

SECTION 26 05 05 CONDUCTORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
 - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. B3, Standard Specification for Soft or Annealed Copper Wire.
 - c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - d. B496, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
2. Insulated Cable Engineer's Association, Inc. (ICEA):
 - a. S-58-679, Standard for Control Cable Conductor Identification.
 - b. S-73-532, Standard for Control Thermocouple Extensions and Instrumentation Cables.
 - c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
3. National Electrical Manufacturers' Association (NEMA):
 - a. CC 1, Electric Power Connectors for Substations.
 - b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
 - c. WC 70, Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
4. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
5. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
6. UL:
 - a. 13, Standard for Safety for Power-Limited Circuit Cables.
 - b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
 - c. 62, Standard for Safety for Flexible Cord and Cables.
 - d. 486A-486B, Standard for Safety for Wire Connectors.
 - e. 486C, Standard for Safety for Splicing Wire Connectors.
 - f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
 - g. 854, Standard for Safety for Service-Entrance Cables.

- h. 1072, Standard for Safety for Medium-Voltage Power Cables.
- i. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
- j. 1569, Standard for Safety for Metal-Clad Cables.
- k. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Action Submittals:

- 1. Product Data:
 - a. Wire and cable.
 - b. Wire and cable accessories.
- 2. Cable Pulling Calculations:
 - a. Ensure submitted and reviewed before cable installation.
 - b. Provide for the following cable installations:
 - 1) Medium voltage cable runs that cannot be hand pulled.
 - 2) Multiconductor 600-volt cable sizes larger than 2 AWG that cannot be hand pulled.
 - 3) Feeder circuits; single conductors #4/0 and larger.

B. Informational Submittals:

- 1. Factory Test Report for conductors 600 volts and below.
- 2. Factory Test Report per AEIC CS 8, including AEIC qualification report for conductors above 600 volts.

1.03 QUALITY ASSURANCE

- A. Provide the Work in accordance with NFPA 70. Material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization in order to provide a basis for approval under NEC.
- B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark.
- C. CAT6: RJ-45 Connector: In compliance with ISO-8877 and TIA 568 standards.
- D. Installer Qualifications for Network Cabling: Lead cabling installation personnel shall have BICSI Installer 2 or Technician certification.

E. Tester Qualifications for Network Cabling:

1. CAT6: BICSI Certification: BICSI Installer 2, Copper or Technician certification.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Physical Characteristics:

1. Conductor Type:
 - a. 120-volt and 277-volt lighting, 10 AWG and smaller: Solid copper.
 - b. 120-volt receptacle circuits, 10 AWG and smaller, solid copper.
 - c. All Other Circuits: Stranded copper.
 - d. Insulation: THHN/THWN-2, except for sizes 10 AWG and larger, with XHHW-2 insulation.
2. Flexible Cords and Cables: Type SOOW with ethylene propylene rubber insulation in accordance with UL 62.

B. Functional Characteristics:

1. Conform to applicable requirements of NEMA WC 70.
2. Flexible Cords and Cables: Conform to physical and minimum thickness requirements of NEMA WC 70.

C. Performance Characteristics: None.

2.02 600-VOLT RATED CABLE

A. General:

1. Physical Characteristics:
 - a. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
 - b. Overall Outer Jacket: PVC, flame-retardant, sunlight-resistant and oil-resistant.
2. Functional Characteristics:
 - a. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.

- b. Suitable for installation in open air, in cable trays, or conduit.
- c. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
- 3. Performance Characteristics: None.

B. Type 1:

- 1. Physical Characteristics:
 - a. Multiconductor foil shielded control cable.
 - b. 14 AWG, concentric seven strand copper.
 - c. Outer Jacket: Black direct burial PVC with thickness per ICEA S-73-532.
 - d. Aluminum or copper foil shield, 100 percent coverage with 14 AWG tinned copper drain wire.
 - e. Conductors:
 - 1) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - 2) Insulation: 10-mil nominal color-coded PVC.
 - 3) Jacket: 4-mil nominal nylon.
 - 4) Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
- 2. Functional Characteristics: NEMA WC 57 and UL Type TC (1277).
- 3. Performance Characteristics: Pass ICEA T-29-520, 210.000 Btu per hour Vertical Tray Flame Test.

C. Type 2:

- 1. Physical Characteristics:
 - a. Multiconductor power cable.
 - b. Stranded copper.
 - c. Outer Jacket: Black tray use and direct burial PVC.
 - d. Conductors:
 - 1) Bare soft annealed copper, Class B, stranded concentric meeting requirements of ASTM B8.
 - 2) Insulation: 10-mil nominal cross-linked ethylene-propylene or cross-linked polyethylene.
 - 3) Jacket: 4-mil nominal nylon.
 - 4) Color Code:
 - a) Conductors, size 8 AWG and smaller, color coded in accordance with ICEA S-58-679, Method 1, Table 1.
 - b) Conductors, size 6 AWG and larger, color coded in accordance with ICEA S-73-532, Method 4.
- 2. Functional Characteristics: NEMA WC 57 and UL 1277 Type TC.

D. Type 3:

1. Physical Characteristics:
 - a. 16 AWG, twisted, shielded single pair, instrumentation cable.
 - b. Outer Jacket: 45-mil nominal thickness.
 - c. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
 - d. Dimension: 0.31-inch nominal OD.
 - e. Conductors:
 - 1) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - 2) Insulation: 15-mil nominal PVC.
 - 3) Drain Wire: 20 AWG tinned copper.
 - 4) Jacket: 4-mil nominal nylon.
 - 5) Color Code: Pair conductors, black and red.
2. Functional Characteristics: NEMA WC 57.
3. Performance Characteristics: Designed for noise rejection for process control, computer, or data log applications.

E. Type 4:

1. Physical Characteristics:
 - a. 16 AWG, twisted, shielded single triad, instrumentation cable.
 - b. Outer Jacket: 45-mil nominal thickness.
 - c. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
 - d. Dimension: 0.32-inch nominal OD.
 - e. Conductors:
 - 1) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - 2) Insulation: 15-mil nominal PVC.
 - 3) Drain Wire: 20 AWG, tinned copper.
 - 4) Jacket: 4-mil nominal nylon.
 - 5) Color Code: Triad conductors, black, blue, and red.
2. Functional Characteristics: NEMA WC 57.
3. Performance Characteristics: Designed for noise rejection for process control, computer, or data log applications.

F. Type 5:

1. Physical Characteristics:
 - a. 16 AWG, multi-twisted, shielded single pairs, instrumentation cable.
 - b. Outer Jacket: 45-mil nominal thickness.
 - c. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.

- d. Overall Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
- e. Dimension: 0.32-inch nominal OD.
- f. Conductors:
 - 1) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - 2) Insulation: 0.030 inches nominal color-coded PVC, ICEA Method 1, Table E-2.
 - 3) Drain Wire: 20 AWG, tinned copper.
 - 4) Jacket: 4-mil nominal nylon.
 - 5) Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
- 2. Functional Characteristics: NEMA WC 57.
- 3. Performance Characteristics: Designed for noise rejection for process control, computer, or data log applications.

G. Type 6:

- 1. Physical Characteristics:
 - a. 16 AWG, multi-twisted, shielded single pairs, instrumentation cable.
 - b. Outer Jacket: 45-mil nominal thickness.
 - c. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
 - d. Overall Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
 - e. Dimension: 0.32-inch nominal OD.
 - f. Conductors:
 - 1) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - 2) Insulation: 0.030 inches nominal color-coded PVC, ICEA Method 1, Table E-2.
 - 3) Drain Wire: 20 AWG, tinned copper.
 - 4) Jacket: 4-mil nominal nylon.
 - 5) Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
- 2. Functional Characteristics: NEMA WC 57, UL 1277 Tray Cable, direct buy listed, wet locations.
- 3. Performance Characteristics: Designed for noise rejection for process control, computer, or data log applications.

H. Type 8:

- 1. Physical Characteristics:
 - a. Multiconductor variable/adjustable frequency drive cable.
 - b. Stranded copper.

- c. Outer Jacket: Black tray use PVC per UL 1569.
- d. Conductors:
 - 1) Bare soft annealed copper, Class B, stranded concentric meeting requirements of ASTM B8.
 - 2) Insulation: 600-volt, cross-linked ethylene-propylene or cross-linked polyethylene, UL Type XHHW-2.
 - 3) Grounding Conductors: Insulated stranded copper.
- e. Sheath:
 - 1) UL 1277 Type TC, 90 degrees C.
 - 2) Continuous shield, A1/polyester foil, drain wires, overall copper braid.
- 2. Functional Characteristics: NEMA WC 57 and UL 1277 Type TC.

2.03 SPECIAL CABLES

- A. Type 30, refer to Section 26 05 10, Network Communication Systems.
- B. Type OS2, refer to Section 26 05 10, Network Communication Systems.

2.04 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

- A. Tape:
 - 1. Physical Characteristics:
 - a. General Purpose: Flame retardant, 7-mil vinyl plastic.
 - b. Flame Retardant: 8.5-mil vinyl plastic.
 - 2. Functional Characteristics:
 - a. General Purpose: UL 510.
 - 3. Performance Characteristics: None.
- B. Identification Devices:
 - 1. Physical Characteristics:
 - a. Sleeves: Permanent, PVC, yellow or white, with legible machine-printed black markings.
 - b. Heat Bond Marker:
 - 1) Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
 - 2) Self-laminating protective shield over text.
 - 3) Machine printed black text.
 - c. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
 - d. Tie-On Cable Marker Tags:
 - 1) Chemical-resistant white tag.
 - 2) Size: 1/2 inch by 2 inches.
 - e. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

2. Functional Characteristics: None.
3. Performance Characteristics: None.

C. Connectors and Terminations:

1. Physical Characteristics:
 - a. Nylon, self-insulated crimp connectors.
 - 1) Suitable for 16-14 AWG wires.
 - 2) Tinned copper contact.
 - 3) Nylon ferrule insulation.
 - b. Nylon, Self-Insulated Crimp Locking Fork Type: Seamless.
 - 1) Suitable for 16-14 AWG wires.
 - 2) Tinned copper contact.
 - 3) Nylon ferrule insulation.
 - c. Self-Insulated, Lever-Type Wire Connectors:
 - 1) Clear shell.
 - 2) Color-coded for size.
 - d. Self-Insulated, Set Screw Wire Connector:
 - 1) Two piece compression type with set screw in brass barrel.
 - 2) Insulated by insulator cap screwed over brass barrel.
2. Functional Characteristics: UL listed.
3. Performance Characteristics:
 - a. Nylon, Self-Insulated Crimp Locking Fork Type: Suitable for use with 75 degrees C wire at full NFPA 70, 50 degree ampacity.

D. Cable Lugs:

1. Physical Characteristics: Made from same material as conductor.
2. Functional Characteristics:
 - a. In accordance with NEMA CC 1.
 - b. Rated 600 volts.
3. Performance Characteristics: Suitable for use with 75 degrees C wire at full NFPA 75 degrees C ampacity.

E. Cable Ties:

1. Physical Characteristics: Nylon.
2. Functional Characteristics: Adjustable, self-locking, and reusable.
3. Performance Characteristics: None.

F. Heat Shrinkable Insulation:

1. Physical Characteristics:
 - a. Single wall for insulation and strain relief.
 - b. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
 - c. Thermally stabilized cross-linked polyolefin.

2. Functional Characteristics: None.
3. Performance Characteristics: None.

2.05 PULLING COMPOUND

- A. Physical Characteristics: Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant.
- B. Functional Characteristics:
 1. Approved for intended use by cable manufacturer.
 2. UL listed.
- C. Performance Characteristics:
 1. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.
 2. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

2.06 WARNING TAPE

- A. As specified in Section 26 05 33, Raceways and Boxes.

2.07 SOURCE QUALITY CONTROL

- A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

PART 3 EXECUTION

3.01 GENERAL

- A. Conductor installation shall be in accordance with manufacturer's recommendations.
- B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.
- C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.
- D. Terminate conductors and cables, unless otherwise indicated.
- E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors.
- F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

- G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches on center.
- H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.
- I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.
- J. Cable Tray Installation:
 - 1. Install wire and cable parallel and straight in tray.
 - 2. Bundle, in groups, wire and cable of same voltage having a common routing and destination; use cable ties, at maximum intervals of 8 feet.
 - 3. Clamp cable bundles prior to making end termination connections.
 - 4. Separate cables of different voltage rating in same cable tray with barriers.
 - 5. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals:
 - a. Horizontal Runs: 20 feet.
 - b. Vertical Runs: 5 feet.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

- 1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
- 2. 8 AWG and Smaller: Provide colored conductors.
- 3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts, Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue

System	Conductor	Color
240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow
Note: Phase A, B, C implies direction of positive phase rotation.		

4. Tracer: Outer covering of white with identifiable colored strip, other than green, in accordance with NFPA 70.

3.03 CIRCUIT IDENTIFICATION

- A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
- B. Instrumentation and Control Circuits: Wire labels shall be made up using terminal number and “origination/destination” style numbering system. Wire labels for instrumentation and control circuits shall match wire labels shown on the I/O wiring diagrams created as part of the integration package.
- C. Lighting and Receptacle Circuits: Wire labels for lighting and receptacle circuits shall consist of the panel board and circuit number and a unique node number (i.e., LP#3-A, LP#3-B, LP#3-N).
- D. All Other Power Circuits: Wire labels shall be made up using and “origination/destination” style numbering system and phase or neutral letter. Origination and destination information shall be based on the “To and From” Columns on the Conduit and Wire Routing Schedules on the Drawings.
- E. Method:
 1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
 2. Cables and Conductors 2 AWG and Larger:
 - a. Identify with marker plates or tie-on cable marker tags.
 - b. Attach with nylon tie cord.
 3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

- A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.
- B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Contracting Officer.
- C. Connections and Terminations:
 - 1. Install wire nuts only on receptacle, lighting, and other panelboard branch circuits with 20A breakers or less only.
 - 2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
 - 3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
 - 4. Install uninsulated crimp connectors and terminators for power circuit conductors 4 AWG through 2/0 AWG.
 - 5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
 - 6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
 - 7. Place no more than one conductor in any single-barrel pressure connection.
 - 8. Install crimp connectors with tools approved by connector manufacturer.
 - 9. Install terminals and connectors acceptable for type of material used.
 - 10. Compression Lugs:
 - a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
 - b. Do not use plier type crimpers.
- D. Do not use soldered mechanical joints.
- E. Splices and Terminations:
 - 1. Insulate uninsulated connections.
 - 2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
 - 3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
 - 4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.
- F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.
2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Cable Protection:
 - a. Under Infinite Access Floors: May install without bundling.
 - b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
 - c. Maintain integrity of shielding of instrumentation cables.
 - d. Ensure grounds do not occur because of damage to jacket over shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

J. CAT6 Cable:

1. Cable counts, routing, origination, and terminating points are indicated on the Drawings.
2. Installation by BICSI certified installer.
3. Install cables and terminate cables in accordance with manufacturer's requirements.

K. Data and Telephone Outlets: Terminate UTP cable in accordance with TIA/EIA 568 B.2 and wiring configuration specified.

L. Patch Cords: Install securely in NIPs per manufacturer's instructions.

3.05 CONDUCTORS ABOVE 600 VOLTS

- A. Do not splice unless specifically indicated or approved by Contracting Officer.
- B. Make joints and terminations with splice and termination kits, in accordance with kit manufacturer's instructions.
- C. Install splices or terminations as continuous operation in accessible locations under clean, dry conditions.
- D. Single Conductor Cable Terminations: Provide heat shrinkable stress control and outer nontracking insulation tubings, high relative permittivity stress relief mastic for insulation shield cutback treatment, and a heat-activated sealant for environmental sealing.
- E. Install terminals or connectors acceptable for type of conductor material used.
- F. Provide outdoor rain skirts for outdoor terminations.
- G. Provide shield termination and grounding for terminations.
- H. Provide necessary mounting hardware, covers, and connectors.
- I. Where elbow connectors are specified, install in accordance with manufacturer's instructions.
- J. Give 2 working days' notice to Contracting Officer prior to making splices or terminations.

END OF SECTION