles: NEMA 5-20R
- B. Receptacle bodies and bases: Fire resistant non-absorptive hot molded phenolic composition material or approved equivalent with metal plaster ears integral with supporting member.
- C. Provide receptacles with light colored terminal facilities for neutral connections, amber or brass colored for phase conductor connections and green colored hexagonal machine screws for equipment grounding conductor and connections.
- D. Receptacle contacts including grounding contact: Double grip bronze type with spring steel backup clips to ensure both sides of each male prong of plug will be in firm contact.
- E. Provide receptacles with self-grounding clip or mounting strap green screws.
- F. Ground fault circuit interrupter duplex receptacles: 120 Volt, 60Hz, 20 ampere with built-in test, reset buttons. Interrupt circuit within 1/30 second on a five milliamperes earth leakage current. Maximum circuit capacity 20 amperes. Straight blade, heavy duty, industrial specification grade.
- G. Ground Fault Circuit Interrupter Duplex Outlet (GFI): 20 amp, 125 Volt ac, 3 wire, grounding type, straight blade. Ivory color: Hubbell # GF5362IA, Pass & Seymour # 2095-SI, Leviton #7899-SGI, or Engineer approved equal.
- H. Weatherproof Metallic Covers for Duplex GFI Receptacles: WPO listed, covers with this listing shall meet NFPA 70, Section 406.8(A) and 406.8(B) as applicable, and UL 514A receptacle requirements for wet location that is rated for wet location for either cover closed and/or cover open with device in use ("open"):
  - 1. Surface Mounted: Appleton or Crouse-Hinds Type FS or FD cast box or equal with rated for wet location metal cover with gasket:
    - a. Appleton cover type FSK, Hubbell HBL5206WO, or Engineer approved equal

## **2.04 DEVICE COVER PLATES**

- A. Interior plates: Vandal resistance, stainless steel 14 gauge.
- B. Exterior plates: Device cover plates shall be cast aluminum with self-closing hinged cover, rated for damp location.
- C. Gang Plates: Use gang type plates for multiple units.
- D. Screws: Vandal resistance stainless steel.

## **PART 3 – EXECUTION**

### **3.01 GENERAL REQUIREMENTS**

- A. Install all wiring devices indicated complete with cover plates. Cover plates shall fit snugly against finished surfaces and line-up true with adjacent building lines, and be symmetrical in location and appearance.
- B. Unless otherwise noted on the Contract Drawings, receptacles shall be installed in the vertical position with the grounding pin down.

**END OF SECTION**



## SECTION 16450 PANELBOARDS

### PART 1 - GENERAL

#### 1.01 DESCRIPTION

- A. Section includes requirements for panelboards providing fault interrupting capability and overcurrent protective devices.

#### 1.02 REFERENCE STANDARDS

- A. California Code of Regulations (CCR):
  - 1. Title 24, Part 3, California Electrical Code
- B. National Electrical Manufacturers Association (NEMA):
  - 1. NEMA AB1 Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
  - 2. NEMA AB-4 Guidelines for Inspection and Preventative Maintenance Of Molded Circuit Breakers Used in Commercial and Industrial Applications
  - 3. NEMA PB1.1 General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less
  - 4. NEMA PB1 Panelboards
  - 5. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
- C. International Electrical Testing Association (NETA):
  - 1. NETA ATS Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
- D. National Fire Protection Association (NFPA):
  - 1. NFPA 70 National Electrical Code (NEC)
- E. Underwriters Laboratories Inc. (UL):
  - 1. UL 50 Enclosures for Electrical Equipment, Non-Environmental Considerations
  - 2. UL 67 Panelboards
  - 3. UL486A-486B Wire Connectors

- 4. UL 489 Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
- 5. UL 943 Ground-Fault Circuit-Interrupters

**1.03 SUBMITTALS**

- A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
- B. Product Data: Submit for each type of panelboard, overcurrent protective device, transient voltage surge suppressor (TVSS) device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- C. Shop Drawings: Submit for each panelboard and related equipment.
  - 1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
    - a. Enclosure types and details for types other than NEMA 250, Type 1.
    - b. Bus configuration, current, and voltage ratings.
    - c. Short-circuit current rating of panelboards and overcurrent protective devices.
    - d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - 2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.
- D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified under Quality Assurance herein.
- E. Test Procedure for Overcurrent Protective Devices: Test procedures shall comply with NEMA AB-4 guidelines.
- F. Field Test Reports: Submit written test reports and include the following:
  - 1. Test procedures used
  - 2. Test results that comply with requirements
  - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements
- G. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

- H. Maintenance Data: Submit operations and maintenance manuals for panelboards and components as specified in Section 01730, Operations and Maintenance Manuals.
  - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

**1.04 COORDINATION**

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

**1.05 MAINTENANCE MATERIALS**

- A. Keys: Furnish six spare keys of each type of panelboard cabinet lock.
- B. Accessory Set: Furnish tools and miscellaneous items required for test, inspection, maintenance, and operation.

**PART 2 - PRODUCTS**

**2.01 GENERAL**

- A. Panelboards shall comply with UL 67 requirements. Include the following panelboards:
  - 1. Lighting and appliance branch-circuit panelboards
  - 2. Distribution panelboards

**2.02 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed.
- B. Panelboards, Overcurrent Protective Devices, and Accessories:
  - 1. Eaton Corp.; Cutler-Hammer Products
  - 2. General Electric Co.; Electrical Distribution & Control Division
  - 3. Siemens Energy & Automation, Inc.
  - 4. Square D Company
  - 5. Or Engineer approved equal

### 2.03 FABRICATION AND FEATURES

- A. Enclosures: Surface-mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.
- B. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
- C. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
- D. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
- E. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.
- F. Bus: Hard-drawn copper, 98 percent conductivity.
- G. Main and Neutral Lugs: Mechanical type suitable for use with conductor material.
- H. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
- I. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.
- J. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- K. Skirt for Surface-Mounted Panelboards: Same gauge and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

### 2.04 PANELBOARD SHORT-CIRCUIT RATING

- A. Fully rated to interrupt symmetrical short-circuit current available at terminals.

### 2.05 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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

### 2.06 DISTRIBUTION PANELBOARDS

- A. Doors: Front mounted, except omit in fused-switch panelboards; secured with vault-type latch with tumbler lock; keyed alike.
- B. Main Overcurrent Protective Devices: Circuit breaker.
- C. Branch overcurrent protective devices shall be one of the following:

1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

## 2.07 OVERCURRENT PROTECTIVE DEVICES

- A. General: Devices shall be the latest approved design as manufactured by a nationally recognized manufacturer and in conformity with applicable standards and listings of nationally recognized testing laboratories. Devices shall comply with UL requirements 489, 50, 67 and 943.
  1. Overcurrent protective devices shall be molded-case circuit breakers as specified herein.
- B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
  1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- C. Breakers shall be bolt-on type suitable for individual as well as panelboard mounting. Breakers shall be bolt-on type, no "plug-on" type panelboard breakers allowed.
- D. Breakers shall meet current National Electrical Manufacturers Association (NEMA) and Underwriters Laboratories (UL) specifications as applicable to frame size, standard rating, and interrupting capability.
- E. Breakers shall be one, two, or three pole as scheduled, and shall be of the quick-make, quick-break thermal magnetic type. They shall be trip free to prevent closing when a fault exists. The handle positions shall clearly indicate "ON", "OFF", and "TRIPPED" positions. Two pole breakers shall be physically the same size as two single-pole breakers, thereby permitting any combination of one, two, or three pole breakers.
- F. Operating handle shall open and close all poles simultaneously on a multi-pole breaker.
- G. Provide Class A (5ma sensitivity) breakers where GFI Type breakers are required.
- H. Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.
- I. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
- J. Size overcurrent protective devices as shown on the panel schedule in the Contract Documents or as required by the load being served. Provide separate neutral conductors for circuits protected by GFI breakers.

## 2.08 FEATURES

- A. Fungus Proofing: Permanent fungicidal treatment for panelboard interior, including overcurrent protective devices and other components.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Comply with mounting and anchoring requirements for seismic zone 4 location.
- C. Mounting Heights: Top of trim 74 inches above finished floor, unless otherwise indicated.
- D. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- E. Circuit Directory: Refer to Section 16000, Basic Electrical Requirements. Create a directory to indicate installed circuit loads after balancing panelboard loads.
- F. Install filler plates in unused spaces.
- G. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

### 3.02 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 16000, Basic Electrical Requirements.

### 3.03 CONNECTIONS

- A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.04 FIELD QUALITY CONTROL

- A. 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 indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

- B. Balancing Loads: When all loads are connected, measure load balancing and make circuit changes as follows:
  - 1. Measure as directed during period of normal system loading.
  - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data-processing, computing, transmitting, and receiving equipment.
  - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
  - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.
- C. Infrared Scanning: When all loads are connected, perform an infrared scan of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.
  - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
  - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 3. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### **3.05 ADJUSTING**

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

### **3.06 CLEANING**

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

**END OF SECTION**





## **SECTION 16800**

### **SITE LIGHTING**

#### **PART 1 – GENERAL**

##### **1.01 DESCRIPTION**

- A. Section includes requirements for site lighting system, including lighting control and protection components.

##### **1.02 REFERENCE STANDARDS**

- A. American National Standards Institute (ANSI):
  - 1. ANSI C82.4 Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)
- B. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. IEEE C2 National Electrical Safety Code (NEC)
- C. National Fire Protection Association (NFPA):
  - 1. NFPA 70 National Electrical Code (NEC)
- D. Underwriters Laboratories (UL):
  - 1. UL 1029 High-Intensity-Discharge Lamp Ballasts
  - 2. UL 1598 Luminaires

##### **1.03 SUBMITTALS**

- A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
- B. Submit shop drawings including dimensions and components for each luminaire which is not a standard product of the manufacturer. Submit shop drawings of the lighting control cabinet, including layout drawing, control schematic, and wiring diagram.
- C. Submit product data including dimensions, ratings, and performance data.
- D. Submit test reports indicating measured illumination levels.
- E. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency.
- F. Manufacturer's Instructions: Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

- G. Maintenance Data: Submit maintenance data including instructions for maintaining luminaires.

**1.04 REGULATORY REQUIREMENTS**

- A. Conform to requirements of NEC.
- B. Furnish products listed and classified by a nationally recognized testing laboratory.

**PART 2 – PRODUCTS**

**2.01 LIGHTING FIXTURES - GENERAL**

- A. Refer to Contract Drawings for Lighting Fixture Schedule. Provide lamp type as indicated on the Contract Drawings and as specified herein.
- B. All lighting fixtures shall have a polycarbonate shield for vandalism. All fixtures shall be waterproof and vandal-proof.
- C. The exterior lighting fixtures for the temporary station platforms shall be high pressure sodium vapor as indicated on the Contract Drawings. Fixtures shall have fully adjustable bilateral reflectors. The housing shall be constructed of extruded aluminum with an extruded aluminum hinged door for access to the lamp. The lamp holder shall be of the grip-tight mogul socket. Fixture voltage shall be selected to coordinate with the existing source available.
- D. Luminaires shall comply with UL 1598. High intensity discharge ballast shall comply with UL 1029 and ANSI C82.4.
- E. The finish of exterior luminaires shall be corrosion resistant, electrostatically applied on painted components.
- F. Fixtures shall have ballasts pre-wired with high power factor and designed for minus 20 degree F, or below, starting. The capacitor shall be separate and replaceable. The starting current of the ballast shall be less than the normal running current. The ballasts shall be of the high endurance type with a 3 year written manufacturer's guarantee covering damage to the ballasts due to lamp failures in open or short circuit conditions. Ballast shall have a protect feature which will prevent pulses to burn out lamps.
- G. Fixtures shall be listed by a nationally recognized testing laboratory for wet locations.
- H. Gaskets shall be high quality, high temperature gaskets providing positive weatherproof seals.
- I. Furnish mounting hardware and appurtenances with each fixture.

## 2.02 FIXTURE MOUNTING HARDWARE

- A. Lighting fixtures shall be designed with mounting brackets to provide the nominal mounting heights of luminaires as indicated on the Contract Drawings.
- B. Arms, mounting brackets, lighting poles, bases, and all hardware shall be from the same manufacturer as lighting fixtures. All shall be compatible in appearance, finish, and assembly.
- C. Where applicable, lighting poles shall be provided with grounding lugs capable of accepting a #2 AWG tap from the OCS (Overhead Catenary System) system counterpoise ground. This shall be in addition to the ground lug provided for connection to the equipment grounding conductor and supplementary ground.
- D. Mounting brackets for temporary station platform lights shall be suitable for wood pole mounting, fabricated from standard pipes, with an insulated wire inlet and rod to secure arm to wood pole. Wood pole shall be ANSI Class 5, of the length indicated on the Contract Drawings.

## 2.03 LIGHTING CONTROL EQUIPMENT

- A. Lighting control cabinet shall be NEMA Type 12 for indoor installation and NEMA Type 4 for outdoor installation. Cabinets shall be designed for wall mounting or shall be self standing, with dimensions as indicated on the Contract Drawings. Outdoor cabinets shall have outer and inner doors, backpanel, and hasp for padlocking.
  - 1. Time Switches: Digital type, two channels, with 365 days advance single holiday and seasonal schedule. Time switch clock input shall be 120 volts, 60 hertz, and shall be provided with two DPDT contacts rated a minimum of 10 amperes continuous duty. Time switch shall be able to retain the schedule for 40 years without power.
  - 2. Photoelectric Unit: Furnish photoelectric unit and necessary hardware suitable for mounting where required on the Drawings.
  - 3. Control Relays: Control relays shall be general purpose, blade type, 3PDT contact configuration with neon indicating light, rated minimum of 10 amperes at 240VAC. Provide matching socket base with hold down clips.
  - 4. Selector switch: Selector switch shall be NEMA 4X, oiltight/watertight, with contact block arrangement as required on the Contract Drawings.
  - 5. Lighting contactors: Lighting contactors shall be magnetically held, multi-pole, with coil rated at 120VAC, 60 hertz. Contact rating shall be a minimum of 30 amperes continuous. Number of contacts shall be as indicated on the Contract Drawings.
  - 6. Lightning arrester: Lightning arrester shall be a secondary surge arrester for electrical wiring.

7. Terminal blocks: Terminal blocks shall be provided for all incoming and outgoing circuits. Terminal blocks shall be rated 600 volts, and shall be UL listed. Terminal blocks for incoming circuits shall be suitable for wire sizes ranging from #20 AWG to #6 AWG. Terminal blocks for outgoing circuits shall be suitable for wiring ranging from #8 AWG to #4 AWG.
  8. Wire management: Plastic wire duct with slotted sidewall and with cover, sized as indicated on the Contract Drawings or as required.
- B. Control equipment shall provide components and connections which will allow automatic control of the lighting system. The controls shall provide on-off control of the lighting in response to two modes of operation:
1. Manual
  2. Automatic: In the automatic mode, the primary control device shall be the photocell unit. The time clock shall be wired into the control circuit such that certain lights may be turned off for a preset period of time during the normal photocell on period. The time clock controlled off operation shall be completely programmable for periods of time as short as 15 minutes and the setting shall be visible on the face of the time clock.

### **PART 3 – EXECUTION**

#### **3.01 GENERAL**

- A. Provide grounding to fixtures in accordance with Section 16060, Grounding and Bonding. Wiring methods and devices shall be in accordance with Sections 16100, Wiring Methods, and 16250, Wiring Devices. Handholes and pull boxes for running wiring to the luminaires and posts shall be in accordance with Section 16138, Concrete Handholes and Pull Boxes.

#### **3.02 LIGHTING FIXTURES**

- A. Install in accordance with manufacturers' instructions.
- B. Install lighting poles at locations indicated on the Contract Drawings. Locations on Contract Drawings are diagrammatic. Obtain Engineer's approval of exact locations in field.
- C. Install lamps in each luminaire.
- D. Bond luminaire, metal accessories, and metal poles to branch circuit equipment grounding conductor. Provide supplementary grounding electrode in the adjacent handhole or at the pole base where indicated on the Contract Drawings. Provide additional bonding to the OCS system counterpoise ground where indicated on the Contract Drawings. Refer to Section 016060, Grounding and Bonding.
- E. Avoid interference with and provide clearance for equipment. Where the indicated locations for the lighting fixtures conflict with the locations for

equipment, change the locations for the lighting fixtures by a minimum distance necessary as approved by the Engineer. For purposes of this Section, clearances and interferences will be as defined in the NESC.

- F. Photoelectric controls shall provide control to the lighting contactors for the lighting systems and shall be powered independent of the wiring to the luminaire ballast system.

### **3.03 LIGHTING CONTROL DEVICES**

- A. Apply labels or stencil to control components to identify components and their purpose.
- B. Lightning Arrestor: Install lightning arrestor within the control cabinet.

### **3.04 FIELD QUALITY CONTROL**

- A. Take light meter readings in the presence of the Engineer at night to ensure proper lighting levels of all lighting systems. Provide the labor and equipment to make any required adjustments at this time. Notify the Engineer at least 48 hours prior to performing this test. This test shall be accomplished in the presence of the Engineer. Submit the test results to the Engineer in writing prior to Final Inspection. Record results on the Project Record Drawings.
- B. After completion of the work, place illumination system in operation. Final acceptance will not be made until the system has operated satisfactorily for a period of not less than 30 days from the date designated by the Engineer. This test period shall be included with the specified Contract time. Operation of the system shall not in any way be construed as an acceptance of the system or any part of it or as a waiver of any of the provisions of the Contract. The Contractor shall be responsible for the system during this period of operation and shall make any adjustments or repairs which may be required and remedy defects or damage which may occur.

**END OF SECTION**