

SECTION 16120

WIRE, CABLE AND BUSWAYS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section specifies providing wire, cable and busways.
- B. Definitions:
 - 1. Cable: Cable having low smoke generating characteristics.
- C. Requirements for single-conductor cable and for multiple-conductor cable as stated except as otherwise specified.
- D. Related Work Specified Elsewhere:
 - 1. Grading, excavating and backfilling: Section 02320.
 - 2. Wire connection accessories: Section 16125.
 - 3. Raceways, boxes and cabinets: Section 16130.

1.02 QUALITY ASSURANCE:

- A. Qualifications: Select a manufacturer who is engaged in production of similar wire, cable and busways.
- B. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. National Electrical Code (NEC).
 - 3. Insulated Cable Engineers Association (ICEA): S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
 - 4. IEEE: 1202-1991 IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies, 383-1974 IEEE Standard for Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
 - 5. National Electrical Manufacturers Association (NEMA): BU1, WC70, WC71, WC74.
 - 6. American National Standards Institute (ANSI): *C37.20.1, Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear; C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear; C37.20.3, Metal-Enclosed Interrupter Switchgear; Z55.1, Gray Finishes for Industrial Apparatus and Equipment.*
 - 7. UL: 44, Rubber-Insulated Wires and Cables Thermoset-Insulated Wires and Cables; 62, Flexible Cord and Fixture Wire; 857, Electric Busways and Associated Fittings; and 1581, Standard for Electrical Wires, Cables, and Flexible Cords.
 - 8. American Standards of Testing and Materials (ASTM): B3-95, Standard Specification for Soft or Annealed Copper Wire; B8-99, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; D471-98e1, Standard Test Method for Rubber Property-Effect of Liquids, E662-97, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.
 - 9. ITS: Directory of ITS Listed Products
- C. Source Quality Control:
 - 1. Cable and busways: Listed or labeled per UL or ITS directory.

1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
 - 1. Shop Drawings.
 - 2. Samples:
 - a. Smoke-density test sample for jacket material: Specified sample will become property of the Authority.
 - 3. Certification:
 - a. Certified flame-retardancy test reports (VW-1, IEEE 383, and IEEE 1202, Article 18) and data for tests performed not more than 12 months prior to submittal, for materials which are identical to those of cable furnished. Include test reports with submittal of shop drawings.
 - b. Submit smoke-density test reports and data for tests performed on the jacket material not more than 12 months prior to the submittal, for materials which are identical to those of the furnished cable. Include test reports with submittal of shop drawings.
 - c. Certified test reports demonstrating that cable complies with specified requirements and those of referenced ICEA Standards. Submit test reports prior to cable shipments.
 - d. Certificates from manufacturers verifying that products conform to specified requirements. Include certificate with submittal of shop drawings and with each cable shipment.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each single-conductor cable, each multiple-conductor cable and each busway to show label per referenced UL or ITS directory, size, voltage, manufacturer and number of conductors or phases in accordance with NEC requirements.
- B. Ship each unit securely packaged and labeled for safe handling and shipment.
- C. Store products in a dry and secure facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

- A. General Requirements for Single-Conductor and Multiple-Conductor Cable:
 - 1. Type and size: As shown.
 - 2. Rated voltage: 600 volts.
 - 3. Conductors:
 - a. ASTM B3 or B8 annealed copper.
 - b. Size 10 AWG and smaller: Solid or Class B or Class C stranded.
 - c. Size 8 AWG and larger: Class B stranded.
 - 4. Standards: Except as modified, wires and cable complying with the following standards:
 - a. Cross-linked polyethylene (XLPE) insulated cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
 - b. Other cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
 - 5. Non-metallic jacket for single-conductor cable and an overall covering on multiple-conductor cable:
 - a. Chlorosulfonated polyethylene or cross-linked polyolefin.

- b. Cross-linked polyolefin complying with the following physical requirements. Properties tested in accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570 if ethylene-propylene-rubber (EPR) insulation is used, or with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.
 - 1) Tensile strength, minimum pounds per square inch: 1,800.
 - 2) Elongation at rupture, minimum percent: 150.
 - 3) Aging requirement: After 168 hours in air oven test at 100C, plus-or-minus one degree C:
 - a) Tensile strength, minimum percentage of unaged value: 100.
 - b) Elongation at rupture, minimum percentage of unaged value: 80.
 - 4) Oil immersion: 18 hours at 121C, plus-or-minus one degree C, ASTM D471, Table 1, No. 2 oil:
 - a) Tensile strength, minimum percentage of unaged value: 80.
 - b) Elongation at rupture, minimum percentage of unaged value: 80.
 - c. Jacket materials other than cross-linked polyolefin complying with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Jacket material free of PVC and PVC-based compounds.
6. Flame retardancy: Single-conductor and multiple-conductor cable tested by independent agency demonstrating flame retardancy in accordance with the following:
- a. Single-conductor cable and individual conductors of multiple-conductor cable passing vertical wire (VW-1) flame test in accordance with UL1581 or ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Cable size for testing: 14AWG.
 - b. Single-conductor cable, size 1/0 AWG and larger, passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202 or IEEE 383. Cable size for testing: 1/0 AWG.
 - c. Multiple conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 383 or IEEE 1202. Cable size for testing: 7/C or 9/C with No. 12 AWG or No. 14 AWG conductors.
7. Smoke generation: Single and multiple-conductor cable jacket materials demonstrating low-smoke generation when tested in accordance with ASTM E662 by independent, nationally recognized testing agency.
- a. Conduct tests on specimens of overall jacket material for multiple-conductor cable and of jacket material for single-conductor cable.
 - b. Prepare slab specimens for each material .100 inch, plus-or-minus .005-inch thick, identical to those of finished cables and meeting minimum physical requirements specified.
 - 1) Prior to testing, submit six-inch square portion of each specimen. Tag sample with manufacturer's jacket or insulation identification code or number.
 - c. Test values for chlorosulfonated polyethylene not to exceed the following:
 - 1) Flaming mode:
 - a) Uncorrected maximum specific optical density during first four minutes of test: 325.
 - b) Uncorrected maximum specific optical density for entire 20-minute test: 400.
 - 2) Nonflaming mode:
 - a) Uncorrected maximum specific optical density during first four minutes of test: 325.

- b) Uncorrected maximum specific optical density for entire 20-minute test: 480.
 - d. Test values for cross-linked polyolefin not to exceed the following:
 - 1) Flaming mode:
 - a) Uncorrected maximum specific optical density during first four minutes of test: 150.
 - b) Uncorrected maximum specific optical density for entire 20-minute test: 300.
 - 2) Nonflaming mode:
 - a) Uncorrected maximum specific optical density during first four minutes of test: 150.
 - b) Uncorrected maximum specific optical density for entire 20-minute test: 300.
8. Applied voltage testing:
 - a. Single-conductor cable and individual conductors of multiple-conductor cable to be given applied ac voltage dielectric-strength test, i.e., six-hour water-immersion test.
 - b. For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.
 - c. Test procedures:
 - 1) Polyethylene-insulated conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.
 - 2) Other conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570.
- B. Single-Conductor Cable:
- 1. Insulated with ethylene-propylene-rubber with non-metallic jacket as specified. UL-Labeled as Type RHW-2.
 - 2. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
- C. Multiple-Conductor Cable:
- 1. Individual conductors:
 - a. Number of conductors: As shown.
 - b. Construction: Complying with one of the following:
 - 1) Insulated with ethylene-propylene-rubber, with or without non-metallic jacket.
 - 2) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, without outer jacket.
 - 3) Insulated with filled cross-linked polyethylene without jacket.
 - c. Phase and neutral conductors: Individually insulated.
 - d. Neutral conductors: Same size as phase conductors.
 - e. Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.
 - f. UL Listed as Type RHW-2 or XHHW-2.
 - 2. Conductors assembled with nonwicking, flame-retardant filler to form cable of circular cross section.
 - 3. Metallic sheath:
 - a. Provide one of the following:
 - 1) Size 1 AWG and larger:
 - a) Interlocked aluminum-tape armor.
 - b) Continuous corrugated aluminum sheath conforming to ICEA S-19-81, Table 4-26A.
 - 2) Size 2 AWG and smaller: As specified for 1 AWG and larger or continuous smooth aluminum sheath conforming to ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

- b. Metallic covering not required for multiple-conductor TC cable with overall non-metallic jacket when installed in cable tray.
 - 4. Multiple-conductor cable provided with overall non-metallic jacket as specified.
 - 5. Cable UL-listed as follows:
 - a. Non-metallic-sheathed cable: Type TC, suitable for wet and dry locations.
 - b. Metallic-sheathed cable: Type MC, suitable for wet and dry locations.
 - 6. Color coding:
 - a. Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
 - b. Control cables: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.
- D. Fixture Wire: UL 62, with the following additional requirements:
 - 1. Type: SF-2 silicone-rubber insulated or as necessary to suit temperature rating of lighting fixture, minimum 90C.
 - 2. Conductor: Stranded copper conductor 16AWG or larger as shown.
- E. Bare Conductors: ASTM B3 or B8, annealed copper conductor; 8AWG and larger, Class B stranded, unless otherwise shown or specified.
- F. Busway (Busduct) and Fittings:
 - 1. UL 857, NEMA BU1.
 - 2. Totally enclosed, three-phase, four-wire feeder busway system, as shown, with necessary fittings, hanging devices, accessories and provision for flange bolting over circuit breaker.
 - 3. Continuous current rating:
 - a. Secondary tie duct for use in combined substation: Sized in accordance with ANSI C37.20.1, C37.20.2, C37.20.3, and NEC.
 - 4. Voltage rating: 480/277 volts.
 - 5. Busway system braced to withstand minimum short-circuit current of 75,000 amperes symmetrical, unless otherwise shown.
 - 6. Maximum allowable temperature rise in busway at continuous full load above maximum ambient temperature of 40C: 55C.
 - 7. Housing: Nonventilated, fabricated from galvanized sheet steel. Removable gasketed cover provided at transformer connection for maintenance and test. Hardware galvanized or cadmium-plated.
 - 8. Joints:
 - a. Single-bolt pressure joint designed for optimum electrical contact and mechanical strength.
 - b. To permit safe testing of its tightness without de-energizing systems.
 - c. To permit removal of duct sections without disturbing adjacent pieces.
 - d. To permit making up joint from one side when busway is installed against wall or ceiling.
 - 9. Busbars: Fabricated from 98-percent-conductivity copper and insulated over entire length except at joints and contact surface. Joints and contact surfaces tin-plated or silver-plated. Neutral bar same size as phase bar. Ground bar half size of phase bar.
 - 10. Entire busway system polarized.
 - 11. Expansion fittings provided where necessary.
 - 12. Flexible connections, braided or laminated, provided for connecting bus conductor to transformer terminals.
 - 13. Finish: Light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install type cable as specified.
- B. Install single-conductor cable in conduit, underfloor duct or wireway. Install UL Type TC multiple-conductor cable in cable trays only. Install UL Type MC multiple-conductor cable and ground cable on channel inserts, cable trays, racks, trench or trough using straps and fasteners as specified in Section 16130. Install UL Type MC multiple-conductor cable in conduit where shown or required. On walls or ceilings, fasten cable and bus duct directly to channel inserts, or use expansion-bolt anchors to attach to concrete and toggle bolts to attach to concrete masonry unit walls. Splice cable only when unavoidable.
- C. Install motor feeders, service connections and extensions in accordance with reference codes. Install motor feeder in 18-inch minimum length liquid-tight flexible conduit at motor conduit box.
- D. Use nylon straps to bundle and secure wire and cable located in panelboards, cabinets, switchboards, motor control centers and switchgear.
- E. Minimum bending radius 12 times outer diameter of cable. Where shown, use shorter bending radius as permitted by NEC, ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692, and cable manufacturer.
- F. To facilitate pulling cable, use listed per UL or ITS directory lubricant recommended by cable manufacturer.
- G. Use direct-burial cable only for stray current and cathodic protection.
- H. To install direct-burial cable, prepare trench of uniform width and free of sharp projections and rocks and place three-inch bed of sand. Do not pull cable directly into trench from stationary reel; unreel cable beside trench. Place cable on sand bed and backfill with three-inch deep sand cover. Fill remainder of trench with approved fill material and compact in accordance with Section 02320. Provide temporary supports in trench as necessary to prevent damage to insulation or jacket during installation.
- I. In damp and dusty indoor locations, tunnel areas, manholes and outdoor locations, seal cable at conduit termination using duct-sealing compound.
- J. Where shown or necessary, install cable-seal fitting specified in Section 16130 to prevent entry of water into electrical facilities. Where approved, use seal compound specified in Section 16130.

3.02 IDENTIFICATION:

- A. Identify cable terminations, feeders and power circuits using non-metallic fiberboard tags or plastic labels. Attach tags to cable with slip-free plastic lacing or nylon bundling straps. Use designation shown.

3.03 FIELD QUALITY CONTROL:

- A. Furnish equipment required to perform tests. Prior to insulation and high-potential tests, disconnect instruments and equipment which might be damaged during such tests. Conduct tests in presence of the Engineer.
- B. Submit test procedure for approval and perform approved tests including, but not limited to, the following:

1. Single-conductor cable and multiple-conductor cable:
 - a. Test continuity of cable conductors using ohmmeter.
 - b. Proof-test insulation resistance to ground and between insulated conductors for minimum of one minute using 1,000-volt megger. Insulation resistance: 200,000 ohms minimum.
 - c. When cable shows unsteady insulation resistance of less than 200,000 ohms, perform high-potential test at 80 percent of factory ac test voltage or as recommended by cable manufacturer.
 2. Busway:
 - a. Clean contact surfaces before making connections. For bolted connections, apply torque recommended by manufacturer.
 - b. Test resistance of busway connections. Resistance not to exceed value recommended by manufacturer.
 - c. Test insulation resistance to ground and between insulated busbars for minimum of one minute using 1,000-volt megger. Insulation resistance: One-megohm minimum. When busway shows insulation resistance of less than one-megohm minimum, perform high-potential test.
- C. Submit certified test reports.

END OF SECTION