

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Building Wire and Cable.
2. Metal Clad Cable (Type MC).
3. Wiring Connectors and Connections.

B. Related Sections:

1. Section 26 05 53 - Identification for Electrical Systems: Product requirements for wire identification.
2. Division 31 - Trenching: Execution requirements for trenching required by this section.
3. Division 31 - Fill: Requirements for backfill to be placed by this section.

1.02 REFERENCES

A. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

B. National Fire Protection Association:

1. NFPA 70 - National Electrical Code.
2. NFPA 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

C. Underwriter's Laboratories:

1. UL 83 – Thermoplastic-Insulated Wire and Cables.
2. UL 486A & 486B – Wire Connectors.
3. UL 486C – Splicing Wire Connectors.
4. UL 486D – Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.
5. UL 486E – Standard for Safety for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.
6. UL 510 – Standard for Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.

7. UL 1569 – Standard for Metal-Clad Cables.
8. UL 1581 – Reference Standard for Electrical Wires, Cables and Flexible Cords.
9. UL 2225 – Standard for Metal-Clad Cables and Cable-Sealing Fittings for Use in Hazardous (Classified) Locations.
10. UL 2196 – Tests for Fire Resistive Cables.

1.03 SYSTEM DESCRIPTION

A. Product Requirements: Provide products as follows:

1. Solid conductor for feeders and branch circuits 12 AWG and smaller.
2. Stranded conductors for control circuits.
3. Conductor not smaller than 12 AWG for power and lighting circuits.
4. Conductor not smaller than 14 AWG for control circuits.
5. Use minimum No. 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet (25 m). Use minimum No. 8 AWG conductors for 20 ampere, 120 volt branch circuits longer than 200 feet (67 m). Increase conductor size for larger distances to limit voltage drop to code acceptable levels.
6. Use minimum No. 10 AWG conductors for 20 ampere, 277 volt branch circuits longer than 200 feet (160 m).). Increase conductor size for larger distances to limit voltage drop to code acceptable levels.

B. Wiring Methods: Provide the following wiring methods:

1. Concealed Dry Interior Locations: ~~Use only building wire in raceway or Metal clad cable.~~ **Metal clad cable.**
2. Exposed Dry Interior Locations: Use only building wire, in raceway.
3. Above Accessible Ceilings: ~~Use only building wire in raceway or Metal clad cable.~~ **Metal clad cable.**
4. Wet or Damp Interior Locations: Use only building wire in raceway.
5. Exterior Locations: Use only building wire, Type USE-2 or XHHW insulation, in raceway.
6. Underground Locations: Use only building wire, Type USE-2 or XHHW insulation in raceway.

1.04 SUBMITTALS

A. Division 01 - Submittal Procedures: Requirements for submittals.

B. Product Data:

1. Submit for building wire (each cable assembly type).

2. Submit for wiring connectors, including insulating materials.
 3. Submit for tapes, including arc-proofing tapes.
 4. Submit for cable ties.
- C. Test Reports: Indicate procedures and values obtained.
- D. Test Reports: Submit Calibration reports for torque drivers and torque wrenches used for electrical connections. Torque drivers and wrenches shall be lab calibrated prior to use on the project and every three months thereafter.

1.05 CLOSEOUT SUBMITTALS

- A. Division 01 - Execution and Closeout Requirements: Requirements for submittals.
- B. Project Record Documents: Record actual locations of components and circuits.

1.06 QUALITY ASSURANCE

- A. Provide wiring materials located in plenums with peak optical density not greater than 0.5, average optical density not greater than 0.15, and flame spread not greater than 5 feet (1.5 m) when tested in accordance with NFPA 262.
- B. Perform work in accordance with NFPA 70 – The National Electrical Code as amended by Authorities Having Jurisdiction.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years documented experience.

1.08 FIELD MEASUREMENTS

- A. Verify field measurements are as indicated on Drawings.

1.09 COORDINATION

- A. Division 01 - Administrative Requirements: Requirements for coordination.
- B. Where wire and cable destination is indicated and routing is not shown, determine routing and lengths required.

PART 2 - PRODUCTS

2.01 BUILDING WIRE AND CABLE

- A. Subject to the requirements of the specifications, manufacturers offering products that may be suitable for use on this project include, but are not limited to, the following unless otherwise noted:
1. Colonial Wire and Cable Co.

2. Diamond Wire & Cable Co.
3. Essex Group Inc.
4. General Cable Co.
5. Southwire, Inc.
6. American Insulated Wire, Inc.
7. Tyco Thermal Controls Pyrotenax 1850.
8. Substitutions: Division 01 - Product Requirements.

2.02 BUILDING WIRE

- A. Product Description: Single conductor insulated wire.
- B. Conductor: Copper. Solid for No. 12 AWG and smaller; stranded (Class B) for No. 10 AWG and larger.
- C. Insulation Ratings: 600 volt; 90 degrees C.
- D. Insulation Types:
 1. Type THHN/THWN or XHHW insulation for feeders and branch circuits No. 6 AWG and larger.
 2. Type THHN/THWN for feeders and branch circuits No. 8 AWG and smaller.
 3. Type RHW-2/USE-2 for feeders and branch circuits No. 2 AWG and larger, installed under floor slabs, underground or in wet or damp locations.
- E. For conductor sizes No. 6 AWG and smaller, conductor insulation shall be color coded as indicated in the table under Item 3.6.

2.03 METAL CLAD CABLE TYPE MC

- A. Conductor: Copper.
- B. Insulation Voltage Rating: 600 volts; 90 degrees C.
- C. Insulation Material: Type THHN/THWN or XHHW.
- D. Conductor insulation shall be color coded as indicated in the table under Item 3.7.
- E. Armor Material: Steel.
- F. Armor Design: Interlocked metal tape.
- G. Ground: Full size, green insulated.
- H. AC Type cable will not be allowed on this project.
- I. **Cables shall be bundled per code requirements or minimum 6 cables per bundle, whichever is more stringent. Support cables at maximum 6 feet on center.**

2.04 MINERAL-INSULATED METAL-SHEATED CABLE (MI)

- A. Description: NFPA 70 Type MI, Single conductor insulated cable.
- B. Conductor: Copper, solid for No. 10 AWG to 500 Kcmil.
- C. Insulation Ratings: 600VAC, 90 degrees C.
- D. Termination Temperature Rating: 105 degrees C.
- E. Cable Ampacity Rating: 90 degrees C based on single conductors in free air per Table 310.17 of NFPA 70.
- F. Insulation Material: Magnesium Oxide refractory mineral.
- G. Metal-Sheath Material: Seamless soft-drawn copper.
- H. Fire Rating: Cable assembly, including supports shall have a 2-hour fire rating as listed and classified by Underwriters Laboratories, Inc.

2.05 MI CABLE TEST REQUIREMENTS

- A. Cable shall meet Vibration test requirement in specification SEC 1999 – 01.
- B. Cable shall meet Impact requirement of SEC 1999 – 02.
- C. Cable shall be capable of demonstrating Compression to 50% of diameter without failure. Specification SEC99-03 applies.
- D. Cable shall be capable of passing electrical impulse test requirement of BIL: 7kV; Switching surge: 5kV.

2.06 WIRING CONNECTORS

- A. General:
 - 1. Temperature rating of all connections and insulation materials shall not be less than that of the conductors and in no case shall be less than 75 degrees C.
 - 2. Connectors with a copper rating shall be copper with tin-plating.
 - 3. Pre-molded insulators shall be by the same manufacturer as the connector.
- B. Hydraulic Compression Splices – Standard or long barrel butt splices:
 - 1. FCI Burndy: YS-L or YS series.
 - 2. Thomas & Betts: 54800 or 54500 series.
 - 3. IlSCO: CT or CTL series.
- C. Hydraulic Compression Terminations – one-hole and two-hole, long barrel lugs:

1. FCI Burndy: YA, YAZ or YA-2N series.
 2. Thomas & Betts: 54100, 54900 or 54800 series.
 3. IlSCO: CRA, CRL or CRL2 series.
- D. Hydraulic Compression Taps – 'H' shaped copper crimp tap:
1. FCI Burndy: YH or YSH series.
 2. Thomas & Betts: CHT series.
- E. Lugs, Bolt Type:
1. FCI Burndy, Type KA-U.
 2. ILSCO Type TA.
- F. Heat Shrink Tubing:
1. FCI Burndy, Type HS-H-PF.
 2. ILSCO Type Heavy Wall.
 3. Tyco Electronics/Raychem Type WCSM.
 4. Thomas & Betts Type HSFR.
- G. Spring Wire Connectors:
1. Buchanan.
 2. Ideal.
 3. King Industries.
 4. NSI Industries.
 5. Thomas & Betts.
 6. 3M.
- H. Crimp Type Connectors (power and control wiring, No 10 AWG and smaller):
1. FCI Burndy.
 2. Buchanan.
 3. ILSCO.
 4. Thomas & Betts.

2.07 POWER DISTRIBUTION BLOCKS

- A. Power distribution blocks shall consist of a tin-plated copper or tin-plated aluminum (6061-T6) box connector mounted on a polycarbonate base with a see through cover.

- B. The blocks shall have line and load connections as indicated on the Drawings. Blocks shall be constructed using tin-plated 6061-T6 aluminum and shall be UL Listed for both copper and aluminum conductors. Blocks shall have the number of poles as indicated on the Drawings.
- C. Power distribution blocks shall be equal to Bussmann No. 16300 Series.
- D. Other Acceptable manufacturers include Ferraz-Shawmut, IlSCO, and Littelfuse.

2.08 CONDUCTOR PULLING LUBRICANTS

- A. Description: Water soluble, polymer-based, non-toxic and non-sensitizing wire lubricant with volatile solids less than 6%. The lubricant shall have no flash point in gel state and shall leave a non-flammable residue when dry. Lubricant shall be approved by the conductor manufacturer as being suitable for use with their insulation.
- B. Appearance: Thick gel material, suitable for application with electrically operated pumping equipment.
- C. Useful temperature range: 20 - 100 degrees F.
- D. Lubricant shall be equal to the following:
 - 1. American Polywater Corporation; Polywater Clear, Polywater J.
 - 2. Ideal Industries; Clear Glide or AquaGel II.

2.09 TAPE

- A. Insulation tape shall have a minimum of 350 volts per mil dielectric strength. Vinyl tape shall be equal to 3M Scotch No. 33. Tape for conductor phase identification shall be equal to 3M Scotch No. 35.
- B. Rubber tape shall be self-fusing, non-corrosive, with minimum 350 volts per mil dielectric strength, and meeting the requirements of Federal Specification HH-I-553. Self-fusing rubber tape shall be equal to 3M No. 2155.

2.10 ARC/FIREPROOFING TAPE

- A. Subject to the requirements of the specifications, manufacturers offering products that may be suitable for use on this project include, but are not limited to, the following unless otherwise noted:
 - 1. 3M.
 - 2. Plymouth Rubber Company/ Bishop.
 - 3. Or Approved Equal
- B. The tape shall consist of a flexible, unsupported intumescent elastomer. The tape shall be .030 inches thick and shall be capable of 100% elongation. The tape shall be self-extinguishing and shall not support combustion. The tape shall be non-corrosive to metallic cable sheaths and compatible with synthetic cable jackets. The tape shall be secured by a band consisting of two layers of glass cloth electrical tape.

- C. Arc-proofing tape shall be 3M No. 77 with 3M Scotch No. 69 glass cloth tape or Bishop No. 53 with Plymouth/Bishop No. 77 Plyglas glass cloth tape.
- D. All fireproofing tapes shall be products of one manufacturer.

2.11 CABLE SUPPORTS

- A. Cable Supports for Vertical Conduit shall be as specified in Section 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.

2.12 CABLE TIES

- A. Cable ties shall be self-locking type with a minimum width of .180 inches.
- B. All cable ties shall be suitable for use in air handling plenums or equipment and shall be manufactured using Halar or an equal low smoke density material and shall meet UL 94V-O flammability requirement.
- C. Cable ties shall be as manufactured by the following:
 - 1. FCI Burndy.
 - 2. Panduit.
 - 3. Thomas & Betts.
 - 4. Approved Equal.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Division 01 - Administrative Requirements: Coordination and project conditions.
- B. Verify interior of building has been protected from weather.
- C. Verify mechanical work likely to damage wire and cable has been completed.
- D. Verify raceway installation is complete and supported.

3.02 PREPARATION

- A. Conduits and raceways shall be installed and completed prior to the installation of conductors.
- B. Prior to installing cables in conduits, visually inspect conduits for damage. Thoroughly swab conduits and raceways before installing conductors. Verify that bushings are in place and properly secured to prevent damage to conductors.

3.03 APPLICATION

- A. Wire and cable for miscellaneous systems, such as Intercom, CATV, CCTV, Fire Alarms, Security Alarm Systems, and Telecommunications are specified in the Technical Specification Sections for those systems.

3.04 GENERAL WIRING REQUIREMENTS

- A. Wiring shall be provided complete from point of service connection to all receptacles, lighting fixtures, power outlets, outlets for future extensions and other devices as shown. Slack wire shall be provided for all future connections. Unless otherwise specified, branch circuit conductors shall be No. 12 AWG or larger. In outlet boxes for future installations, ends of wires shall be taped and blank covers installed. Type of blank covers in finished areas are to be coordinated with Architect. Circuit identification shall be indicated on box cover and on a cable tag within the box.
- B. Cables shall not be bent either permanently or temporarily during installation to radii less than that recommended by the manufacturer.
- C. Conductors not larger than No. 10 AWG located in branch circuit panelboards, signal cabinets and switchboard shall be bundled. Conductors larger than No. 10 AWG located in switchboard, distribution panels and pullboxes shall be bundled in individual circuits. Bundling and cabling shall be done with cable ties.
- D. Use minimum No. 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet (25 m). Use minimum No. 8 AWG conductors for 20 ampere, 120 volt branch circuits longer than 200 feet (67 m). Increase conductor size for larger distances to limit voltage drop to code acceptable levels.
- E. Use minimum No. 10 AWG conductors for 20 ampere, 277 volt branch circuits longer than 200 feet (160 m).). Increase conductor size for larger distances to limit voltage drop to code acceptable levels.
- F. Where homerun circuit numbers are shown, such numbers shall be followed in connecting circuits to panelboards. Each branch circuit homerun containing two or more circuits with a common neutral shall be connected to the circuit breakers or switches in a three or four-wire branch circuit panelboard so that no two of the circuits will be fed from the same phase.
- G. Where conductors of different feeders are bundled by circuit in switchboards, distribution panels, pull boxes and cable support boxes, the conductor bundles shall be provided with arc-proofing as specified below.

3.05 INSTALLATION

- A. Route wire and cable to meet Project conditions.
- B. Neatly train and secure wiring inside boxes, equipment, and panelboards.
- C. Identify wire and cable under provisions of Section 26 05 53. Identify each conductor with its circuit number or other designation indicated. Wire shall be color coded as indicated in Item 3.7 below.
- D. Special Techniques - Building Wire in Raceway:
 - 1. Installation equipment shall be provided to prevent cutting and abrasion of conduits or conductors. Ropes used for pulling of feeders shall be made of polyethylene or other non-metallic material.

2. Pulling lines shall be attached to conductor cables by means of either woven basket grips or pulling eyes attached directly to the conductors. Rope hitches shall not be used.
 3. Pull all conductors into raceway at same time.
 4. Install building wire 4 AWG and larger with pulling equipment.
 5. Apply conductor pulling lubricant to conductors No. 4 AWG and larger as the conductors enter the raceway. For conductors No. 1/0 AWG and larger, the lubricant shall be applied as recommended by the cable manufacturer, as the conductors enter the conduit.
 6. Upon completion of conductor pulling, clean wire pulling lubricant from exposed portions of cables. If cables will not be immediately terminated, cut exposed copper conductor to insulation and seal conductor ends.
 7. Install vertical conductor supports when installing conductors. Conductor supports shall be installed in accordance with the manufacturer's instructions.
- E. Special Techniques - Cable:
1. Protect exposed cable from damage.
 2. Support cables above accessible ceiling, using spring metal clips or plastic cable ties (use only Velcro Ty-wraps for telecom cabling) to support cables from structure. Do not rest cable on ceiling panels.
 3. Use suitable cable fittings and connectors.
- F. Special Techniques - Wiring Connections:
1. Perform all connection work in strict accordance with recommendations of manufacturers of the wire and connecting devices, unless otherwise noted.
 2. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.
 3. Clean conductor surfaces before installing lugs and connectors.
 4. Apply anti-oxidation inhibitor compound containing copper to all stranded copper wire connections.
 5. Install hydraulic compression connectors for terminations, splices and taps, for conductor sizes No. 6 AWG and larger.
 6. Utilize hydraulic tools for compression connectors in accordance with manufacturers' recommendations. Tools shall be non-removable until completion of the connection and shall leave an embossed mark to verify that proper die has been used.
 7. Tools shall provide a hexagonal or circumferential crimp to the connectors. Indentation type tools are not acceptable.
 8. Splices, taps and termination lugs shall be insulated with heavy wall heat shrink tubing. Tubing shall overlap the conductor insulation by a minimum of

2-inches. The tubing shall be applied using electric heat guns. Open flames or torches shall not be used.

9. Tighten all busbar and stud connections with Belleville washers, or manufacturer standard washers, utilizing torque wrench or torque indicating washer designed for the purpose by the connector manufacturer.
10. Install solderless pressure connectors with insulating covers for copper conductor splices and taps, No. 6 AWG and larger.
11. Install insulated spring wire connectors with plastic caps for copper conductor splices and taps, No. 8 AWG and smaller.

G. Connector Application

1. Connectors applications listed shall be utilized when equipment is not provided with factory installed lugs.
2. Wire to busbar for wire sizes No. 1/0 AWG and smaller; one-hole hydraulic compression lug.
3. Wire to busbar for wire sizes No. 2/0 AWG and larger; two-hole hydraulic compression lug.
4. Wire to Stud, switch, or circuit breaker; one-hole mechanical lug.
5. Stranded wire, No. 8 AWG or larger splice, tap, or pigtail connection; hydraulic compression connector with heavy-wall heat shrink tubing or pre-molded thermoplastic insulator by connector manufacturer with two half-lapped layers of vinyl tape.

H. Install solid conductor for feeders and branch circuits No. 12 AWG and smaller.

- I. Where branch circuit conductors are terminated on terminal strips within equipment or control panel enclosures, stranded conductors may be used for branch circuits 10 AWG and smaller. When stranded conductors are used in lieu of solid conductors, install crimp-on terminals for conductor terminations. Do not place bare stranded conductors directly under terminal screws.

3.06 WIRE COLOR

- A. The covering of wires and cables shall have a distinctive color code for identification of individual conductors.
- B. Secondary service, feeder and branch circuit conductors throughout the electrical system shall be color coded as follows:

<u>Phase</u>	<u>208/120 Volts</u>	<u>480/277 Volts</u>
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Neutral	White	Gray or white with tracer
Ground	Green	Green
Isolated Ground	Green with tracer	

<u>Phase</u>	<u>208/120 Volts</u>	<u>480/277 Volts</u>
Neutral of Ground fault circuit	White with tracer	

- C. For conductor sizes No. 6 AWG and smaller, conductor insulation shall be color coded as indicated in the table above.
- D. For conductor sizes No. 4 and larger, conductors shall be identified colored tape or heat shrink tubing at terminals, splices and boxes. Tape shall be applied half lapped, with a minimum length of 6 inches.
- E. Neutral Conductors: When two or more neutrals are located in one conduit, individually identify each neutral to match the related phase conductor.

3.07 ARC/FIREPROOFING

- A. Where more than one set of cables, that are protected by more than one over-current protective device, are installed in a common equipment enclosure or box and any wire is larger than No. 4 AWG, then all sets of conductors shall be covered with arcproof and fireproof tape. Where necessary to facilitate taping, boxes shall be oversized.
- B. Tape shall be applied in a single layer, one half lapped, or as recommended by the manufacturer to conform to the above requirements. The tape shall be applied with the coated side next to the cable and shall be held in place with a random wrap of one half inch wide, pressure-sensitive fiberglass backed color plastic film tape. This tape shall not support combustion per ASTM.

3.08 MOTOR AND CONTROL WIRING

- A. Provide all wiring to and between motors, starters, disconnect switches and other related electrical equipment except where such items are factory wired.
- B. Provide control wiring in conduit at 120 volts or higher for control devices wired with branch circuits serving utilization equipment, unless otherwise specified in other Division of the Specifications.
- C. For control devices operating at voltages lower than 120 volts nominal, refer to the respective equipment Sections.

3.09 FIELD QUALITY CONTROL

- A. Division 01 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.
- B. In addition to any testing specified elsewhere in these Specifications, the Contractor shall perform basic testing of his work.
- C. Contractor shall verify the continuity of all branch circuit wiring.
- D. Contractor shall verify that branch circuits are properly terminated.
- E. Measure the tightness of all conductor terminations using calibrated torque drivers or torque wrenches.

- F. Verify the insulation integrity of all feeders using a 1,000 volt insulation resistance tester. Digital multi-meters shall not be used to verify insulation integrity.
- G. Inspect and test in accordance with NETA ATS, except Section 4 – Division of Responsibility.
- H. Perform inspections and tests listed in NETA ATS, Section 7.3.2 – Cables, Low-Voltage, 600 Volt Maximum.
- I. The Contractor shall provide a written report of the testing and shall include the following information:
 - 1. Name of the test technician and the technicians company.
 - 2. Contact information for the testing company.
 - 3. Date of tests, including start and stop time.
 - 4. Temperature and humidity (measured) conditions and general observation of the testing environment.
 - 5. Instruments used, including serial numbers, calibration date and documentation of calibration.
 - 6. Identification of circuit or equipment tested. Identification shall correspond to the project drawings.
 - 7. Test performed and test results.

END OF SECTION