

## SECTION 26 05 24

### LOW VOLTAGE WIRES AND CABLES

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Wire and cable markings.
- B. 600 volt single conductor cable.
- C. Multiple conductor cable.
- D. Fixture wire.
- E. Bare conductor.
- F. Low-voltage control circuit wire.
- G. Thermocouple cable.
- H. Color coding of conductors (600V)
- I. Cable supports and fasteners.
- J. Conductor bundling straps.

##### 1.02 RELATED SECTIONS

- A. Interface and coordinate the work of this Section with Section 20 70 26 - Common Materials and Methods for Electrical Systems, and Section 20 50 13 - Raceways for Facility Services.

##### 1.03 MEASUREMENT AND PAYMENT

- A. General: Low voltage wires and cables, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for the related item of work in the Bid Schedule of the Bid Form.

##### 1.04 REFERENCES

- A. Association of American Railroads (AAR):
  - 1. AAR Signal Manual
- B. American National Standards Institute (ANSI):
  - 1. ANSI MC96.1 Temperature Measurement Thermocouples
- C. American Society for Testing and Materials (ASTM):
  - 1. ASTM B3 Specification for Soft or Annealed Copper Wire

2. ASTM B8 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
  3. ASTM B33 Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
  4. ASTM B172 Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors
  5. ASTM B189 Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes
  6. ASTM D2671 Test Methods for Heat-Shrinkable Tubing for Electrical Use
  7. ASTM E662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials
- D. Insulated Cable Engineers Association, Inc. (ICEA):
1. ICEA S-84-608 Telecommunications Cable Filled, Polyolefin Insulated, Copper Conductor Technical Requirements
  2. ICEA T-28-562 Test Method for Measurement of Hot Creep of Polymeric Insulations
- E. Institute of Electrical and Electronics Engineers (IEEE):
1. IEEE 383 Standard for qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations
- F. Military Specifications (MIL):
1. MIL-C-915 General Specifications for Cable and Cord, Electrical, for Shipboard Use
- G. National Electrical Manufacturers Association (NEMA):
1. NEMA HP 100.2 High Temperature Instrumentation and Control Cables Insulated and Jacketed with ETFE Fluoropolymers
  2. NEMA WC70 Nonshielded Power Cable Rated 2000 Volts or Less for the Distribution of Electrical Energy
- H. National Fire Protection Association (NFPA):
1. NFPA 258 Standard Research Test Method for Determining Smoke Generation of Solid Materials
  2. NFPA 70 National Electrical Code (NEC)

- I. Rural Electrification Administration (REA):
  - 1. REA PE-210 Crystalline Propylene-Ethylene Copolymer Raw Material
  - 2. REA 345-67 Filled Telephone Cables
  
- J. Underwriters Laboratories Inc. (UL):
  - 1. UL 62 Flexible Cord and Fixture Wire
  - 2. UL 719 Nonmetallic-Sheathed Cables
  - 3. UL 1581 Electrical Wires, Cables, and Flexible Cords
  - 4. UL 1666 Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
  
- K. California Code of Regulations
  - 1. Title 24, Part 2 California Building Code
  - 2. Title 24, Part 3 California Electrical Code

**1.05 REGULATORY REQUIREMENTS**

- A. Refer to Section 20 70 26 - Common Materials and Methods for Electrical Systems, for requirements.

**1.06 SUBMITTALS**

- A. General: Refer to Section 01 33 00 - Submittal Procedures, and Section 01 33 23 - Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.
  
- B. Submittal Requirements: Before installation of wires and cables, submit the following information for each type and size of wire and cable:
  - 1. Manufacturer of wire and cable, and certificate of compliance;
  - 2. Number and size of strands composing each conductor;
  - 3. Conductor insulation composition type in accordance with California Electrical Code and thickness in mils;
  - 4. Average overall diameter of finished wire and cable;
  - 5. Minimum insulation resistance in megohms per 1000 feet at 30 degrees C ambient;
  - 6. Jacket composition and thickness in mils;
  - 7. Total number of conductors per cable;

8. Shield material (if any) and thickness;
9. Conductor resistance and reactance in ohms per 1000 feet at 25 degrees C ambient; and
10. Conductor ampacities at 30 degrees C ambient air temperature and a t20 degrees C ambient earth temperature, and 100 percent load factor for 600V wire and cable.

**1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.
- B. Store wire and cable in secure and dry storage facility.

**PART 2 - PRODUCTS**

**2.01 WIRE AND CABLE MARKINGS**

- A. Wire and cable markings shall be in accordance with applicable NEMA and California Electrical Code requirements. Each item shall be UL listed.

**2.02 600 VOLT SINGLE CONDUCTOR CABLE**

- A. Conductor Material: ICEA stranded or solid copper meeting requirements of ASTM B3, soft drawn.
- B. Conductor Type: Unless specified otherwise, conductor types shall be as follows:
  1. Size 12 AWG and Smaller: Solid conductor.
  2. Size 10 AWG and Larger: Class B stranded.
  3. Size 14 AWG to Size 1/0 AWG: California Electrical Code, Type THHN or THWN, polyvinyl chloride (PVC) thermoplastic insulated in accordance with NEMA WC70. Cable shall be jacketed with clear polyamide nylon over the insulation.
  4. Size 2/0 AWG and Larger: California Electrical Code, Type RHH, ethylene-propylene-rubber-insulated in accordance with NEMA WC70.
- C. Temperature Rating: Temperature ratings of all cables shall be not less than 75 degrees C.
- D. Fire-Retardant Properties: Power cables for emergency fans and related equipment and emergency lighting cables shall pass the flame propagating criteria of IEEE 383 and shall have a minimum circuit time of five minutes in the flame test of IEEE 383. Type test certificate is required with every shipment of cables.
- E. Low Smoke Low Halogen Properties: Cables used in train control rooms and tunnels shall have low smoke low halogen properties.
- F. Insulation Rating: 600 V.

**2.03 MULTIPLE CONDUCTOR CABLE**

- A. Provide multiple conductor cable conforming to NEMA WC70, approved for use in cable tray, with the following additional requirements:
  - 1. Number of Insulated Conductors: As indicated.
  - 2. Provide multiple conductor cable for all power applications, except receptacles when installed in cable tray for sizes up to 4/0 AWG, as indicated.
  - 3. Insulation: As specified above for single conductor cable.
  - 4. Overall Covering: Cable shall be jacketed over the insulation.
  - 5. Multiple conductor for control wire shall be minimum of 14 AWG stranded copper.
  - 6. Insulation Rating: 600 V.
- B. Multi-conductor cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form using fillers that are compatible with other materials in the cable. The jacket used shall fit tightly to form a firm assembly.

**2.04 FIXTURE WIRE**

- A. Provide fixture wire conforming to UL 62 and the following additional requirements:
  - 1. Type: SF-2 silicone rubber insulated.
  - 2. Conductor: Stranded copper conductor 16 AWG or larger as indicated.

**2.05 BARE CONDUCTOR**

- A. ASTM B3, Class B stranded, annealed soft-drawn copper conductor, unless otherwise indicated, size as indicated. Bare conductor shall be used for ground wire only.

**2.06 LOW-VOLTAGE CONTROL CIRCUIT WIRE:**

- A. Wires for low-voltage, 50 volts and below, control circuits shall be as follows:
  - 1. For HVAC and irrigation control systems: solid, copper.
  - 2. For fire protection systems: stranded, copper.
  - 3. For all other control systems: subject to District approval.

**2.07 THERMOCOUPLE CABLE**

- A. Provide thermocouple cable with solid conductors meeting requirements of ANSI MC96.1 and of type compatible with the thermocouple leads furnished with the motor or temperature sensor. Thermocouple cable shall have flame-retardant insulation, pair-assembled with left-hand lay, with flame-retardant outer jacket, with overall shield, and UL-listed as Type PLTC.

**2.08 COLOR CODING OF CONDUCTORS (600 V)**

- A. Individual conductors of multi-conductor cables shall be identified by means of solid colors, stripes, or printing, unless otherwise approved by the Engineer.
  - 1. Jacket Printing: Cables shall be identified by printing on the jacket or by a printed marker tape under the jacket. Information shall include, but not be limited to, the number of conductors, conductor size, voltage rating, name of manufacturer, manufacturer's type, and date of manufacture. This information shall appear at intervals of not more than 30 inches.
  - 2. Footage Marker Tape: Cables shall be provided with a footage marker tape under the jacket or by footage printing on the jacket.
  - 3. Multi-conductor Switch-and-Lock Movement Control and Indication Cable Color Coding: Colors shall be durable and recognizable. Color sequence shall be in accordance with NEMA WC70, Appendix K, Method 3 or 4.
  - 4. Two-Conductor Switch-and-Lock Movement: Color shall be black.
  - 5. Power Cables: Color-coding of conductors for power cables shall be in accordance with NEMA WC70, Appendix I, Method 1 as follows:

<u>Conductor</u>	<u>277/480 V</u>	<u>120/208 V</u>
Phase A	Brown	Black
Phase B	Orange	Red
Phase C	Yellow	Blue
Neutral	White	White
Ground	Green	Green

- B. Branch circuit phase conductors 10 AWG and smaller and all neutral and equipment grounding conductors shall be solid color insulation or solid color coating.
- C. Phase conductors having colored tracers shall have background color other than white or green.
- D. Solid color coatings and tracers shall have a strongly adherent paint or dye not injurious to the insulation and will not be obliterated by pulling into a conduit or raceway.
- E. On-site coloring of ends of conductor may be permitted by the Engineer upon receipt of satisfactory evidence that the Contractor is unable to order color coded wire and cable as specified. Provide certification from the cable manufacturer that the paint or dye proposed for field application is non-injurious to the insulation.

**2.09 CABLE SUPPORTS AND FASTENERS**

- A. Provide for use with channel inserts. Conform with California Electrical Code.

**2.10 CONDUCTOR BUNDLING STRAPS**

- A. Provide conductor bundling straps formed from self-extinguishing nylon having a temperature range of minus 40 degrees F to plus 185 degrees F.
- B. Equip each strap with a locking hub or head with a stainless steel locking barb on one end and a taper on the other end.
- C. Wire and cable ties for installation outdoors and in exposed locations shall be ultraviolet-resistant nylon material.

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

- A. Coordinate installation of wires and cables with the requirements of Section 20 70 26 -Common Materials and Methods for Electrical Systems, and Section 20 50 13 - Raceways for Facility Services.
- B. Provide wiring complete as indicated. Provide ample slack for field terminated wires and preformed cables with connections, including wires for motor loops, service connections, and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.
- C. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impractical and shorter radii are permitted by the California Electrical Code and NEMA WC70, Appendix N.
- D. Bundle cable and conductors neatly and securely with nylon straps located in branch circuit panelboards, cabinets, control boards, switchboards, and motor control centers. Use nylon bundling straps. Bundle power cables separately from control cables.
- E. Install motor feeders, service connections, and extensions in accordance with the referenced codes. Install motor feeder in liquid-tight flexible conduit of 18 inches minimum length at motor conduit box.
- F. For wire pulling, comply with the requirements of Section 20 70 26 - Common Materials and Methods for Electrical Systems, Section 20 50 13 - Raceways for Facility Services, and the following:
  - 1. Install wire and cable in conduit as indicated. Do not pull wires into conduit until conduits and outlets have been thoroughly cleaned and swabbed. Do not use block and tackle or other mechanical means for pulling conductors smaller than 2 AWG in raceways.
  - 2. Provide suitable installation equipment to prevent cutting and abrasion of conduits and wire during the pulling of feeders. Use lubricant and installation procedure as recommended by the cable manufacturer.

3. Pulling tension shall not exceed manufacturer's recommendations. For conduit runs with three bends, and cable sized larger than 2 AWG, provide the Engineer with cable pulling calculations prior to making the pull.
  4. Provide masking or other means to prevent obliteration of cable identifications when solid color coating or colored tracers are used.
  5. Multiple cables to be installed in a single conduit shall be pulled together.
- G. Power and Control Cable Installation in Manholes and Pull boxes: Cables shall be routed along the manhole or handhole walls providing the longest possible slack. Cables shall be formed closely parallel to the walls, shall not interfere with duct entrances, and shall be supported on brackets and cable insulators, spaced at a maximum of 4 feet. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, the existing locations of cables, cable supports, and grounding shall be modified as required to provide a properly arranged and supported installation.
- H. Refer to Section 20 70 26 - Common Materials and Methods for Electrical Systems, for other related requirements.

### **3.02 IDENTIFICATION**

- A. Provide nonmetallic fiberboard or plastic identification tags or pressure sensitive labels designed for fastening to cables, feeders, and power circuits in vaults, pull boxes, manholes, and switchboard rooms, and at all terminations of cable or wire.
- B. Stamp or print tags or labels to correspond with markings on the Contract Drawings, or mark so that feeder or cable may be readily identified.
- C. If suspended type identification tags are provided, attach the tags to slip-free plastic cable lacing units or to nylon bundling straps.
- D. Provide wire labels at both ends of all conductors terminated inside panels, pull boxes and hand holes. The wire labels shall be self-laminating, shrink type, wire marker labels which are resistant to oil, water and solvents. The wire identification shall include the identification indicated on the manufacturer's wiring diagram and/or the circuit number.

### **3.03 FIELD TESTING**

- A. Insulation Resistance Test: Insulation resistance test shall be measured on all cables between conductor to grounded shield and shield to ground. Cable manufacturers recommended method and values shall be applied.
  1. The test shall be made after cable installation, but before splicing or terminating.
  2. If the splicing or terminating is not performed immediately after cable installation, second insulation resistance test shall be made just before splicing or terminating.
  3. Each cable installation shall be tested after all splices and terminations are complete. No equipment shall be connected to the cable system during tests.

LOW VOLTAGE WIRES AND CABLES

- B. Cable Failure: If any field tests fail, the Contractor shall correct deficiency and retest. If the test fails again, the Contractor shall replace the entire cable segment at no additional cost to the District.

**END OF SECTION 26 05 24**