SECTION 26 05 19

**LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**

**BASED ON DFD MASTER ELECTRICAL SPEC DATED 12/22/21**

This section has been written to cover most (but not all) situations that you will encounter. Depending on the requirements of your specific project, you may have to add material, delete items, or modify what is currently written. The Division of Facilities Development expects changes and comments from you.

**PART 1 - GENERAL**

**SCOPE**

The work under this section includes furnishing and installing required wiring and cabling systems including pulling, terminating and splicing. Included are the following topics:

PART 1 - GENERAL

 Scope

 Related Work

 References

 Submittals

 Project Conditions

PART 2 - PRODUCTS

 General

 Building Wire

 Service Entrance Conductors

 Variable Frequency Drive (VFD) Wire

 Aboveground Wire for Exterior Work

 Underground Wire for Exterior Work

 Emergency Circuits (2-hour rated)

 Wiring Connectors

PART 3 - EXECUTION

 General Wiring Methods

 Wiring Installation in Raceways

 Wiring Connections and Terminations

 Field Quality Control

 Wire Color

 Branch Circuits

 Emergency Circuits

 Construction Verification Items

**RELATED WORK**

Applicable provisions of Division 1 govern work under this Section.

Section 26 05 33 – Raceway and Boxes for Electrical Systems.

Section 26 05 53 – Identification for Electrical Systems.

Section 26 08 00 - Commissioning of Electrical.

Section 01 91 01 or 01 91 02 – Commissioning Process

**REFERENCES**

SPS 316- Electrical

**SUBMITTALS**

Submit product data: Provide for each cable assembly type.

Submit factory test reports: Indicate procedures and values obtained.

Submit shop drawings for modular wiring system including layout of distribution devices, branch circuit conduit and cables, circuiting arrangement, and outlet devices.

Submit manufacturer's installation instructions. Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.

**PROJECT CONDITIONS**

Verify that field measurements are as shown on Drawings.

Conductor sizes are based on copper.

Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required for project conditions.

Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

**PART 2 - PRODUCTS**

***The product specification includes options which are recognized by Underwriters Laboratories or a Nationally Recognized Testing Laboratory (NRTL) as identified by the United States Occupational Safety and Health Adminisration (OSHA), per OSHA Nationally Recognized Testing Laboratory Program. Certain options may not be appropriate for a particular project. Delete wiring options that do not apply to the project. Application information may be obtained by referring to the UL Electrical Construction Materials Index and to the National Electrical Code.***

***Other wire and cable types may be required for a particular project specification to accommodate high temperatures or other unusual applications. Add requirements as needed for the project.***

**GENERAL**

All wire shall be new, delivered to the site in unbroken cartons and shall be less than one year old out of manufacturer's stock.

All conductors shall be copper. Aluminum conductors size #1/0 and larger may be substituted for copper and used for phase and neutral conductors for transformer feeders, switchboard feeders, and panelboard feeders. All ground conductors shall be copper.

Aluminum conductors shall not be used for serving individual motors, chillers, VFD’s and motor controllers.

The following requirements shall be met when aluminum conductors are used:

Aluminum alloy conductors shall be compact stranded conductors of a recognized Aluminum Association 8000 Series aluminum alloy conductor material (AA-8000 series alloy).

It is the responsibility of the contractor to increase the size of the conduit, wire gutter, or enclosure, if necessary, to accommodate the aluminum conductors and meet allowable code requirements.

It is the responsibility of the contractor to increase the size of the aluminum conductor and associated termination lugs to match the ampacity of the copper conductor circuit shown on the Drawings.

The contractor shall submit a feeder schedule to the Engineer for all conductor substitutions indicating the aluminum conductor wire size and the conduit size. The contractor shall not begin the installation until written approval is granted by the Engineer.

All aluminum conductors shall terminate on a mechanical screw-type connector or mechanical compression-type connector. Connector shall be dual rated (AL7CU or AL9CU) and Listed by UL for use with aluminum and copper conductors, and sized to accept aluminum conductors of the required ampacity. When using compression-type connectors, the lugs shall be marked with wire size, die index, number and location of crimps and shall be suitably color-coded. Using a suitable stripping tool, remove insulation from the required length of the conductor. Wire brush the conductor and apply a Listed joint compound. Tighten or crimp the connection per the connector manufacturer’s recommendation. Wipe off any excess joint compound.

When terminating aluminum conductors to aluminum bus, prepare a mechanical screw-type or compression-type connection. Bolts shall be anodized alloy and conform to current ANSI and ASTM chemical and mechanical property limits. Nuts shall be aluminum alloy and conform to current ANSI standards. Washers shall be flat aluminum alloy, Type A plain, standard wide series conforming to current ANSI standards. Lubricate and tighten the hardware per manufacturer’s recommendations.

When terminating aluminum conductors to copper bus, prepare a mechanical screw-type or compression-type connection. Bolts shall be plated or galvanized medium carbon steel; heat treated, quenched and tempered equal to current ASTM standard or SAE grade 5. Nuts shall conform to current ANSI standards. Washers shall be steel, Type A plain, standard wide series conforming to current ANSI standards. Belleville conical spring washers shall be of hardened steel, cadmium plated or silicone bronze. Lubricate and tighten the hardware per manufacturer’s recommendations.

The final tightening torque shall be recorded for all aluminum conductor mechanical screw-type connections and provided in report form, in the completed O&M manuals.

The contractor shall perform an infrared survey of all aluminum conductor connections after the installation is complete and in normal service. Infrared surveys shall be performed during periods of maximum possible loading with at least 30% of rated load of the equipment being inspected. All connections with elevated temperatures shall be corrected by the contractor. The infrared survey results shall be provided in report form, in the completed O&M manuals.

**No copper-to-aluminum transitions permitted when splicing onto existing copper feeders.**

Insulation shall have a 600 volt rating.

All conductors shall be stranded.

Stranded conductors may only be terminated with UL OR ETL Listed type terminations or methods: e.g. stranded conductors may not be wrapped around a terminal screw but must be terminated with a crimp type device or must be terminated in an approved back wired method.

**BUILDING WIRE**

Description: Single conductor insulated wire 90 degree C.

Insulation: Type THHN/THWN-2, XHHW-2 insulation.

**SERVICE ENTRANCE CONDUCTORS**

Description: Single conductor or multi-conductor insulated wire. 90 degree C sized at the 75 degree C table.

Insulation: Type USE-2, XHHW-2 insulation for service entrance conductors routed from exterior source to exterior termination location.

Type XHHW-2 insulation for services entrance conductors routed from exterior source to interior termination location.

**VARIABLE FREQUENCY DRIVE (VFD) WIRE**

All power wiring from the VFD output to the motor shall be type XHHW-2 insulation, single conductor wire.

**ABOVEGROUND WIRE FOR EXTERIOR WORK**

Description: Single conductor insulated wire, 90 degree C.

Insulation: Type XHHW-2 insulation.

**UNDERGROUND WIRE FOR EXTERIOR WORK**

Description: Stranded single or multiple conductor insulated wire, 90 degree C.

Insulation: Type USE-2, XHHW-2, RHW-2 insulation.

This wiring shall be used in all underground feeder and branch circuit applications, except THHN/THWN-2 is permitted when run in a concrete-encased ductbank.

**EMERGENCY CIRCUITS (2-HOUR RATED)**

Description: Power cable assembly for fire pump circuits and emergency circuits requiring a minimum 2-hour rating.

Horizontal and Vertical Installations:

Insulation: Type MI mineral insulated cable installed as a listed electrical circuit protective system with a minimum 2-hour fire-resistive cable rating per Factory Mutual testing. UL 2196 and ULC-S139-00 approved.

Insulation: Type MC Two-Hour Fire Resistive Multi- Conductor Cables with listed connectors, splices and boxes, installed as a listed electrical circuit protective system with a minimum 2-hour fire-resistive cable rating per Factory Mutual testing. UL 2196 and Electrical Circuit Integrity System (FHIT) No 50 identified.

Horizontal Installations:

Insulation: Type RHW-2 or RW90 Two-Hour Horizontal, insulated cable installed as a listed electrical circuit protective system with a minimum 2-hour fire-resistive cable rating per Factory Mutual testing. UL 2196 and Electrical Circuit Integrity System (FHIT) No 25B identified.

Install and support cabling system per manufacturer’s requirements.

**WIRING CONNECTORS**

Split Bolt Connectors: Not acceptable.

Solderless Pressure Connectors: High copper alloy terminal. May be used only for cable termination to equipment terminals. Not approved for splicing.

Twist Type Wire Connectors: Solderless twist type spring connector (wire-nut) with insulating cover for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller. The manufacturer’s wire fill capacity must be followed. Use Silicone filled twist type spring connectors in all wet location areas.

Mechanical Spring Actuation Connectors: Toolless type spring actuation connector (push-in) with spacers for copper wire splices and taps. Use for conductor sizes 12 AWG and smaller. The manufacturer’s wire fill capacity must be followed. Use in interior, dry locations only.

All wire connectors used in underground or exterior pull boxes or hand holes shall be gel filled twist connectors or a connector designed for damp and wet locations. Gel filled twist type connectors can be used for copper conductor sizes 6 AWG and smaller for site lighting applications. The manufacturer’s wire fill capacity must be followed.

Mechanical Connectors: Bolted type tin-plated; high conductivity copper alloy; spacer between conductors; beveled cable entrances.

Compression (crimp) Connectors: Long barrel; seamless, tin-plated electrolytic copper tubing; internally beveled barrel ends. Connector shall be clearly marked with the wire size and type and proper number and location of crimps. Connector must be installed with a crimper tool listed for use with the manufacturer and type of compression connector.

Insulation Piercing Connectors: Molded insulated body, copper teeth, wrench tightened, UL 486B Listed. May be used only for connection of a tap conductor in run and tap type applications when main conductor is 8 AWG and larger.

**PART 3 - EXECUTION**

**GENERAL WIRING METHODS**

All wire and cable shall be installed in conduit.

Do not use wire smaller than 12 AWG for power and lighting circuits.

All phase, neutral and ground conductors shall be sized to prevent excessive voltage drop at rated circuit ampacity. As a minimum use 10 AWG conductors for 20 ampere, 120 volt branch circuit home runs longer than 100 feet (30 m), and for 20 ampere, 277 volt branch circuit home runs longer than 200 feet (61 m).

Ground conductor size shall be increased per NEC 250.122(B) when phase and phase/neutral conductors are increased in size.

Make conductor lengths for parallel conductors equal.

Splice only in junction or outlet boxes.

No conductor less than 10 AWG shall be installed in exterior underground conduit.

Identify ALL low voltage wire, 600V and lower, per section 26 05 53.

Neatly train and lace wiring inside boxes, equipment, and panelboards.

**WIRING INSTALLATION IN RACEWAYS**

Pull all conductors into a raceway at the same time. Use Listed water or silicone based wire pulling lubricant for pulling 4 AWG and larger wires and for other conditions when necessary. Wax based lubricants are not allowed. Pulling lubricant is not required for low friction type products where the cable manufacturer recommends that cables be pulled without lube.

Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

Completely and thoroughly swab raceway system before installing conductors.

Place all conductors of a given circuit (this includes phase wires, neutral (if any), and ground conductor) in the same raceway. If parallel phase and/or neutral wires are used, then place an equal number of phase and neutral conductors in same raceway or cable.

Manufacturers maximum pulling tensions shall be not be exceeded and individual pulls shall not exceed 270 degrees.

VFD Installations: Install VFD input wiring and output wiring in separate conduit systems. Do not mix VFD input power and output power, or control wiring in a common raceway.

In high ambient spaces, mechanical rooms, utility rooms and exterior exposed conduit, 90 degree C, XHHW-2 conductors shall be utilized.

**WIRING CONNECTIONS AND TERMINATIONS**

Splice only in accessible junction boxes.

Wire splices and taps shall be made firm, and adequate to carry the full current rating of the respective wire without soldering and without perceptible temperature rise.

All splices shall be so made that they have an electrical resistance not in excess of two feet (600 mm) of the conductor.

Use solderless twist type spring connectors (wire nuts) with insulating covers for copper wire splices and taps, 10 AWG and smaller or toolless type actuation connectors (push-in) with spacers for copper wire splices and taps, 12 AWG and smaller. Use mechanical or compression connectors for wire splices and taps, 8 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of the wiring.

Thoroughly clean wires before installing lugs and connectors.

At all splices and terminations, leave tails long enough to cut splice out and completely re-splice.

**FIELD QUALITY CONTROL**

Field inspection and testing will be performed under provisions of Section 26 05 04.

Additional testing as follows shall be performed if aluminum conductors are used:

Feeders terminated with aluminum conductors shall be tested with a thermal imager and recorded.

Conductors shall be closely checked for loose or poor connections, and for signs of overheating or corrosion.

Test procedures shall meet NETA guidelines.

Test results and report shall be provided to the engineer and included in O&M manual under AL conductors/ tests.

Contractor shall correct all deficiencies reported in the test report.

**WIRE COLOR**

General:

Solid colored insulation is required for all THHN/THWN-2 wire. For other wire types use colored wire or identify wire with colored tape at all terminals, splices and boxes. Wire shall be colored as indicated below.

In existing facilities, use existing color scheme.

In new facilities, use black and red for single phase circuits at 120/240 volts, use Phase A black, Phase B red and Phase C blue for circuits at 120/208 volts single or three phase, and use Phase A brown, Phase B orange and Phase C yellow for circuits at 277/480 volts single or three phase. Note: This includes fixture whips except for Listed whips mounted by the fixture manufacturer on the fixture and Listed as a System.

Switch legs shall be the same color as their associated circuit, except for the second switch leg used for dual-level switching. The second switch leg shall be the next phase color, e.g. if the first switch leg is brown (277/480V phase A), the second switch leg shall be orange (277/480V phase B).

Traveler conductors run between 3 and 4 way switches shall be colored pink or purple.

Neutral Conductors: White for 120/208V and 120/240V systems, Gray for 277/480V systems. Where there are two or more neutrals in one conduit, each shall be individually identified with a different stripe.

Branch Circuit Conductors: Three or four wire home runs shall have each phase uniquely color coded.

Feeder Circuit Conductors: Each phase shall be uniquely color coded.

Ground Conductors: Green colored insulation for THHN/THWN-2 wire. For other wire types use green colored wire or identify wire with green tape at both ends and at all access points, such as panelboards, motor starters, disconnects and junction boxes. When isolated grounds are required, contractor shall provide green with yellow tracer.

**BRANCH CIRCUITS**

The use of single-phase, multi-wire branch circuits with a common neutral is not permitted. All single-phase branch circuits shall be furnished and installed with an individual accompanying neutral, sized the same as the phase conductors.

**EMERGENCY CIRCUITS**

All Emergency, Legally Required Standby and Optional Standby system wiring shall be installed in separate raceways after their associated transfer switches. The wiring shall be separate from each other and from all normal system wiring.

All emergency wiring serving fire pumps, requiring minimum 2 hour fire rating shall comply with NEC 695.6(B).

All emergency wiring serving NEC 700 loads, requiring minimum 2 hour fire rating shall comply with NEC 700.10(D)(1).

All generator control conductors installed between transfer equipment and the emergency generator serving Emergency, Legally Required Standby and Optional Standby systems shall be kept entirely independent of all other wiring. This shall require a dedicated conduit system between each transfer switch and the emergency generator. If a Fire Pump is served off the emergency generator, a separate conduit shall be provided between fire pump controller and generator.

**CONSTRUCTION VERIFICATION**

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

END OF SECTION