SECTION 26 0519 - INSULATED CONDUCTORS, CABLES, WIRES AND TERMINATIONS

Maintain Section format, including the UH master spec designation and version date in bold in the center columns of the header and footer. Complete the header and footer with Project information.

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

This Section uses the term "Engineer." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

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

Delete hidden text after this Section has been edited for the Project.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. The Contractor's attention is specifically directed, but not limited, to the following documents for additional requirements:

1. The current version of the *Uniform General Conditions for Construction Contracts*, State of Texas, available on the web site of the Texas Facilities Commission.
2. The University of Houston's *Supplemental General Conditions and Special Conditions for Construction.*

1.2 DESCRIPTION OF WORK

A. Work Included: Provide medium voltage (kV) and 600 / 300 volt electrical conductors, cable, wire, and terminations for work as shown, scheduled, indicated, and as specified.

B. Types: The types of low voltage electrical conductor, cables, wire, and connectors required for the Project include, but are not limited to, the following:

1. Medium voltage (kV) wire and cable.
2. Medium voltage (kV) wire and cable terminations.

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3. 600 volt building wire and cable.
4. 600 volt building wire and cable terminations.
5. 600 volt building RHH 2 hr. rated building wire and cable.
6. 600 volt mineral insulated (MI) cable.
7. 600 volt mineral insulated cable connectors.
8. 300 volt control/signal wire and cable.
9. 300 volt control/signal wire and cable terminations.

C. Application: The applications for cables, wires, and terminations required on the Project are as follows:

Medium Voltage Cables

1. Underground power utility distribution
2. Medium voltage switchgear wiring
3. Electrical vault wiring
4. Motor branch circuitry
5. Power transformer primary wiring

300 / 600 Volt Cables

1. Power distribution circuitry
2. Lighting branch circuitry
3. Appliance, receptacle and equipment branch circuitry
4. Motor branch circuitry
5. Control wiring
6. Outdoor lighting and power

1.3 STANDARDS

A. Products shall be designed, manufactured, tested, and installed in compliance with the following standards:

1. NEMA WC 3 - Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
2. NEMA WC 5 - Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
3. ANSI/U.L. 83 – Thermoplastic- insulated wires and cables
4. AEIC CS8-07 – Extruded Dielectric Shielded Power Cables Rated 5 through 46 kV
5. AEIC No. 6 – Specifications for Ethylene-Propylene-Rubber-Insulated Power Cables 5,000 to 35,000 Volts
6. ASTM B3 – Soft or annealed copper wire
7. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
8. ICEA S-93-639/NEMA WC74 – Shielded Power Cables Rated 5 – 46 kV
9. ICEA S-94-649 – Concentric Neutral Cables Rated 5 – 46 kV
10. ICEA S-97-682 – Utility Shield Power Cables Rated 5 – 46 kV
11. IEEE 48 – Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5kV through 765 kV
12. ANSI/IEEE 386 – Separable Insulated Connectors for Power Distribution Systems Above 600 Volts
13. IEEE 400 – Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems
14. UL 1072 – Medium-Voltage Power Cables

15. NFPA 70 – National Electric Code (NEC)
16. NFPA 70E – Standard for Electrical Safety in the Workplace

B. Where application of applicable codes, Trade Association standards, or publications appears to be in conflict with the requirements of this Section, an interpretation shall be obtained from the Architect/Engineer.

1.4 QUALITY ASSURANCE

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A. Manufacturers: Provide products complying with these Specifications and produced by one of the following:

1. Medium Voltage (kV) Wire and Cable:
   a. Aetna Insulated Wire
   b. Alcan (Aluminum)
   c. American Insulated Wire Corporation
   d. Cerro Wire and Cable Company
   e. Essex Group, Inc.
   f. Prysmian Group (General Cable)
   g. Okonite Company
   h. Republic Wire Inc.
   i. Southwire Company
   j. United Copper Industries
   k. Kerite Co; Hubbell Incorporated

   Note: Aluminum wire is allowed on a case by case basis for some type of medium voltage installations but only as approved in writing by Owner.

2. Medium Voltage Terminations:
   a. Wesco
   b. 3M; Electrical Products Division
   c. Raychem Corp; Telephone Energy and Industrial Division; Tyco International Ltd.
   d. Elastimold
3. 600 Volt Building Wire and Cable:
   a. Aetna Insulated Wire
   b. Cerro Wire and Cable Company
   c. Prysmian Group (General Cable)
   d. Okonite Company
   e. Republic Wire Inc.
   f. Southwire Company
4. 600 Volt 2 Hour Rated Building Wire and Cable
   a. Prysmian Group (Draka USA). (2 Hr. rated cable)
5. 600 Volt Mineral Insulated Cable

a. Wrexham
b. Pyrotenax Cable

6. Type MC Cable:
   a. AFC
7. 300 Volt Wire and Cable:
   a. Alpha
   b. Belden
   c. West Penn
8. Conductor, wire, and cable terminations:
   a. AMP, Inc.
   b. Buchannan
   c. Burndy Corporation
   d. O. Z. Gedney Company
   e. Ideal Industries, Inc.
   f. Mac Products, Inc.
   g. Minnesota Mining and Manufacturing Company (3M)
   h. Penn-Union
   i. Thomas & Betts Company
   k. Pyrotenax Cable (MI cable)

B. UL Label: All cable, wire, and connectors shall be UL-labeled.

1.5 SUBMITTALS

A. Submit all items to the Engineer and Owner's Representative for review and approval. Shop drawing submittals shall include, but not be limited to, the following:
   1. List of the proposed manufacturers of wire and cable, cable lugs, cable connectors and termination fittings listed herein. Contractor may install wire and cable, cable lugs, cable connectors and termination fittings furnished by any manufacturer listed on the approved submittal.
   2. Conduit fill calculations based on the wire size and type.
   3. Cut sheets on all insulated conductors with manufacturers name, ratings and capacities, insulation characteristics, and available colors, clearly listed.
   4. Cut sheets indicating all cable lugs, termination fittings and cable connectors.
   5. Cut sheets indicating types of conductor identification bands.

1.6 DELIVERY, STORAGE AND HANDLING

A. Provide factory-wrapped waterproof flexible barrier material for covering wire and cable wood reels, where applicable; and weather resistant fiberboard containers for factory-packaging of cable, wire and connectors, to protect against physical damage in transit. Damaged cable, wire, or connectors shall be removed from project site and replaced with new product

B. Store cable, wire, and connectors in their factory-furnished coverings and in a clean, dry indoor space that provides protection against the weather.

PART 2 - PRODUCTS

2.1 MEDIUM VOLTAGE CABLES AND TERMINATIONS

A. Size: As shown on the Drawings

B. Single Conductor Construction:

1. Single uncoated annealed copper conductor with Class B stranding.
2. Extruded semi-conducting thermosetting conductor screen firmly bonded to the overlaying insulation.
3. Ethylene-propylene-rubber (EPR) insulation 220 mils thick.
4. Extruded semi-conducting thermosetting insulation screen.
5. Copper shielding tape 5 mils thick helically applied with a minimum 12.5 percent overlap or 6 corrugated drain wires embedded in jacket.
6. Polyvinyl chloride jacket 80 mils thick.

C. Factory Testing and Reports:

1. Corona level test with a maximum partial discharge of 5 picocoulombs.
2. AC test: 33 kV for 5 minutes (15 kV).
3. DC test: 64 kV for 15 minutes (15 kV).
4. Insulation resistance test: IR constant to be 20,000 megohms per 1000 feet minimum per standards ICEA S-93-639 and MEMA WC74.
5. Use test procedures given in ICEA S-68-516 and AEIC No. 6.
6. Certified test reports with test data and corona level plots are to be submitted for review by Contractor, Engineer, and Owners Rep prior to shipment.
7. Engineer and Owner's Representative may witness test.

D. Pre-Energization Field Testing and Reports:

1. All tests will be performed by third party company with 10 years minimum related experience.
2. Corona level test with a maximum partial discharge of 5 picocoulombs.
3. AC test: 33 kV for 5 minutes (15 kV).
4. DC test: 64 kV for 15 minutes (15 kV).
5. Insulation resistance test: IR constant to be 50,000 megohms per 1000 feet minimum.
6. Use test procedures given in ICEA S-68-516 and AEIC No. 6.
7. Submit certified test reports with test data and corona level plots to Contractor, Engineer and Owner's Representative.
8. Prior to energization field testing, reports must be signed off as satisfactory readings by third party Company.
9. Engineer and Owner's Representative may witness test.

E. Medium Voltage Terminations:

1. Terminations:
    a. Use Elastimold, 3M, or Raychem RTE 15 kV class, 200 – 600 ampere load-break submersible, fully shielded, pre-molded, elbow connector with tape shield

adapter for use on 15 kV cables with 133 percent insulation level.

b. In addition, at each transformer provide a 15Kv fully shielded dead front MOVE (Metal Oxide Varistor Elbow). Arrester shall have a 7.65kV MCOV (Maximum Continuous Operating Voltage). Ground arrester as shown on plans.

c. Compatibility. Terminating materials must be compatible with the cable supplied. Submit proof of acceptability by the cable manufacturer of any splicing or terminating materials

2. Terminations in manholes:

a. Use Elastimold or RTE 15 kV class (or approved equal), 600-ampere dead break submersible, fully shielded, pre-molded, elbow connector with tape shield adapter for use on 15 kV cables with 133 percent insulation level.

b. Provide Eaton/Cooper (or approved equal) 600A 15/25kV class dead break junctions (one per phase per feeder) mounted to the wall of the manhole in locations where feeders ERP-1 and ERP-2 (ERP is now UH Technology Bridge).

c. T- Body Connections: Provide a minimum of one spare interface at each junction with a limit of 4 connection points per phase per manhole.

F. Medium Voltage Splices:

1. Splice Kits:

a. Description: For connecting medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.

b. Standard: Comply with IEEE 404.

c. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

1) Combination tape and cold-shrink-rubber sleeve kit with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
2) Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
3) Premolded, cold-shrink-rubber, in-line splicing kit.
4) Premolded, EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.
5) Separable multiway splice system with all components for the required splice configuration.

d. Submersible: Splices for medium voltage conductors shall be permanent, waterproof, and suitable for continuous submergence in water, including direct-buried and fully submerged applications.

e. Use 3M QS-III cold shrink or Raychem HVS-C heat shrink splice kits with tape shield adapter for use on 15 kV cables with 133 percent insulation level. For product substitutions, refer to Section 01 2500 “Substitution Procedures.”

f. Splices shall be certified by the manufacturer.

g. Splices may be used only with written permission of the Owner’s Representative.

2.2 600 VOLT BUILDING CABLE, WIRE AND CONNECTORS

A. General: Except as otherwise indicated, provide cable, wire, and connectors of manufacturer's standard materials, as indicated by his published product information, designed and constructed as instructed by the manufacturer, and as required for the installation.

B. Wire and Cable: Provide factory-fabricated wire and cable of the size, rating, material, and type as indicated for each service. Where not indicated, provide proper selection as required to comply with installation requirements and with NEC standards. The minimum size wire to be used for power or lighting circuits shall be No. 12 copper (No. 14 for light fixture pigtails) with insulation as noted below. Minimum size for control wiring shall be No. 14 copper. Specify stranded except where metal-clad (MC) is allowed.

C. Conductors: Provide soft or annealed copper wires meeting, before stranding, the requirements of ASTM B3, "Standard Specification for Soft or Annealed Copper Wire for Electrical Purposes," latest edition.

1. All conductors for power wiring shall be stranded. Stranded conductors shall be terminated on back wired wiring devices where wiring is mechanically secured via a side screw. Conductors for control wiring sized No. 10 AWG and smaller shall be stranded.
2. Stranding shall be Class B meeting the requirements of ASTM B8, "Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard, or Soft."
3. Where MC cable is allowed, solid conductors are acceptable.

D. Insulation: Insulation shall meet or exceed the requirements of UL 83, "Standard for Thermoplastic Insulated Wires."

1. Insulation for conductors sized No. 10 AWG and smaller shall be UL Type **["THW" (rated at 75°C in dry locations and 60°C in wet locations) or]** "THHN/THWN" (rated at 90°C in dry locations and 75°C in wet locations).
2. Insulation for conductors sized No. 8 AWG and larger shall be UL Type **["THW" (rated at 75°C in dry locations and 60°C in wet locations) or]** "THHN/THWN" (rated at 90°C in dry locations and 75°C in wet locations).
3. Insulation for conductors sized No. 8 AWG and larger shall be UL Type "RHH" for two-hour fire rated cable (rated at 90°C in dry locations).
4. All wiring inside lighting fixtures shall be temperature rated per the NEC.
5. Branch circuit wiring within 3 inches of fluorescent ballasts or LED drivers shall be temperature rated for 90°C.
6. **[In the ceiling areas of equipment rooms where the temperature may exceed 102°F under operating conditions, higher temperature insulation shall be used on conductors. Acceptable types are "RHH", "THHN", and "XHHW".]**

E. Connectors for Building Wire and Cable: Provide factory-fabricated, metal connectors of the size, rating, material, type, and class required for each use.

[VERIFY THE FOLLOWING AT NON-HEALTH CARE FACILITIES]

2.3 TYPE MC CABLE:

A. Metal-clad Type MC Cable: Type MC cable may be used for lighting fixture connections, receptacle circuits (only in existing walls), and switch legs (only in existing walls) to the junction box grid system in finished areas. Type MC cable shall consist of two No. 12 AWG copper THHN insulated phase conductors and one No. 12 AWG THHN insulated copper ground conductor, all enclosed in cable tape and a galvanized steel flexible armor. MC cable to be marked on insulation and externally with a color code to identify whether the cable is carrying high-voltage 480/277-volt (V) or low-voltage 208/120V.

Refer to Section 26 05 53 “Identification for Electrical System” for color specification. Type MC cable terminations shall be made using approved anti-short fittings. **Note: Type MC Cable shall not be used for wiring any emergency systems.**

2.4 300 VOLT CONTROL/SIGNAL CABLE, WIRE AND CONNECTORS

A. General: Except as otherwise indicated, provide cable, wire, and connectors of manufacturer's standard materials, as indicated by published product information, designed and constructed as instructed by the manufacturer, and as required for the installation.

B. Wire and Cable: Provide factory-fabricated wire and cable of the size, rating, material, and type as indicated for each use.

C. Conductors: Provide soft or annealed copper wires as individual conductors, twisted together or shielded, where required, and meeting, before stranding, the requirements of ASTM B3, "Standard Specification for Soft or Annealed Copper Wire for Electrical Purposes,” latest edition.

D. Conductor Gauge: Provide conductor gauge as required for the application with a minimum of 24 AWG. Conductors shall be stranded or solid as required by the application or manufacturer.

E. Insulation: Insulation shall meet or exceed the requirements of UL 83, "Standard for Thermoplastic Insulated Wires,” and the requirements of NEC Article 725 for Class 2 wiring.

1. Insulation shall be rated for a maximum working voltage of 300 volts; PVC jacket; UL-listed.
2. Insulation of cables used in environmental air spaces shall be nonmetallic jacket UL-listed for use in air plenums.

F. Connectors: Provide factory-fabricated, metal connectors of the size, rating, material, type, and class required for the application.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install electrical cable, wire and connectors as shown, in accordance with the manufacturer's written instructions, the applicable requirements of NEC, the NECA's "Standard of Installation", and recognized industry practices to ensure that products serve the intended functions.

B. Coordination:

1. Coordinate cable and wire installation work with electrical raceway and equipment installation work, as necessary for proper interface.
2. Installer shall examine the areas and conditions under which cable, wire and connectors are to be installed and notify the Contractor in writing of conditions detrimental to the

proper and timely completion of the work. Inspect wire and cable for physical damage. Do not proceed with the work until unsatisfactory conditions have been corrected.

C. Medium Voltage Wire and Cable:

1. Feeder are to be run their entire length in continuous pieces without joints or splices to the maximum extent practicable. Splices shall be allowed in locations as approved by Owner's Representative in writing.
2. Bonding: At each termination, bond tape shield to grounding conductor.
3. Terminations: Provide terminations as specifically indicated. Have terminations installed by an experienced cable terminator in strict accordance with the termination manufacturer's instructions and the cable manufacturer's recommendations. Submit cable terminator's qualifications for Owner's approval.
4. Terminations in manholes: Mount junctions to wall of manhole per manufacturer's instructions.
5. Fireproofing: Fireproof each individual high voltage insulated conductor for entire length exposed in each manhole. Use Scotch 77 tape with Scotch 69 glass cloth overlay wrapped in the opposite direction. Provide a minimum 25 percent overlap of each tape layer.
6. Installation: Wrap cables horizontally around each manhole passed through a minimum of one time before exiting. Cable racks for cable support are existing. Use plastic cable ties to secure cables to racks.
7. Identification: Identify each circuit in manhole with a laminated plastic tag securely fastened to the conductors with tie wrap.

D. 600 Volt Building Wire and Cable:

1. Mains and feeders are to be run their entire length in continuous pieces without joints or splices**,** unless otherwise indicated or noted.
2. Conductors may be run in multiple on sizes No. 1/0 AWG through 600 kcmil inclusive, provided all multiple conductors are the same size, length, and type of insulation, and are so arranged and terminated as to ensure equal division of the total current between all conductors involved. Refer to Section 26 0553 "Identification for Electrical Systems" for color coding description.
3. Before any wire is pulled into any conduit, the conduit shall be thoroughly swabbed in such a manner as to remove all foreign material and to permit the wire itself to be pulled into a clean, dry conduit. All conductors shall be pulled into the conduit at the same time.
4. Cables shall be selected on the basis of their purpose and UL-listing. Generally, use Types "THWN" and "THHN" in building interiors and other dry locations. Outdoors and underground in raceways, use Type "THWN". Conductors subject to abrasion, such as in lighting poles, shall be Type "THWN" or "THHN".
5. Feeder conductors shall be sized such that the voltage drop from the source to the load served shall not exceed 2 percent at maximum load and 80 percent power factor, at 120/208 volts and 1 percent at maximum load and 80 percent power factor at 277/480 volts.

6. Where pulling lubricant is required, use only non-wax based cable lubricants equal to American Polywater as a lubricant. Wire pulling lubricant shall not be used when installing branch circuit conductors from panelboards with "isolation" transformers.
7. Pull all conductors together when more than one conductor is being installed in a raceway. A conductor derating factor per NEC Table 310-15(B)(2)(a) shall be applied to conductor ampacity. No more than six power conductors may be installed in a single conduit.
8. The use of shared branch circuit neutrals is not permitted. Separate neutral conductors shall be pulled for all branch circuits served by single pole and where required for two and three pole circuit breakers.
9. No conductor smaller than No. 12 AWG shall be used for power or lighting purposes (except light fixture tails). Switch legs shall be No. 12 AWG. Control circuit wiring may be No. 14 AWG minimum and shall not be run in same conduit with power wiring.
10. Lighting and power branch circuit conductors shall be sized such that the voltage drop from the panelboards to the farthest point on the circuits shall not exceed 2 percent at maximum load and 80 percent power factor, at 120/208 volts and 1 percent at maximum load and 80 percent power factor at 277/480 volts.
11. Provide all voltage drop calculations to Architect/Engineer for review and approval.
12. For 120 volt, 20 amp branch circuits with a length of 75' or more to the homerun junction box or first outlet, provide minimum No. 10 AWG conductors to the homerun junction box or first outlet. Where the additional circuit length from the homerun junction box or first outlet to the last outlet exceeds 75 feet, provide minimum No. 10 AWG conductors to the last outlet.
13. For 208 volt, 20 amp branch circuits with a length of 100 feet or more, provide minimum No. 10 AWG conductors for the entire branch circuit.
14. For 208 volt, 30 amp branch circuits with a length of 100' or more, provide minimum No. 8 AWG conductors for the entire branch circuit.
15. For 277 volt, 20 amp branch circuits with a length of 150 feet or more to the first outlet, provide minimum No. 10 AWG conductors to the center of the load (minimum first outlet, where there is only one outlet).
16. Lighting fixtures shall not be used for raceways for circuits other than parallel wiring of fixtures. Fixtures must also have visible rating to be used as raceways.
17. Conductors for connection to individual light fixtures in grid type ceilings from their associated junction boxes, shall be 3 No. 14 AWG THHN copper 600 volt, solid conductors in 72-inch long, 3/8 inch flexible metal conduit fixture-tails, or by Type MC cable fixture tails where permitted by the local Authority Having Jurisdiction, in lengths not to exceed 8 feet.
18. All conductors in vertical conduits or raceways shall be supported in the manner set forth in the latest edition of the NEC.
19. Two-hour rated cables shall be installed in conduit and supported per UL to provide a two-hour installed rating.
20. Do not use a pulling means, including fish tape, cable or rope that can damage the raceway.

21. 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.
22. Install exposed wire and cable, parallel and perpendicular to surface or exposed structural members and follow the surface contours, where possible.
23. All wire shall be new, unused, in good condition, and shall be delivered in standard coils, packages, or rolls. Samples of all wire shall be submitted by the Contractor when requested by the Engineer for the purpose of determining acceptability of the wire.
24. Wire rejected by the Engineer shall not be used again. Decisions as to the quality of the wire furnished and the acceptance of such wire shall be made by the Owner's Representative.
25. Do not permit conductors entering or leaving a junction or pull box to deflect so as to cause pressure on the conductor insulation.
26. Splices and taps on branch circuits shall occur only when such circuits divide as shown on the Drawings and shall consist of one "through" circuit to which the circuit shall be spliced or tapped. Through wiring of receptacles and other devices is not allowed, except for GFCI devices noted on the Drawings to protect downstream devices.
27. Connections to devices (receptacles, switches, etc.) shall be made with individual conductors. The devices shall not be used for "feed-thru" purposes. Where "feed-thru" conditions exist, use "pig-tail" splices as described above. Color coding of "pig-tail" splices shall conform to Section 26 0553, "Identification for Electrical Systems."
28. No splices or taps shall be made in any conductor except in outlet boxes, junction boxes, splice boxes, or other devices and equipment in exposed and accessible locations approved for the purpose by the latest edition of the NEC.
29. All wire connections or splices on conductors No. 18 AWG through No. 8 AWG shall be made with pre-insulated spring type connectors. No other type of mechanical connector shall be used for No. 8 AWG and smaller conductors.

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30. **[All copper main service feeder conductors terminated on the "line" side bus of all service entrance switchboards shall be terminated with hydraulically applied high conductivity, copper compression lugs approved for the purpose.]**
31. **[All conductors terminated on the "line" side of all chiller starters, "line" and "load" side of the fire pump starter and at the fire pump, shall be terminated with hydraulically applied, high conductivity, copper compression lugs approved for the purpose.]**
32. All No. 6 AWG and larger copper conductors terminated on the "load" side lugs of all switchboard circuit devices, and the "line" and "load" side lugs of all other devices, shall be terminated with set-screw type pressure connectors approved for the purpose.
33. All No. 6 AWG and larger copper conductors that are to be spliced or tapped in wireways, gutters, or junction boxes shall be spliced or tapped using hydraulically applied, high conductivity compression connectors, or with set-screw type pressure connectors approved for the purpose, using 3-M electrical tape or manufactured connector covers approved for the purpose.

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34. The manufacturer's recommended installing tool shall be used for the installation of all hydraulically applied compression type lugs or connectors.
35. Support cables above accessible ceilings; do not rest on ceiling tiles. Use spring metal clips or plastic cable ties to support cables from structure. Include bridle rings or drive rings.
36. Multiple circuit wires in bundles or harnesses terminating in control panels, switchboards, panelboards, etc., shall be loosely bundled, trained, and laced to achieve a neat and workmanlike appearance.
37. Surplus wire shall be trimmed to proper length. Do not fold and stuff surplus wires into wiring gutters.
38. Wires exiting harness shall be trained at 90 degree angles to termination point.
39. Refer to Section 26 0553, "Identification for Electrical Systems," for color coding and identification of conductors.

E. 600 Volt Mineral Insulated Cable:

1. Install MI cable, connectors and bands in accordance with manufacturers written instructions. The applicable requirements of the NEC and recognized industry practices to ensure that products serve the intended function.
2. Provide all tools and accessories as required for a complete install.
3. Provide a continuous length of MI cable from source to load as shown. Factory shall provide 2-hour fire-rated joints as required to obtain a continuous length.

[VERIFY THE FOLLOWING FOR NON HEALTH CARE FACILITIES]

F. Type MC Cable:

1. Type MC cable may be used, where approved by the local Authority Having Jurisdiction and allowed in the NEC: for drops in partitions to receptacles (only in existing walls); for lay-in fixture pigtails (10 foot maximum length); for switch leg drops (only in existing walls); from fixture junction boxes to non-lay-in fixtures; or for single circuit branch circuit wiring from fixture to fixture (except lay-in fixtures) and fixture to junction box.
2. Type MC cable shall not be used for branch circuit homeruns.
3. Type MC cable shall not be used for receptacle to receptacle wiring in partitions; where more than three conductors (phase/neutral/ground) are required; where exposed; or in lengths exceeding 20 feet.
4. Type MC cable in partitions shall be protected in accordance with the requirements of the NEC.
5. Type MC cable shall be supported as specified herein and in accordance with the NEC.
6. Refer to the Drawings for additional requirements concerning the use of Type MC cable.

[VERIFY THE FOLLOWING FOR HEALTH CARE FACILITIES]

G. 300 Volt Control/Signal Cable and Wire:

1. Install all low voltage wiring in a suitable raceway except in areas with accessible (lay-in) ceilings unless otherwise noted on Drawings or other Division 26 sections.
2. Where cable is routed without a raceway, bundle all cables and suspend to one foot above ceiling using loop rings on five foot centers.

3. Do not run cable loose on top of suspended ceilings. Do not attach cables to suspended ceiling supports or any mechanical, plumbing, or sprinkler piping.
4. Conceal conduit except in mechanical rooms and areas where other conduit and piping are exposed.
5. Fasten flexible conductors that bridge cabinets and doors neatly along hinge side and protect against abrasion. Tie and support the conductors neatly.
6. Remote control wires shall be no smaller than No. 14 AWG. Control wires shall be run in separate conduits. Departures from the sizes so determined shall be made only in those cases in which the NEC requires the use of larger conductors. The sizes as determined from NEC tables shall be regarded as the acceptable minimum under all other circumstances. In no case, however, shall there be a voltage drop greater than that specified in any feeder or branch circuit. This voltage drop shall be based on the full load, 70 percent power factor, the total impedance drop of 60 Hz alternating current and with the reactance drop in the respective metal conduits duly considered.
7. Contractor may, if he deems it necessary or advisable, use larger sized conductors than those shown. Under no circumstances, however, shall the Contractor use any conductors sized in a manner that does not conform to the above mentioned tables without having first secured the written approval of the Owner's Representative.
8. Number code or color code conductors appropriately for future identification and servicing of the system. Refer to Section 26 0553, "Identification for Electrical Systems," for additional requirements.
9. Make all splices and connections in stranded conductors using UL-approved solderless crimp connectors.

3.2 TESTING

A. Medium Voltage Conductors:

1. Field Testing:
   a. High potential proof tests shall be made on all high voltage cables before final inspection and acceptance of work. Thirty days before the installation of cables is complete and ready for testing, Contractor shall notify the Owner for approval of the testing company. Contractor shall cooperate with and give all necessary assistance to this agency while tests are being conducted.
   b. A non-destructive DC testing service, such as "Kenotron" or Westinghouse "High Pot Tester," or a substitution approved in accordance with Section 01 2500, "Substitution Procedures," that is capable of generating approximately 100,000 V DC under normal leakage conditions of acceptable cable shall be used for the tests. Provide options to utilize AC VLF in lieu of DC hipot to Engineer and Owner for review and approval.
   c. All cables shall be tested in place with terminations made up but not connected to switchgear or any other load device or dead-end seal. Cables with dead-end seals shall be temporarily opened and resealed.
   d. In case of failure during the test, Contractor shall locate the faulty component. The Owner shall be notified before repairs are made.

e. Should the test reports indicate that the condition of the cable is unsatisfactory in the opinion of the Owner, the Contractor shall make all necessary repairs and replacements. Additional tests shall be made at Contractor's expense on all repaired sections using the same testing agency. Cable installations will not be accepted until satisfactory certified proof test reports are obtained.

f. Adequate means shall be taken to ensure safety during the tests and all safety instructions of the test operator shall be carried out.

g. Prior to each high potential test, each high voltage cable conductor shall be separately "meggered" with a 2,500-volt mega-ohms meter, or equal, from conductor to sheath or ground. Low megger readings of less than 25 mega-ohms shall be cause for rejection of the cables.

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B. Feeder Insulation Resistance Test: Each new **[and reused existing]** 600 volt feeder conductor shall have its insulation resistance tested after the installation is complete except for connection at its source and point of termination. All testing shall be witnessed by Owner. Contractor shall keep a log of testing and furnish it to Owner on request.

1. Tests shall be made using a Biddle Megger or equivalent test instrument at a voltage of not less than 1000 volt DC. Resistance shall be measured between phase, neutral, and ground conductors and from conductors to raceway (ground). Readings shall be taken after 30 seconds and 60 seconds of Megger operation at slip speed and insulation resistance shall not be less than the following:

Wire/Cable Voltage	Minimum Test Voltage DC	Resistance (Megaohms)
600V	1,000	100
5,000 V	2,500	1,500
15,000 V	2,500	5,000

2. New conductors that do not meet or exceed the insulation resistance values listed above shall be removed, replaced, and retested.

3. **[Where reused existing feeders fail to meet the above insulation requirements, notify the Engineer in writing for direction prior to placing the existing feeders back in service.]**

C. Neutral Testing: After all feeder and branch circuit conductors are terminated, neutral to ground testing shall comply with the following:

1. The resistance of the system's neutral to ground shall be greater than 10 K-ohms with the system bonding jumper disconnected.

2. Repeat neutral to ground test for neutrals of separately derived systems.

D. Pre-energization Check: Prior to energization, check all new **[and reused existing]** branch circuit cable and wire for continuity of circuitry and for short circuits. Correct malfunction when detected. No submittal is required for this test. All testing shall be witnessed by Owner. Contractor shall keep a log of testing and furnish it to Owner on request.

E. Voltage and Current Values: The voltage and current in each main feeder conductor shall be measured and recorded after all connections have been made and the feeder is under load.

F. Submittals: Contractor shall furnish all instruments and personnel required for tests. Submit four copies of certified test results to Architect/Engineer for review. Test reports shall include conductor tested, date and time of test, test results, relative humidity, temperature, and weather conditions. Refer to Section 26 0125, "Electrical Testing," for additional requirements.

3.3 AS BUILT DRAWINGS

A. As-Built Drawings: Refer to Section 26 0001, "Electrical General Provisions," for applicable requirements.

3.4 IDENTIFICATION

A. Identification: Refer to Section 26 0553, "Identification for Electrical Systems," for color-coding and markings for all conductors and cables.

END OF SECTION 26 0519