SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

Revise this Section by deleting and inserting text to meet Project-specific requirements.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

See "Sustainable Design Considerations" Article in the Evaluations for a discussion of sustainable design requirements that may impact editing of this Section.

1. GENERAL
   * + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
      1. SUMMARY
         1. Section Includes:

Copper building wire.

Aluminum building wire.

Metal-clad cable, Type MC.

Armored cable, Type AC.

Photovoltaic cable, Type PV.

Mineral-insulated cable, Type MI.

Tray cable, Type TC.

Fire-alarm wire and cable.

Connectors and splices.

* + - 1. DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

* + - * 1. PV: Photovoltaic.
        2. RoHS: Restriction of Hazardous Substances.
        3. VFC: Variable-frequency controller.
      1. SUBMITTALS
         1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
         2. Manufacturer’s installation instructions shall be provided along with product data.
         3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
         4. Product Data: For each type of product.
         5. Product Schedule: Indicate type, use, location, and termination locations.
         6. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
         7. Qualification Data: For [**testing agency**] [**manufacturer's authorized service representative**].

Retain "Field quality-control reports" paragraph below if Contractor is responsible for field quality-control testing and inspecting.

* + - * 1. Field quality-control reports.
      1. QUALITY ASSURANCE

Retain "Testing Agency Qualifications" Paragraphparagraph below if Contractor selects testing agency or if Contractor is required to provide services of a qualified testing agency in "Field Quality Control" Article. Qualification requirements are in addition to those specified in Section 014000 "Quality Requirements."

* + - * 1. Testing Agency Qualifications: Member company of NETA.

Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

* + - * 1. Qualifications: The persons performing the Work of this Section and their supervisor shall be personally experienced in electrical work and shall have been regularly performing such work for a minimum of 3 years.
        2. UL Listing: Equipment and materials for which Underwriters’ Laboratories, Inc. (UL) provides product listing service shall be listed and bear the listing mark.
        3. Underwriter’s Certificate: A New York Board of Fire Underwriters inspection or certificate is not required.
        4. Equipment Qualifications For Products Other Than Those Specified:

At the time of submission provide written notice to the Director of the intent to propose an “or equal” for products other than those specified. Make the “or equal” submission in a timely manner to allow the Director sufficient time to review the proposed product, perform inspections and witness test demonstrations.

If products other than those specified are proposed for use furnish the name, address, and telephone numbers of at least 5 comparable installations that can prove the proposed products have performed satisfactorily for 3 years. Certify in writing that the Director’s Representative owners of the 5 comparable installations will allow inspection of their installation by the Director's Representative and the Company Field Advisor.

Make arrangements with the Director’s Representative owners of 2 installations (selected by the Director) for inspection of the installations by the Director's Representative. Also obtain the services of the Company Field Advisor for the proposed products to be present. Notify the Director a minimum of 3 weeks prior to the availability of the installations for the inspection, and provide at least one alternative date for each inspection.

Only references from the actual Director’s Representative owner or Director’s Representative owner’s representative (Security Supervisor, Maintenance Supervisor, etc.) will be accepted. References from dealers, system installers or others, who are not the actual Director’s Representative owners of the proposed products, are not acceptable.

Verify the accuracy of all references submitted prior to submission and certify in writing that the accuracy of the information has been confirmed.

The product manufacturer shall have test facilities available that can demonstrate that the proposed products meet the contract requirements.

Make arrangements with the test facility for the Director's Representative to witness test demonstrations. Also obtain the services of the Company Field Advisor for the proposed product to be present at the test facility. Notify the Director a minimum of 3 weeks prior to the availability of the test facility, and provide at least one alternative date for the testing.

Provide written certification from the manufacturer that the proposed products are compatible for use with all other equipment proposed for use for this system and meet all contract requirements.

Edit number of hours to suit.

* + - * 1. Company Field Advisor: Secure the services of the cable manufacturer’s Company Field Advisor for a minimum of 4 working hours at the contract site for the following:

Witness installation of at least one splice and termination by each person who will be doing the actual cable splice and termination.

Certify with an affidavit that the aforementioned particulars are satisfactory and the cable is installed in accordance with cable manufacturer’s recommendations.

1. PRODUCTS
   * + 1. DATE OF MANUFACTURER:

Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications. For definitions of terms and requirements for Contractor’s product selection, see Section 016000 “Product Requirements.” No conductor more than one year old when delivered to the site will be acceptable.

* + - 1. COPPER BUILDING WIRE

Retain this article to specify allowable types of copper building wire. Separate articles are included in the Specification for aluminum building wire, Type AC cable (copper and aluminum), Type MC cable (copper and aluminum), and Type PV cable.

* + - * 1. Description: Flexible, insulated, and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
        2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Cerro Wire LLC.

General Cable Technologies Corporation.

Southwire Company.

Or equal.

* + - * 1. Standards:

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

RoHS compliant.

See the Evaluations for discussion of UL's "Wire and Cable Marking and Application Guide."

Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

First option in "Conductors" Paragraphparagraph below is standard for most conductors. Second option is specific to Type TC-ER cables or larger conductors requiring compact stranding.

* + - * 1. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with [**ASTM B8**] [**ASTM B496**] for stranded conductors.

Common insulation types are described below; however, numerous other insulation types and flame-resistance options are available. Coordinate with Drawings.

* + - * 1. Conductor Insulation:

Type NM: Comply with UL 83 and UL 719.

[**Type RHH**] [**and**] [**Type RHW-2**]: Comply with UL 44.

[**Type USE-2**] [**and**] [**Type SE**]: Comply with UL 854.

Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.

[**Type THHN**] [**and**] [**Type THWN-2**]: Comply with UL 83.

[**Type THW**] [**and**] [**Type THW-2**]: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.

Type UF: Comply with UL 83 and UL 493.

Type XHHW-2: Comply with UL 44.

<**Insert Type and standard**>.

* + - * 1. Shield:

Retain one shield option in "Type TC-ER" Subparagraphsubparagraph below. This cable is commonly used for VFCs, but it is also approved for other uses.

Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, [**spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire**] [**dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires**], and sunlight- and oil-resistant outer PVC jacket.

* + - 1. ALUMINUM BUILDING WIRE

Retain this article to specify allowable types of aluminum building wire. Separate articles are included in the Specification for copper building wire, Type AC cable (copper and aluminum), Type MC cable (copper and aluminum), and Type PV cable. If retaining multiple types of conductor or cable, indicate where used on Drawings.

* + - * 1. Description: Flexible, insulated, and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
        2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Cerro Wire LLC.

General Cable Technologies Corporation.

Southwire Company.

Or equal.

* + - * 1. Standards:

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

RoHS compliant.

See the Evaluations for discussion of UL's "Wire and Cable Marking and Application Guide."

Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

* + - * 1. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.

Common insulation types are described below; however, numerous other insulation types and flame-resistance options are available. Coordinate with Drawings.

RHW-2: Insulation rated 600 V conforming to UL requirements for type RHW-2 insulation (90 degrees C wet or dry).

XHHW-2: Moisture and heat resistant cross-linked polyethylene insulation rated 600 V conforming to UL requirements for type XHHW-2 insulation (90 degrees C wet or dry).

USE-2: Dual rated heat and moisture resistant insulation rated 600 V with jacket or dual purpose insulation/protective covering conforming to UL requirements for type USE-2 service entrance cables.

* + - * 1. Conductor Insulation:

Type NM: Comply with UL 83 and UL 719.

[**Type RHH**] [**and**] [**Type RHW-2**]: Comply with UL 44.

[**Type USE-2**] [**and**] [**Type SE**]: Comply with UL 854.

Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.

[**Type THHN**] [**and**] [**Type THWN-2**]: Comply with UL 83.

[**Type THW**] [**and**] [**Type THW-2**]: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.

Type XHHW-2: Comply with UL 44.

<**Insert Type and standard**>.

MC: Insulated conductors with flexible metal armor conforming to UL requirements for type MC metal-clad, having:

MC: Insulated conductors with flexible metal armor conforming to UL requirements for type MC metal-clad, having:

Aluminum armor strip formed into interlocking armor sheath.

Aluminum conductors insulated with phase identified XHHW-2 insulation rated 600 V conforming to UL requirements for type XHHW-2 insulation (90 degrees C).

Internal full size ground conductor.

Connectors for MC cable; Arlington Industries Inc.’s Saddle Grip, Electroline Mfg. Co.’s L-67, L17, L-18, L-19, ETP Div. of Burger Industries Inc.’s AMC, or Thomas & Betts Co.’s Tite-Bite. Anti-short bushings; Electroline Mfg. Co.’s AS.

Retain one shield option in "Type TC-ER" subparagraph below. This cable is commonly used for VFCs, but it is also approved for other uses.

* + - 1. METAL-CLAD CABLE, TYPE MC

If retaining multiple types of conductor or cable, indicate where used on Drawings.

* + - * 1. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
        2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Atkore International (AFC Cable Systems).

General Cable Technologies Corporation.

Southwire Company.

Or equsl.

* + - * 1. Standards:

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

Comply with UL 1569.

Not all Type MC cable will comply with RoHS requirements, such as some types with galvanized-steel armor. Consult manufacturer.

RoHS compliant.

See the Evaluations for discussion of UL's "Wire and Cable Marking and Application Guide."

Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

* + - * 1. Circuits:

Retain first option in first subparagraph below for single-circuit Type MC cable. Retain second option to allow multiple circuits per cable. If retaining both options, indicate where used on Drawings.

[**Single circuit**] [**and**] [**multicircuit with color-coded conductors**].

Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

* + - * 1. Conductors: [**Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors**] [**Aluminum, complying with ASTM B800 and ASTM B801**].
        2. Ground Conductor: [**Bare**] [**Insulated**] [**None**].
        3. Conductor Insulation:

Type TFN/THHN/THWN-2: Comply with UL 83.

Type XHHW-2: Comply with UL 44.

<**Insert Type and standard**>.

* + - * 1. Armor: [**Steel**] [**Aluminum**], interlocked.
        2. Jacket: PVC applied over armor.
      1. ARMORED CABLE, TYPE AC

If retaining multiple types of conductor or cable, indicate where used on Drawings.

* + - * 1. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in an overall metallic sheath.
        2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Cerro Wire LLC.

General Cable Technologies Corporation.

Southwire Company.

Or equal.

* + - * 1. Standards:

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

Not all Type AC cable will comply with RoHS requirements, such as some types with galvanized-steel armor. Consult manufacturer.

RoHS compliant.

Comply with UL 4.

See the Evaluations for discussion of UL's "Wire and Cable Marking and Application Guide."

Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

* + - * 1. Circuits:

Retain first option in first subparagraph below for single-circuit Type AC cable. Retain second option to allow multiple circuits per cable. If retaining both options, indicate where used on Drawings.

[**Single circuit**] [**and**] [**multicircuit with color-coded conductors**].

Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

* + - * 1. Conductors: [**Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors**] [**Aluminum, complying with ASTM B800 and ASTM B801**].
        2. Ground Conductor: [**Bare**] [**Insulated**] [**None**].
        3. Conductor Insulation: Type THHN/THWN-2. Comply with UL 83.
        4. Armor: [**Steel**] [**Aluminum**], interlocked.
      1. PHOTOVOLTAIC CABLE, TYPE PV
         1. Description: Flexible, insulated, and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated [**2000**] [**600**] V.
         2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

General Cable; General Cable Corporation.

Service Wire Co.

Southwire Company.

Or equal.

* + - * 1. Standards:

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

RoHS compliant.

See the Evaluations for discussion of UL's "Wire and Cable Marking and Application Guide."

Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

* + - * 1. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
        2. Conductor Insulation: Comply with UL 44 and UL 4703.
      1. MINERAL-INSULATED CABLE, TYPE MI

Retain this article to specify a Type MI cable for power with a 2-hour fire rating. See the Evaluations for a discussion of Type MI cable and for information on manufacturers who offer Type MI cable.

* + - * 1. Description: Solid copper conductors encased in compressed metal oxide with an outer metallic sheath, rated 600 V or less.
        2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

nVent (PYROTENAX).

Pentair.

Watlow Electric Manufacturing Company.

Or equal.

* + - * 1. Standards:

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

UL 2196 for fire resistance.

See the Evaluations for discussion of UL's "Wire and Cable Marking and Application Guide."

Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

* + - * 1. Conductors: Copper, complying with ASTM B3 for bare annealed copper.

Magnesium oxide insulation is standard for most Type MI power conductors; however, other materials are available. Consult manufacturer.

* + - * 1. Insulation: [**Compressed magnesium oxide**] <**Insert material**>.

Copper sheaths are standard for most Type MI power conductors; however, other metals may be available. Consult manufacturer.

* + - * 1. Sheath: [**Copper**] <**Insert material**>.
      1. TRAY CABLE, TYPE TC

If retaining multiple types of conductor or cable, indicate where used on Drawings.

* + - * 1. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in a nonmetallic jacket.
        2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

General Cable Technologies Corporation.

Service Wire Co.

Southwire Company.

Or equal.

* + - * 1. Standards:

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

Not all Type TC cable may comply with RoHS requirements. Consult manufacturer.

RoHS compliant.

Comply with UL 1277.

Comply with ICEA S-73-532/NEMA WC 57 for Type TC cables used for control, thermocouple extension, and instrumentation.

Comply with ICEA S-95-658/NEMA WC 70 for Type TC cables used for power distribution.

See the Evaluations for discussion of UL's "Wire and Cable Marking and Application Guide."

Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

* + - * 1. Conductors: [**Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors**] [**Aluminum, complying with ASTM B800 and ASTM B801**].
        2. Ground Conductor: [**Bare**] [**Insulated**] [**None**].
        3. Conductor Insulation: Type XHHW-2. Comply with UL 44.
        4. Shield: [**None**] [**Metallic**].
      1. CONNECTORS AND SPLICES
         1. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
         2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

3M Electrical Products.

Appleton - O-Z/Gedney; Emerson Electric Co., Automation Solutions.

Ideal Industries, Inc.

Or equal.

* + - * 1. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
        2. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

Material: [**Copper**] [**Aluminum**] [**Bronze**].

Type: [**One**] [**Two**] hole with [**standard**] [**long**] barrels.

Termination: [**Compression**] [**Crimp**].

1. EXECUTION
   * + 1. CONDUCTOR MATERIAL APPLICATIONS

This article provides examples of material requirements for conductors and cables. Revise to retain requirements for the various types of wire and cable in this Section. Add other applications and materials if required, revise application and materials to suit Project conditions, authorities having jurisdiction, and practice.

* + - * 1. Feeders:

Retain one of two subparagraphs below.

Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

* + - * 1. Branch Circuits:

Retain one of two subparagraphs below.

Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

* + - * 1. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.
        2. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.
        3. PV Circuits: [**Copper**] [**Aluminum**]. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
      1. CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

This article provides examples of application requirements for conductors and cables. Revise to retain wiring methods for various environments in Project. Add other methods if required. Revise conductor insulation and cable type designations to suit Project conditions, authorities having jurisdiction, and practice. See NFPA 70 and UL's "Wire and Cable Marking and Application Guide" for additional application information about conductor sizes, insulation temperature ratings in cables, and product-use classifications and restrictions.

See the Evaluations for use of Type MI cable as service entrance conductor inside a building.

* + - * 1. Service Entrance: [**Type THHN/THWN-2, single conductors in raceway**] [**Type XHHW-2, single conductors in raceway**] [**Type USE, single conductor in raceway**] [**Mineral-insulated, metal-sheathed cable, Type MI**] [**Multiconductor cable, Type SE**].
        2. Exposed Feeders: [**Type THHN/THWN-2, single conductors in raceway**] [**Type XHHW-2, single conductors in raceway**] [**Armored cable, Type AC**] [**Metal-clad cable, Type MC**] [**Mineral-insulated, metal-sheathed cable, Type MI**] [**Nonmetallic-sheathed cable, Type NM**].
        3. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: [**Type THHN/THWN-2, single conductors in raceway**] [**Armored cable, Type AC**] [**Metal-clad cable, Type MC**] [**Mineral-insulated, metal-sheathed cable, Type MI**] [**Nonmetallic-sheathed cable, Type NM**].

Coordinate "Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground" Paragraphparagraph below with Section 260543 "Underground Ducts and Raceways for Electrical Systems."

* + - * 1. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: [**Type THHN/THWN-2, single conductors in raceway**] [**Type XHHW-2, single conductors in raceway**] [**Underground feeder cable, Type UF**].
        2. Feeders Installed below Raised Flooring: [**Type THHN/THWN-2, single conductors in raceway**] [**Armored cable, Type AC**] [**Metal-clad cable, Type MC**] [**Mineral-insulated, metal-sheathed cable, Type MI**].
        3. Feeders in Cable Tray: [**Type THHN/THWN-2, single conductors in raceway**] [**Type XHHW-2, single conductors larger than No. 1/0 AWG**] [**Armored cable, Type AC**] [**Metal-clad cable, Type MC**] [**Mineral-insulated, metal-sheathed cable, Type MI**] [**Nonmetallic-sheathed cable, Type NM**].

NFPA 70 restricts use of exposed Type NM cable in some types of construction. See NFPA 70, Article 334, for complete listing of restrictions.

* + - * 1. Exposed Branch Circuits, Including in Crawlspaces: [**Type THHN/THWN-2, single conductors in raceway**] [**Armored cable, Type AC**] [**Metal-clad cable, Type MC**] [**Mineral-insulated, metal-sheathed cable, Type MI**] [**Nonmetallic-sheathed cable, Type NM**].
        2. Branch Circuits Concealed in Ceilings, Walls, and Partitions: [**Type THHN/THWN-2, single conductors in raceway**] [**Armored cable, Type AC**] [**Metal-clad cable, Type MC**] [**Mineral-insulated, metal-sheathed cable, Type MI**] [**Nonmetallic-sheathed cable, Type NM**].

Coordinate "Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground" Paragraphparagraph below with Section 260543 "Underground Ducts and Raceways for Electrical Systems."

* + - * 1. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: [**Type THHN/THWN-2, single conductors in raceway**] [**Type XHHW-2, single conductors in raceway**] [**Underground branch-circuit cable, Type UF**].
        2. Branch Circuits Installed below Raised Flooring: [**Type THHN/THWN-2, single conductors in raceway**] [**Armored cable, Type AC**] [**Metal-clad cable, Type MC**] [**Mineral-insulated, metal-sheathed cable, Type MI**].
        3. Branch Circuits in Cable Tray: [**Type THHN/THWN-2, single conductors in raceway**] [**Type XHHW-2, single conductors larger than No. 1/0 AWG**] [**Armored cable, Type AC**] [**Metal-clad cable, Type MC**] [**Mineral-insulated, metal-sheathed cable, Type MI**] [**Nonmetallic-sheathed cable, Type NM**].
        4. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.

Retain one shield option with Type TC-ER cable in "VFC Output Circuits" Paragraphparagraph below.

* + - * 1. VFC Output Circuits: [**Type XHHW-2 in metal conduit**] [**Type TC-ER cable with braided shield**] [**Type TC-ER cable with dual tape shield**].

Retain "PV Circuits, Type USE-2" or "PV Circuits, Type PV" Paragraphparagraph below.

* + - * 1. PV Circuits, Type USE-2: For PV source circuits rated at 600 V or less.
        2. PV Circuits, Type PV: For PV source circuits rated at [**600**] [**1000**] [**2000**] V.
      1. INSTALLATION, GENERAL
         1. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
         2. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
         3. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
         4. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
      2. INSTALLATION OF FIRE-ALARM WIRE AND CABLE
         1. Comply with NECA 1 and NFPA 72.

Retain "Wiring Method" Paragraphparagraph below if wiring methods for system are not indicated on Drawings.

Install plenum cable in environmental airspaces, including plenum ceilings.

Fire-alarm circuits and equipment control wiring associated with fire-alarm system shall be installed in a dedicated pathway system.

Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.

Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is [**not**] permitted.

Signaling Line Circuits: Power-limited fire-alarm cables [**may**] [**shall not**] be installed in the same cable or pathway as signaling line circuits.

* + - * 1. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
        2. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.
        3. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.

For Class A circuits, provide separate conduits or cable for outgoing and return conductors; coordinate with Drawings. Retain "Risers" Paragraphparagraph below if required.

* + - * 1. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.

Retain "Wiring to Remote Alarm Transmitting Device" Paragraphparagraph below if system is monitored by remote central station or for remodeling and alteration projects where fire-alarm system exists and new connections are made to central-station transmitter. Supervised circuits are required for alarm and supervisory functions.

* + - * 1. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the fire-alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.
      1. CONNECTIONS
         1. 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-486B.
         2. Make splices, terminations, and taps that are compatible with conductor material[**and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors**].

Retain subparagraph below if aluminum conductors are specified.

Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

* + - * 1. Wiring at Outlets: Install conductor at each outlet, with at least [**6 inches (150 mm)**] [**12 inches (300 mm)**] of slack.
      1. IDENTIFICATION
         1. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
         2. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.
      2. SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS
         1. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
      3. FIRESTOPPING
      4. FIELD QUALITY CONTROL
         1. Administrant for Tests and Inspections:

Retain one of first four subparagraphs below to specify who administers and performs tests and inspections.

OwnerDirector’s Representative will engage qualified testing agency to administer and perform tests and inspections.

Engage qualified testing agency to administer and perform tests and inspections.

Engage factory-authorized service representativeCompany Service Advisor to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

Administer and perform tests and inspections [**with assistance of Company Service Advisorfactory-authorized service representative**].

* + - * 1. Tests and Inspections:

Performing NETA ATS tests on all conductors and cables can be expensive. Consider limiting testing to a certain group of conductors, such as service entrance and feeder conductors, or to those conductors feeding critical equipment and services.

Retain one of first two subparagraphs below. Retain first subparagraph if only service entrance and feeder conductors need to be tested. Retain second subparagraph to test conductors feeding critical equipment specified.

After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.

After installing conductors and cables and before electrical circuitry has been energized, test [**service entrance and feeder conductors**] [**and**] [**conductors**] feeding the following critical equipment and services for compliance with requirements:

<**Insert, in separate subparagraphs, critical equipment and services to be tested**>.

Perform each of the following visual and electrical tests:

Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.

Test bolted connections for high resistance using one of the following:

A low-resistance ohmmeter.

Calibrated torque wrench.

Thermographic survey.

Inspect compression-applied connectors for correct cable match and indentation.

Inspect for correct identification.

Inspect cable jacket and condition.

Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.

Continuity test on each conductor and cable.

Uniform resistance of parallel conductors.

Consider the cost and benefit of infrared scanning of cable and conductor splices before retaining "Initial Infrared Scanning" Subparagraphsubparagraph below.

Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

Retain "Follow-up Infrared Scanning" Subparagraphsubparagraph below, unless Owner will do follow-up scanning or if Project does not warrant such scanning.

Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

* + - * 1. Cables will be considered defective if they do not pass tests and inspections.
        2. Prepare test and inspection reports to record the following:

Procedures used.

Results that comply with requirements.

Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519