

## **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**