

SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Requirements specified within this section apply to all sections in Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. National Electrical Contractors Association (NECA).
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. Z535.4, Product Safety Signs and Labels.
 - 3. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 70E, Electrical Safety Requirements for Employee Workplaces
 - 4. Underwriters Laboratories, Inc. (UL).

**1.03 COMMUNICATIONS AND BUILDING SYSTEMS/WORK DIVISION OF
RESPONSIBILITY**

- A. Telecommunications equipment, fire alarm equipment, security systems, security card readers and telephones are provided outside this Contract. Under this Contract provide raceways, outlet and junction boxes, cover plates, pull wires, and mounting terminal board as indicated.
- B. Provide complete coordination with outside contractors of building systems to insure raceways, boxes, outlets, power, etc. are located properly at rough-in.

1.04 SUBMITTALS (NOT USED)

1.05 AUTHORITY HAVING JURISDICTION APPROVAL

- A. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the 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 or label or other nationally recognized testing laboratory (NRTL) under OSHA regulations.
- C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.06 ENVIRONMENTAL CONDITIONS

- A. The following areas are classified hazardous, Class II, Division 2, Group F, due to the potential for accumulation of hazardous concentrations of combustible dusts, and for exposure to corrosive environment. Use materials and methods required for such areas.
 - 1. PAC System.
- B. All areas not identified otherwise, and specifically the following areas, are classified nonhazardous wet locations. Use industry and code acceptable materials and methods in these areas.
 - 1. Outdoor above grade areas not covered in “A” above.
 - 2. Below grade.
 - 3. Pipe galleries.
 - 4. Pump rooms.
- C. The following area is classified as indoor and dry:
 - 1. Electrical rooms.
 - 2. Administration and dry storage areas.
- D. Specific area classifications are:
 - 1. NEMA 4X
 - a. All rooms in chemical area in main process building,
 - 2. NEMA 4
 - a. Areas below grade (vaults, manholes, galleries, basements/crawl spaces)
 - 3. NEMA 12
 - a. Filter gallery
 - b. GAC gallery
 - c. Finished Water Building, Pump Room
 - d. Raw Water Intake, Pump Room
 - e. Within 20 feet of open tanks
 - 4. NEMA 3R
 - a. Outside, greater than 20 feet from open tank

- 5. NEMA 1
 - a. Generator Building
 - b. Administration areas
 - c. Finished Water Building, Electrical Room
 - d. Raw Water Intake, Electrical Room

PART 2 PRODUCTS

2.01 GENERAL

- A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.
- B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.
- C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range stated in Section 01 61 00, Common Product Requirements.
- D. Equipment and panels installed outdoors in direct sunlight shall be equipped with sun shields.
- E. Electrical ratings of materials and equipment that are reduced by increased elevation shall be derated as required for Site elevation specified in Section 01 61 00, Common Product Requirements.

2.02 EQUIPMENT FINISH

- A. Manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment in accordance with Section 09 90 00, Painting and Coating.

2.03 NAMEPLATES

- A. Material: Laminated plastic.
- B. Attachment Screws: Stainless steel.
- C. Color: White, engraved to a black core.
- D. Letter Height:

1. Pushbuttons/Selector Switches: 1/8 inch.
2. Other electrical equipment: 1/4 inch.

2.04 SIGNS AND LABELS

- A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

PART 3 EXECUTION

3.01 GENERAL

- A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer and in compliance with NFPA 70 (NEC).
- B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, heaters, ducts, mechanical equipment, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing as to the agreed upon solution reached by the affected trades involved.
- C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.
- D. Keep openings in boxes, raceways, and equipment closed during construction.
- E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of the Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

3.02 ANCHORING AND MOUNTING

- A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for seismic zone criteria given in Section 01 61 00, Common Product Requirements.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

- A. Homerun circuits shown on Drawings indicate functional wiring requirements for power and control circuits. Circuits may be combined into common raceways in accordance with the following requirements:
1. Analog control circuits from devices in same general area to same destination.
 - a. No power or AC discrete control circuits shall be combined in the same conduit with analog circuits.
 - b. No Class 2 or Class 3 circuits, including but not limited to, HVAC control circuits, fire alarm circuits, paging system circuits, shall be combined with power or Class 1 circuits.
 - c. Analog circuits shall be continuous and not spliced from source to destination. Do not add terminal junction box, splice, or combine into a multi-pair cable without authorization of the Engineer.
 - d. Unless otherwise noted on plans, raceways shall be sized per the National Electrical Code and shall not exceed 40 percent fill.
 - e. Changes shall be documented on record drawings.
 2. Discrete control circuits from devices in the same general area to the same destination.
 - a. No power or analog control circuits shall be combined in same conduit with discrete circuits.
 - b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
 - c. Unless otherwise noted on plans, raceways shall be sized per the National Electrical Code and shall not exceed 40 percent fill.
 - d. Changes shall be documented on record drawings.
 3. Power circuits from loads in same general area to same source location (such as: panelboard, switchboard, low voltage motor control center).
 - a. Lighting Circuits: Combine no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
 - b. Receptacle Circuits, 120-Volt Only: Combine no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
 - c. All Other Power Circuits: Do not combine power circuits without authorization of Engineer.
 - d. Unless otherwise noted on plans, raceways shall be sized per the National Electrical Code and shall not exceed 40 percent fill.

3.04 NAMEPLATES, SIGNS, AND LABELS

- A. Arc Flash Protection Warning Signs:

26 05 02 - 5

1. Provide OSHA-recognized labels suitable for outdoor and U.V. exposure. Field mark switchboards, motor control centers, and panelboards to warn of potential arc-flash hazards. Locate marking to be clearly visible to personnel.
 2. Calculate arc flash boundary and energy in accordance with NFPA 70E. Determine the level of personnel protective equipment (PPE) required. Warning label on equipment shall include flash hazard boundary, energy level, PPE level, shock hazard, bolted fault current, equipment name, and a description of all PPE required to work on live equipment.
 3. Use calculated available short circuit current as basis for calculations.
- B. Multiple Power Supply Signage: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying the building, and the area served by each.
- C. Equipment Nameplates:
1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.
 2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.
 3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.
 4. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.

3.05 CLEANING AND TOUCHUP PAINTING

- A. Cleaning: Throughout the Work, clean the interior and exterior of devices and equipment by removing debris and vacuuming.
- B. Touchup Paint:
1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment. Match finish, color, consistency and type of surface with original finish.
 2. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than the original factory finish, meets requirements of this Specification, and is acceptable to the Engineer.

3.06 PROTECTION FOLLOWING INSTALLATION

- A. Protect materials and equipment from corrosion, physical damage, and effects of moisture.
- B. When equipment intended for indoor installation is installed at Contractor's convenience in areas subject to dampness, moisture, dirt or other adverse atmosphere, ensure adequate supplemental protection is provided to prevent damage or corrosion.

END OF SECTION

SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

- A. The following standards shall apply to equipment, materials, devices and methods covered by this specification:
1. ASTM International (ASTM):
 - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
 - c. E814, Method of Fire Tests of Through-Penetration Fire Stops.
 2. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
 3. Instrumentation, Systems, and Automation Society (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation-Part 1: Intrinsic Safety.
 4. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. AB 1, Molded Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
 - c. C12.1 Code for Electricity Metering
 - d. CP 1, Shunt Capacitors.
 - e. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - f. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
 - g. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
 5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 6. Underwriters Laboratories Inc. (UL):
 - a. 98, Standard for Enclosed and Dead-Front Switches.
 - b. 248, Standard for Low Voltage Fuses.
 - c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
 - d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - e. 508, Standard for Industrial Control Equipment.
 - f. 810, Standard for Capacitors.

- g. 943, Standard for Ground-Fault Circuit-Interrupters.
- h. 1059, Standard for Terminal Blocks.
- i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.02 SUBMITTALS

A. Action Submittals:

- 1. Provide manufacturers' data for the following:
 - a. Control devices.
 - b. Control relays.
 - c. Circuit breakers.
 - d. Fused switches.
 - e. Nonfused switches.
 - f. Timers.
 - g. Fuses.
 - h. Magnetic contactors.
 - i. Intrinsic safety barriers.
 - j. Firestopping.
 - k. Enclosures: Include enclosure data for products having enclosures.

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts:

- 1. Fuses, 5,500 Volts and 15,500 Volts: Two of each type for each current rating installed.

PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

- 1. Type: Molded case.
- 2. Trip Ratings: 15-800 amps.
- 3. Voltage Ratings: 120, 240, 277, 480, and 600 Vac.
- 4. Suitable for mounting and operating in any position.
- 5. NEMA AB 1 and UL 489.

B. Operating Mechanism:

- 1. Locking provisions for padlocking breaker in open position.
- 2. ON/OFF and TRIPPED indicating positions of operating handle.
- 3. Operating handle to assume a center position when tripped.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Calibrated for 40 degrees C ambient, unless shown otherwise.
6. Do not provide single-pole circuit breakers with handle ties for multi-pole operation.

D. Short Circuit Interrupting Ratings:

1. Not less than the following RMS symmetrical currents for the indicated trip ratings or the available calculated fault current at the location used:
 - a. Up to 100A, less than 250 Vac: 10,000.
 - b. Up to 100A, 250-600 Vac: 14,000.
 - c. Over 100A: 22,000.
2. Series Connected Ratings: Do not apply series connected short circuit ratings.

E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel). Provide:

1. Ground fault sensor shall be rated same as circuit breaker.
2. Push-to-test button.

F. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).

G. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.

H. Accessories: Where required by plans or code, provide shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, or multiple lugs. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.

I. Connections:

1. Mechanical wire lugs, except crimp compression lugs where shown.

2. Lugs shall be removable/replaceable for breaker frames greater than 100 amperes.
3. Suitable for 75 degrees spare conductors without derating breaker or conductor ampacity.
4. Use bolted bus connections.

J. Enclosures for Independent Mounting:

1. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel. Provide handle that can be locked in the open or closed position.

2.02 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

- A. UL 98 listed for use and location of installation.
- B. NEMA KS 1.
- C. Short Circuit Rating: 200,000 amps RMS symmetrical with Class R, Class J, or Class L fuses installed.
- D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- E. Connections:
1. Mechanical lugs.
 2. Lugs removable/replaceable.
 3. Suitable for 75 degrees Crated conductors at NEC 75 degrees C ampacity.
- F. Fuse Provisions:
1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
 2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.
- G. Enclosures: See Article Enclosures.
- H. Interlock enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel. Provide handle that can be locked in the OPEN position.

2.03 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

- A. NEMA KS 1.
- B. Quick-make, quick break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.
- D. Auxiliary Contact:
 - 1. Operation: Make before power contacts make and break before power contacts break.
 - 2. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.
- E. Enclosures: See Article Enclosures.
- F. Interlock Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.04 FUSE, 250-VOLT AND 600-VOLT

- A. Power Distribution, General:
 - 1. Current-limiting, with 200,000 ampere rms interrupting rating.
 - 2. Provide to fit mountings specified with switches.
 - 3. UL 248.
- B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:
 - 1. Class: RK-1.
 - 2. Type: Dual element, with time delay.
 - 3. Manufacturers and Products:
 - a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
 - b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).
- C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:
 - 1. Class: L.
 - 2. Double O-rings and silver links.
 - 3. Manufacturers and Products:
 - a. Bussmann; Type KRP-C.
 - b. Littelfuse, Inc.; Type KLPC.
- D. Cable Limiters:

1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
2. Manufacturer and Product: Bussmann; K Series.

E. Ferrule:

1. 600V or less, rated for applied voltage, small dimension.
2. Ampere Ratings: 1/10 amp to 30 amps.
3. Dual-element time-delay, time-delay, or nontime-delay as required.
4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
 - a. Bussmann.
 - b. Littlefuse, Inc.

2.05 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

- A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.
- B. Selector Switch Operating Lever: Standard.
- C. Indicating Light: Push-to-test, transformer-type. LED
- D. Pushbutton Color:
 1. ON or START: Black.
 2. OFF or STOP: Red.
- E. Lamp Color:
 1. Running: Green
 2. Stop: Red
 3. Transition: White
- F. Legend Plate:
 1. Material: Aluminum.
 2. Engraving: Enamel filled with high contrasting color.
 3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
 4. Letter Height: 7/64-inch.
- G. Manufacturers and Products (LED versions of the following):
 1. Heavy-Duty, Oil-Tight Type:

- a. General Electric Co.; Type CR 104P.
- b. Square D Co.; Type T.
- c. Eaton/Cutler-Hammer; Type 10250T.
- 2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
 - a. Square D Co.; Type SK.
 - b. General Electric Co.; Type CR 104P.
 - c. Eaton/Cutler-Hammer; Type E34.
 - d. Crouse-Hinds; Type NCS.

2.06 TERMINAL BLOCK, 600 VOLTS

- A. UL 486E and UL 1059.
- B. Size components to allow insertion of necessary wire sizes.
- C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.
- D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.
- E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.
- F. Yoke shall guide all strands of wire into terminal.
- G. Current bar shall ensure vibration-proof connection.
- H. Terminals:
 - 1. Capable of wire connections without special preparation other than stripping.
 - 2. Capable of jumper installation with no loss of terminal or rail space.
 - 3. Individual, rail mounted.
- I. Marking system: Preprinted or field-marked tags.
- J. Manufacturers:
 - 1. Weidmuller, Inc.
 - 2. Allen-Bradley.
 - 3. Phoenix Contact.

2.07 MAGNETIC CONTROL RELAY

- A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.
- B. Continuous and switching contact rating: 10amps
- C. Accessories:
 - 1. Push-to-Test button.
 - 2. Relay status LED.
- D. Mounting: Can be mounted on din rail or panel.
- E. Manufacturers and Products:
 - 1. Eaton/Cutler-Hammer; Type D3PF Series
 - 2. General Electric Co.
 - 3. Allen-Bradley; 700-HB

2.08 TIME DELAY RELAY

- A. Industrial relay with contacts rated 8 amps continuous, 2000VA make or break.
- B. Solid-state electronic, field convertible ON/OFF delay.
- C. One normally open and one normally closed contact (minimum).
- D. Repeat accuracy plus or minus 2 percent.
- E. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.
- F. Manufacturers and Products:
 - 1. Allen-Bradley; 700-HR
 - 2. Eaton/Cutler-Hammer. Type TR
 - 3. General Electric Co.

2.09 ELAPSED TIME METER

- A. Drive: Synchronous motor.
- B. Range: 0 hour to 99,999.9 hours, nonreset type.
- C. Mounting: Semiflush panel.

D. Manufacturers and Products:

1. General Electric Co.; Type 240, 2-1/2-inch Big Look.
2. Eagle Signal Controls; Bulletin 705.

2.10 MAGNETIC CONTACTOR

A. UL listed.

B. Electrically operated, electrically held.

C. Main Contacts:

1. Power driven in one direction with mechanical spring dropout.
2. Silver alloy with wiping action and arc quenchers.
3. Continuous-duty, rated as shown.
4. Poles: As shown.

D. Control: As shown.

E. Auxiliary Contacts: Unless otherwise indicated in plans or control circuit, provide a minimum of one normally open and one normally closed, rated 7200VA make, 720VA break, at 600V, A600 per NEMA ICS 5.

F. Enclosures: See Article Enclosures.

G. Manufacturers and Products:

1. Eaton/Cutler-Hammer; Class A201.
2. General Electric Co.; CR 353.
3. Square D Co.; Class 8910.

2.11 PHASE MONITOR RELAY

A. Features:

1. Voltage and phase monitor relay shall drop out on low voltage, voltage unbalance, loss of phase, or phase reversal.
2. Contacts: Single-pole, double-throw, 10 amperes, 120/240 Vac. Where additional contacts are shown or required, provide magnetic control relays.
3. Adjustable trip and time delay settings.
4. Transient Protection: 1,000 Vac.
5. Mounting: Multipin plug-in socket base.

B. Manufacturer and Product: Automatic Timing and Controls; SLD Series.

2.12 MAGNETIC LIGHTING CONTACTOR

- A. Comply with NEMA ICS 2; provide UL 508 listing.
- B. Electrically operated by dual-acting, single coil mechanism.
- C. Inherently interlocked and electrically held in CLOSED position.
- D. Main Contacts:
 - 1. Double-break, continuous-duty, rated as shown, 600 volts, withstand rating of 14,000 amps rms symmetrical at 480 volts.
 - 2. Marked for electric discharge lamps, tungsten, and general purpose loads.
 - 3. Position not dependent on gravity, hooks, latches, or semi-permanent magnets.
 - 4. Capable of operating in any position.
 - 5. Visual indication for each contact.
- E. Auxiliary contact relay for three-wire Form C control.
- F. One normally open and one normally closed auxiliary contact rated 10 amperes continuous, 7,200VA make, 720VA break with NEMA designation of A600 (600 volts).
- G. Fully rated neutral terminal.
- H. Provision for remote pilot lamp with use of auxiliary contacts.
- I. Clamp type, self-rising terminal plates for solderless connections.
- J. Enclosures: See Article Enclosures.
- K. Manufacturers and Products:
 - 1. ASCO.
 - 2. Eaton/Cutler-Hammer; Class A202.
 - 3. General Electric Co.; Class 360 (electrically held).
 - 4. Square D; Class 8903, Type L (electrically held).

2.13 INDUSTRIAL CAPACITORS

- A. UL 810, NEMA CP 1, IEEE 18, and NFPA 70, Article 460.

- B. Enclosed, indoor, dustproof, three-phase capacitor units containing internally mounted, indicating type, high interrupting-capacity, current-limiting fuses, and discharge resistors.
- C. Units containing PCB dielectric fluid are unacceptable.
- D. Kilovar Ratings:
 - 1. Check motor nameplate, manufacturer's power factor, and no-load current data for actual motor installed.
 - 2. Reduce capacitor rating, if required. Do not exceed motor manufacturer's recommended maximum size, and do not exceed value required to raise motor no-load power factor to 0.95.
- E. Manufacturers:
 - 1. General Electric Co.
 - 2. Square D Co.

2.15 SUPPORT AND FRAMING CHANNELS

- A. Carbon Steel Framing Channel:
 - 1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/A1011M, Grade 33.
 - 2. Finish: Hot-dip galvanized after fabrication.
- B. Paint Coated Framing Channel: Carbon steel framing channel with electro-deposited rust inhibiting acrylic or epoxy paint.
- C. PVC Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.
- D. Stainless Steel Framing Channel: Rolled, ASTM A167, Type 316 stainless steel, 12-gauge minimum.
- E. Extruded Aluminum Framing Channel:
 - 1. Material: Extruded from Type 6063-T6 aluminum alloy.
 - 2. Fittings fabricated from Alloy 5052-H32.
- F. Nonmetallic Framing Channel:
 - 1. Material: Fire retardant, fiber reinforced vinyl ester resin.
 - 2. Channel fitting of same material as channel.
 - 3. Nuts and bolts of long glass fiber reinforced polyurethane.

G. Manufacturers:

1. B-Line Systems, Inc.
2. Unistrut Corp.
3. Aickinstrut.

2.16 INTRINSIC SAFETY BARRIER

- A. Provides a safe energy level for exposed wiring in a Class I, Division 1 or Division 2 hazardous area when circuit is connected to power source in nonhazardous area.
- B. Rating: Power source shall be rated 24 volts dc, nominal, with not more than 250 volts available under fault conditions.
- C. Contact Rating: 5 amps, 250 volts ac.
- D. Mounting: Rail or surface.
- E. Manufacturers and Products:
 1. MTL, Inc.; Series 2000 or Series 3000.
 2. R. Stahl, Inc.

2.17 SWITCHBOARD MATTING

- A. Provide matting having a breakdown voltage of 20 kV minimum.
- B. Manufacturer: U.S. Mat and Rubber Company.

2.18 FIRESTOPS

- A. General:
 1. Refer to architectural plans for fire/smoke barriers.
 2. Provide UL 1479 classified hourly fire-rating equal to, or greater than, the assembly penetrated.
 4. Sealants and accessories shall have fire-resistance ratings in accordance with ASTM E814, by Underwriters Laboratories Inc., or other NRTL recognized by OSHA and local AHJ.
- B. Firestop System:
 1. Formulated for use in indirect contact with cables and conduit.

2. Fill, Void, or Cavity Material: 3M Brand Fire Barrier Caulk CP25, Putty 303, Wrap/Strip FS195, Composite Sheet CS195 and Penetration Sealing Systems 7902 and 7904 Series.
3. Two-Part, Foamed-In-Place, Silicone Sealant: Dow Corning Corp. Fire Stop Foam, General Electric Co. Pensil 851.
4. Fire Stop Devices: See Section 26 05 33, Raceways and Boxes, for raceway and cable fittings.

2.19 ENCLOSURES

- A. Finish: Sheet metal parts shall be completely painted using an electrode position process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.
- B. Color: Manufacturer's standard color (gray) baked-on enamel, unless otherwise shown.
- C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.
- D. Enclosure Selections: Except as shown otherwise, provide electrical enclosures according to the following table:

ENCLOSURES				
Location	Finish	Environment	NEMA 250 Type	IP Rating
Indoor	Finished	Dry	1	IP20
Indoor	Unfinished	Dry	1	IP20
Indoor	Unfinished	Industrial Use	12	IP54
Indoor and Outdoor	Any	Denoted "WP"	3R	IP24
Indoor and Outdoor	Any	Wet	4	IP56
Indoor and Outdoor	Any	Wet, Dust or Oil	4	IP56
Indoor and Outdoor	Any	Wet and Corrosive	4X 316 Stainless Steel	IP66
Indoor and Outdoor	Any	Hazardous Gas	7	--
Indoor and Outdoor	Any	Hazardous Dust	9	--

PART 3 - EXECUTION

3.01 GENERAL

- A. Install equipment in accordance with manufacturer's recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

- A. Unless otherwise shown, install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.
- B. Unless otherwise shown, install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas.

3.03 INDUSTRIAL CAPACITORS

- A. Provide suitable hangers or mounting brackets.

3.04 SUPPORT AND FRAMING CHANNEL

- A. Install where required for mounting and supporting electrical equipment, raceway, cable tray systems, panels, boxes, devices, etc.
- B. Channel Type:
 - 1. Interior, Wet or Dry (Noncorrosive) Locations:
 - a. Aluminum Raceway: Extruded aluminum.
 - b. Steel Raceway, PVC, and other systems not covered: Carbon steel or paint coated.
 - 2. Interior, Corrosive (Wet or Dry) Locations:
 - a. Aluminum Raceway: Extruded aluminum.
 - b. PVC Conduit: Type 316 stainless steel or nonmetallic.
 - c. Other systems not covered: Type 316 stainless steel or nonmetallic.
 - 3. Outdoor, Noncorrosive Locations:
 - a. Steel Raceway: Carbon steel or paint coated framing channel, except where mounted on aluminum handrail, then use aluminum framing channel.
 - b. Aluminum Raceway and other systems not covered: Aluminum framing channel.
 - 4. Outdoor Corrosive Locations:
 - a. PVC Conduit: Type 316 stainless steel or nonmetallic.
 - b. Aluminum Raceway: Aluminum.
 - c. Other systems not covered: Type 316 stainless steel or nonmetallic.

C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
3. Nonmetallic Channel: Epoxy resin sealer.

3.05 INTRINSIC SAFETY BARRIERS

- A. Install in compliance with ISA RP12.06.01.
- B. Arrange conductors such that wiring from hazardous areas cannot short to wiring from nonhazardous area.
- C. Stencil "INTRINSICALLY SAFE CIRCUIT" on all boxes enclosing barriers.

3.06 SWITCHBOARD MATTING

- A. Install 36-inch width at switchgear, switchboard, motor control centers, and panelboards.
- B. Matting shall run full length of all sides of equipment that have operator controls or afford access to devices.

3.07 FIRESTOPS

- A. Install in strict conformance with manufacturer's instructions. Comply with installation requirements established by testing and inspecting agency.
- B. Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION

SECTION 26 05 05 CONDUCTORS

PART 1 GENERAL

1.01 REFERENCES

- A. The following standards apply to materials and methods specified in this section:
1. Association of Edison Illuminating Companies (AEIC):
 - a. CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 kV through 46 kV.
 2. ASTM International (ASTM):
 - a. B3, Standard Specification for Soft or Annealed Copper Wire.
 - b. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - c. B263, Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors.
 3. Electronic Industries Alliance (EIA), Telecommunications Industry Association (TIA): TIA-568-B, Commercial Building Telecommunications Cabling Standard.
 4. Insulated Cable Engineer's Association, Inc. (ICEA):
 - a. S-58-679, Standard for Control Cable Conductor Identification.
 - b. S-73-532, Standard for Control Cables.
 - c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
 5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations 2.5 kV through 765 kV
 - b. 386, Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
 - c. 404, Standard for Extruded And Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
 6. National Electrical Manufacturers' Association (NEMA):
 - a. CC 1, Electric Power Connectors for Substations.
 - b. WC 55, Instrumentation Cables and Thermocouple Wire.
 - c. WC 70, Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
 - d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.
 - e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
 7. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).

- b. 262, Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
- 8. Underwriters Laboratories Inc. (UL):
 - a. 13, Standard for Safety Power-Limited Circuit Cables.
 - b. 44, Standard for Safety Thermoset-Insulated Wires and Cables.
 - c. 62, Standard for Safety Flexible Cord and Fixture Wire.
 - d. 486A-486B, Wire Connectors.
 - e. 486C, Standard for Splicing Wire Connections.
 - f. 510, Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
 - g. 854, Standard for Safety Service-Entrance Cables.
 - h. 1072, Standard for Safety Medium-Voltage Power Cables.
 - i. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - j. 1569, Metal Clad Cables.
 - k. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Action Submittals:

- 1. Wire and cable descriptive product information.
- 2. Wire and cable accessories descriptive product information.
- 3. Cable fault detection system descriptive product information.
- 4. Manufactured wire systems descriptive product information.
- 5. Manufactured wire systems rating information.
- 6. Manufactured wire systems dimensional drawings.
- 7. Manufactured wire systems special fittings.
- 8. Busway descriptive product information.
- 9. Busway rating information.
- 10. Busway dimensional drawings.
- 11. Busway special fitting information.
- 12. Busway-equipment interface information for equipment to be connected to busways.
- 13. Cable Pulling Calculations:
 - a. Calculations shall be submitted and reviewed before cable installation.
 - b. Provide cable pulling calculations for the following cable installations:
 - 1) Medium voltage cable runs that cannot be hand pulled.
 - 2) Multi-conductor 600-volt cable sizes larger than #2 AWG that cannot be hand pulled.
 - 3) Power and control conductor, and control and instrumentation cable installations in ductbanks.
 - 4) Feeder circuits, single conductors #4/0 and larger.

- B. Informational Submittals:
 - 1. Journeyman Lineman splicing credentials.

1.03 QUALITY ASSURANCE

- A. Authority Having Jurisdiction (AHJ):
 - 1. Provide the work in accordance with NFPA 70. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
 - 2. 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.
- B. Terminations and Splices for Conductors above 600 Volts: Work shall be done by Journeyman Lineman with splicing credentials.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

- A. Conform to applicable requirements of NEMA WC 70.
- B. Conductor Type: copper.
- C. Insulation: Type THHN/THWN-2, except for sizes No.6 and larger, with XHHW-2 or Type USE insulation.
 - 1. Above 120 volts to ground, RHW/USE insulation
 - 2. 120 volts or less to ground, RHW/USE, XHHW, or THWN/THHN insulation.
 - 3. Grounding conductors installed in raceways, RHW, THHN/THWN, or XHHW insulation.
 - 4. Control conductors, THHN/THWN insulation.
- D. Direct Burial and Aerial Conductors and Cables:
 - 1. Type USE/RHH/RHW insulation, UL 854 listed, or Type RHW-2/USE-2.
 - 2. Conform to physical and minimum thickness requirements of NEMA WC 70.
- E. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.02 CONDUCTORS ABOVE 600 VOLTS

A. EPR Insulated Cable:

1. Extrusion: Single-pass, triple-tandem, of conductor screen, insulation, and insulation screen.
2. Type: 5 kV and 15 kV, shielded, UL 1072, Type MV-105.
3. Conductors: Copper, concentric lay Class B round stranded in accordance with ASTM B3, ASTM B8, and ASTM B263/B496.
4. Strand Fill: Waterproof strand compound enclosing all conductors.
5. Conductor Screen: Extruded, semiconducting ethylene-propylene rubber in accordance with NEMA WC 71 and AEIC CS 6.
6. Insulation: 133 percent insulation level, ethylene-propylene rubber (EPR), containing no polyethylene in accordance with NEMA WC 71, and AEIC CS 6/8.
7. Insulation Thickness: 115-mil for 5 kV, nominal. 220-mil for 15 kV, nominal.
8. Insulation Screen: Thermosetting, semiconducting ethylene-propylene rubber (EPR), extruded directly over insulation in accordance with NEMA WC 74 and AEIC CS 6/8.
9. Metallic Shield: Uncoated, 5-mil, copper shielding tape, helically applied with 12-1/2 percent minimum overlap.
10. Jacket: Sunlight resistant extruded polyvinyl chloride (PVC) compound applied in accordance with NEMA WC 71 or NEMA WC 74
11. Operating Temperature: 105 degrees C continuous normal operations, 130 degrees C emergency operating conditions, and 250 degrees C short-circuit conditions.
12. Manufacturers:
 - a. Okonite Co.
 - b. Pirelli Wire and Cable.
 - c. General Cable.
 - d. Southwire Co.
 - e. Kerite

2.03 600-VOLT RATED CABLE

A. General:

1. 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.

2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 1, Multiconductor Control Cable:

1. Conductors:
 - a. No. 14 AWG, seven-strand copper.
 - b. Insulation: 15-mil PVC with 4-mil nylon.
 - c. UL 1581 listed as Type THHN/THWN rated VW-1.
 - d. Conductor group bound with spiral wrap of barrier tape.
 - e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
2. Cable: Passes the ICEA T-29-520 210,000 Btu per hour Vertical Tray Flame Test.
3. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:
 - a. Okonite Co.
 - b. Southwire.
 - c. Belden Inc.

C. Type 2, Multiconductor Power Cable:

1. General:
 - a. Meet or exceed UL 1581 for cable tray use.

- b. Meet or exceed UL 1277 for direct burial and sunlight-resistance.
- c. Overall jacket: PVC.
- 2. Conductors:
 - a. Class B stranded, coated copper.
 - b. Insulation: Chemically cross-linked ethylene-propylene or cross-linked polyethylene.
 - c. UL rated VW-1 or listed Type XHHW-2.
 - d. Color Code:
 - 1) Conductors, size No. 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
 - 2) Conductors, size No. 6 AWG and larger, ICEA S-73-532, Method 4.
- 3. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
- 4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2	0.42	45
		3	0.45	45
		4	0.49	45
10	10	2	0.54	60
		3	0.58	60
		4	0.63	60
8	10	3	0.66	60
		4	0.75	
6	8	3	0.66	60
		4	0.75	
4	6	3	0.74	60
		4	0.88	
2	6	3	1.01	80
		4	1.16	
1	6	3	1.10	80
		4	1.25	
1/0	6	3	1.22	80
		4	1.35	
2/0	4	3	1.40	80
		4	1.60	
3/0	4	3	1.40	80
		4	1.60	
4/0	4	3	1.56	80
		4	1.78	110

5. Manufacturers:
 - a. Okonite Co.
 - b. Southwire.
- D. Type 3, No. 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
1. Outer Jacket: 45-mil nominal thickness.
 2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
 3. Dimension: 0.31-inch nominal OD.
 4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. 20 AWG, seven-strand tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nominal nylon.
 - e. Color Code: Pair conductors, black and red.
 5. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.
- E. Type 4, No. 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
1. Outer Jacket: 45-mil nominal.
 2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
 3. Dimension: 0.32-inch nominal OD.
 4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. 20 AWG, seven-strand, tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nylon.
 - e. Color Code: Triad conductors black, red, and blue.
 5. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.

- F. Type 5, No. 18 AWG, Multi-Twisted, Shielded Pairs with a Common, Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 55 requirements.

1. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
 - b. Tinned copper drain wires.
 - c. Pair drain wire size AWG 20, group drain wire size AWG 18.
 - d. Insulation: 15-mil PVC.
 - e. Jacket: 4-mil nylon.
 - f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
 - g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
3. Cable Sizes:

Cable Sizes: Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	60
24	1.16	80
36	1.33	80
50	1.56	80

4. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.

- G. Type 6, No. 18 AWG, Multi-Twisted Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 55.

1. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
 - b. Tinned copper drain wire size AWG 18.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nylon.

- e. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

Cable Sizes: Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.48	45
8	0.63	60
12	0.75	60
16	0.83	60
24	1.10	80
36	1.21	80
50	1.50	80

3. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.

2.04 300-VOLT RATED CABLE

A. General:

1. Type PLTC, meeting requirements of UL 13 and NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 105 degrees C.
5. Passes Vertical Tray Flame Test.
6. Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 24, Twisted Pair Fire Alarm Cable, Shielded: Power limited fire protective signaling circuit cable meeting requirements of NFPA 70, Article 760.

1. Cable: Pass NFPA 262, 70,000 Btu flame test and listed by State Fire Marshall.
2. Outer Jacket: Red in color, identified along its entire length as fire protective signaling circuit cable.

3. Conductors:
 - a. Solid, tinned, or bare copper, shielded with stranded, tinned copper drain wire.
 - b. Insulation: 15-mil PVC.
 - c. Group Shield: Aluminum/mylar spiral wound along entire length.
4. Cable Sizes:

Wire Size	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Inches)
12	0.36	0.042
14	0.32	0.042
16	0.26	0.037
18	0.23	0.037

5. Manufacturers:
 - a. Alpha Wire Corp.
 - b. Triangle PWC, Inc.

2.05 SPECIAL CABLES

- A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:
 1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-B.2-1 Category 6 requirements.
 2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
 3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
 4. NFPA 70 Plenum (CMP) rated, comply with flammability plenum requirements of NFPA 70 and NFPA 262.
 5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
 6. Manufacturer and Product: Belden; 7852A.
- B. Type 34, Profibus PA Cable, 300V:
 1. Outer Jacket: PVC.
 2. Shield: Aluminum foil-polyester tape, 20 AWG tinned copper drain wire.
 3. Dimension: 0.253-inch nominal OD.
 4. Conductors:
 - a. 18 AWG stranded tinned copper.
 - b. Insulation: polyolefin.

5. Manufacturer and Product: Belden; 3076F.

2.06 GROUNDING CONDUCTORS

- A. Equipment: Copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN insulation, #6 minimum.
- B. Direct Buried: Bare stranded copper, #6 and larger, solid #8 and smaller for power, stranded for instrumentation and controls.

2.07 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

- A. Tape:
1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
 2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
 3. Arc and Fireproofing:
 - a. 30-mil, elastomer.
 - b. Manufacturers and Products:
 - 1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
 - 2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.
- B. Identification Devices:
1. Sleeve:
 - a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
 - b. Manufacturers and Products:
 - 1) Raychem; Type D-SCE or ZH-SCE.
 - 2) Brady, Type 3PS.
 2. Heat Bond Marker:
 - a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
 - b. Self-laminating protective shield over text.
 - c. Machine printed black text.
 - d. Manufacturer and Product: 3M Co.; Type SCS-HB.
 3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
 4. Tie-On Cable Marker Tags:
 - a. Chemical resistant white tag.
 - b. Size: 1/2 inch by 2 inches.

- c. Manufacturer and Product: Raychem; Type CM-SCE.
- 5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

- 1. Nylon, Self-Insulated Crimp Connectors:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulug.
 - 3) ILSCO.
- 2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Seamless.
 - c. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulink.
 - 3) ILSCO; ILSCONS.
- 3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
 - a. UL 486C.
 - b. Plated steel, square wire springs. c. Manufacturers and Products:
 - 1) Thomas & Betts.
 - 2) Ideal; Twister.
- 4. Self-Insulated, Set Screw Wire Connector:
 - a. Two piece compression type with set screw in brass barrel.
 - b. Insulated by insulator cap screwed over brass barrel.
 - c. Manufacturers:
 - 1) 3M Co.
 - 2) Thomas & Betts.
 - 3) Marrette.

D. Cable Lugs:

- 1. In accordance with NEMA CC 1.
- 2. Rated 600 volts of same material as conductor metal.
- 3. Uninsulated Crimp Connectors and Terminators:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Manufacturers and Products:
 - 1) Thomas & Betts; Color-Keyed.
 - 2) Burndy, Hydent.
 - 3) ILSCO.
- 4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Locktite.

- 2) Burndy; Quiklug.
- 3) ILSCO.

E. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation:

1. Thermally stabilized cross-linked polyolefin.
2. Manufacturer and Product: Thomas & Betts; SHRINK-KON.

G. Data Cable Accessories: Terminators, connectors, and junctions necessary for a complete system.

2.08 ACCESSORIES FOR CONDUCTORS ABOVE 600 VOLTS

A. There are 2 types of interface systems within the treatment plant (Large and Small). Provide accessories that match interfaces of owner furnished transformers.

A. Elbow Connector Systems:

1. Molded, peroxide-cured, EPDM-insulated, Class 5 kV and 15 kV, 150 kV BIL, 200A, 10,000A rms load-break elbows having copper current-carrying parts in accordance with IEEE 386.
2. Protective Caps: Class 5 kV and 15 kV, 150 kV BIL, 200 amperes, with molded EPDM insulated body.
3. Insulated Standoff Bushings: Class 5 kV and 15 kV, 150 kV BIL, 200 amperes, complete with EPDM rubber body, stainless steel eyebolt with brass pressure foot, and stainless steel base bracket.
4. Bushing Inserts: Class 5 kV and 15 kV, 150 kV BIL, 200A, load-break with EPDM rubber body and all-copper, current-carrying parts.
5. Mounting Plates: Two-way, ASTM A167 stainless steel, complete with universal mounting brackets, grounding lugs and two parking stands.
6. Manufacturers:
 - a. Cooper Industries.
 - b. Elastimold.

A. Molded Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than the cable ampacity, conforming to IEEE 404.

3. Class 5 kV and 15 kV, with compression connector, EPDM molded semiconductive insert, peroxide-cured EPDM insulation, and EPDM molded semiconductive outer shield.
4. Premolded splice shall be rejaacketed with a heat shrinkable adhesive-lined sleeve to provide a waterproof seal.
5. Manufacturers:
 - a. Elastimold.
 - b. Cooper Industries.

B. Heat Shrinkable Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than the cable ampacity, conforming to IEEE 404.
3. Class 5 kV and 15 kV, with compression connector, splice insulating and conducting sleeves, stress-relief materials, shielding braid and mesh, and abrasion-resistant heat shrinkable adhesive-lined rejaacketing sleeve to provide a waterproof seal.
4. Manufacturers:
 - a. Raychem.
 - b. 3M Co.

C. Termination Kits:

1. Capable of terminating 5 kV and 15 kV, single-conductor, polymeric-insulated cables plus a shield ground clamp.
2. Capable of producing a termination with a current rating equal to, or greater than, the cable ampacity, meeting Class I requirements of IEEE48.
3. Capable of accommodating any form of cable shielding or construction without the need for special adapters or accessories.
4. Manufacturers:
 - a. Raychem.
 - b. 3M Co.

D. Bus Connection Insulation:

1. Heat shrinkable tubing, tape, and sheets of flexible cross-linked polymeric material formulated for high dielectric strength.
2. Tape and sheet products to have coating to prevent adhesion to metal surfaces.
3. Manufacturer: Raychem.

E. Cable Lugs:

1. In accordance with NEMA CCI.

2. Rated 5 kV and 15 kV of same material as conductor metal.
3. Manufacturers and Products, Uninsulated Compression Connectors and Terminators:
 - a. Burndy; Hydent.
 - b. Thomas & Betts; Color-Keyed.
 - c. ILSCO.
4. Manufacturers and Products, Uninsulated, Bolted, Two-Way Connectors and Terminators:
 - a. Thomas & Betts; Locktite.
 - b. ILSCO.

2.09 PULLING COMPOUND

- A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.
- B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.
- C. Approved for intended use by cable manufacturer.
- D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.
- E. Manufacturers:
 1. Ideal Co.
 2. Polywater, Inc.
 3. Cable Grip Co.

2.10 WARNING TAPE

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

2.11 SOURCE QUALITY CONTROL

- A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.
- B. Conductors Above 600 Volts: Test in accordance with NEMA WC 71 and AEIC CS 6/8 partial discharge level test for EPR insulated cable.

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, cabinets, 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 a mandrel approximately 1/4 inch smaller than raceway inside diameter, through each raceway.
- 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. No. 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 an area 1-1/2 inches to 2 inches wide.
2. No.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	White
	One Hot Leg	Black
	Other Hot Leg	Red
208Y/120 Volts Three-Phase, Four-Wire	Grounded Neutral	White
	Phase A	Black
	Phase B	Red
	Phase C	Blue
240/120 Volts Three-Phase, Four-Wire Delta, Center Tap Ground on Single-Phase	Grounded Neutral	White
	Phase A	Black
	High (wild) Leg	Orange
	Phase C	Blue
480 Y/277 Volts Three-Phase, Four-Wire	Grounded Neutral	White
	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow
NOTE: Phase A, B, C implies direction of positive phase rotation.		

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

B. Conductors Above 600 Volts: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 inches to 2 inches wide.

1. Colors:
 - a. Grounded Neutral: White.
 - b. Phase A: Brown.
 - c. Phase B: Orange.
 - d. Phase C: Yellow.

3.03 CIRCUIT IDENTIFICATION

- A. Circuits Appearing in Circuit Schedules: Identify power, instrumentation, and control conductor circuits, using circuit schedule designations, at each termination and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
- B. Circuits Not Appearing in Circuit Schedules:
 - 1. Assign circuit name based on device or equipment at load end of circuit.
 - 2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.
- C. Method:
 - 1. Conductors No.3 AWG and Smaller: Identify with sleeves or heat bond markers.
 - 2. Cables and Conductors No. 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 general purpose lighting and receptacle circuits except as sized for voltage drop.
- B. Do not splice incoming service conductors and branch power distribution conductors No.6 AWG and larger, unless specifically indicated or approved by Engineer.
- C. Connections and Terminations:
 - 1. Install wire nuts only on solid conductors.
 - 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 No. 12 AWG and smaller.
 - 4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No.4 AWG through No. 2/0 AWG.
 - 5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors No. 3/0 AWG and larger.
 - 6. Install uninsulated terminators bolted together on motor circuit conductors No. 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. Tape insulate on all uninsulated connections.
 2. Outdoors: Use general purpose, flame retardant tape.
 3. Outdoors: Use flame retardant, cold- and weather-resistant tape.
- 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, 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. Where connections of cables installed under this section are to be made under Section 40 91 00, Process Instrumentation and Control Systems (PICS), leave pigtails of adequate length for bundled connections.
 5. Cable Protection:
 - a. Maintain integrity of shielding of instrumentation cables.
 - b. Ensure grounds do not occur because of damage to jacket over the 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.

3.05 CONDUCTORS ABOVE 600 VOLTS

- A. Do not splice unless specifically indicated or approved by Engineer.
- 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, plus a ground braid and clamp.
- E. Install terminals or connectors acceptable for type of conductor material used.
- F. Provide outdoor rain skirts for riser pole and outdoor switchgear 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. Connections and Terminations:
 - 1. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No.4 AWG through No. 2/0 AWG.
 - 2. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors No. 4/0 AWG and larger.
 - 3. Install uninsulated, bolted, two-way connectors for motor circuit conductors No. 12 and larger.
 - 4. Insulate bus connections with heat shrinking tubing, tape, and sheets.
 - 5. Make bus connections removable and reusable in accordance with manufacturer's instructions.
- K. Give two (2) working days' notice to Engineer prior to making splices or terminations.

3.06 CONDUCTOR ARC AND FIREPROOFING

- A. Install arc and fireproofing tape on 600-volt single conductors and cables, except those rated Type TC at splices in manholes, handholes, vaults, cable trays, and other indicated locations.

- B. Install arc and fireproofing tape on 5 kV cables at splices in manholes, handholes, vaults, cable trays, and other indicated locations.
- C. Wrap conductors of same circuit entering from separate conduit together as a single cable.
- D. Follow tape manufacturer's installation instructions.
- E. Secure tape at intervals of 5 feet with bands of tape binder. Each band to consist of a minimum of two wraps directly over each other.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes grounding and bonding systems and equipment.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. ERICO International Corporation.
3. Harger Lightning and Grounding.
4. ILSCO.
5. O-Z/Gedney; A Brand of the EGS Electrical Group.
6. Siemens Power Transmission & Distribution, Inc.

2.2 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment and No. 869, "Electrical Service Equipment," pertaining to grounding and bonding of systems, circuits, and equipment. In addition, comply with UL Standard 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors." Provide grounding and bonding products which are UL listed and labeled for their intended usage.
- C. IEEE Compliance: Comply with applicable requirements and recommended installation practices of IEEE Standards 80, 81, 141, and 142 pertaining to grounding and bonding of systems, circuits, and equipment.

2.3 CONDUCTORS

- A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: Unless specified on the drawings use 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 - 5. Bonding Conductor: Unless specified on the drawings use No. 4 or No. 6 AWG, stranded conductor.
 - 6. Tinned Bonding Jumper: Unless specified on the drawings use Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 by 120 inches.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Except as otherwise indicated, provide electrical grounding and bonding systems indicated; with assembly of materials including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding electrodes and plate electrodes, bonding jumper braid, surge arresters, and additional accessories needed for complete installation. Where more than one type

component product meets indicated requirements, selection is installer's option. Where materials or components are not indicated, provide products which comply with NEC, UL, and IEEE requirements and with established industry standards for those applications indicated.

- B. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- C. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches below grade.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Exothermic welded connectors.
 - 3. Connections to Ground Rods at Test Wells: Exothermic welded.
 - 4. Connections to Structural Steel: Exothermic welded connectors.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground bus.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 4/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields

according to written instructions by manufacturer of splicing and termination kits.

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
 - 7. Armored and metal-clad cable runs.
- C. Ground each separately derived system neutral to effectively grounded metallic water pipe, effectively grounded structural steel member, and separate grounding electrode.
- D. Connect together system neutral, service equipment enclosures, exposed noncurrent carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.
- E. Terminate feeder and branch circuit insulated equipment grounding conductors with grounding lug, bus, or bushing.
- F. Connect grounding electrode conductors to 1-inch diameter or greater, metallic cold water pipe using a suitably sized ground clamp. Provide connections to flanged piping at street side of flange.
- G. Connect building reinforcing steel, building steel beam, building steel roof and walls and duct bank and vault reinforcing steel to ground mat using No. 4/0 AWG bare copper grounding cable.
- H. Bond bare No. 4/0 AWG grounding cable in duct banks to grounding cable in vaults and to power equipment ground bus at ends of each duct bank.
- I. Bond strut and other metal inside of electrical manholes and vaults to bare No. 4/0 AWG grounding cable carried in duct bank.
- J. Bond grounding cables to both ends of metal conduit or sleeves through which such cables pass.

- K. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque-tightening values for connectors and bolts. Where manufacturer's torqueing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.
- L. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- M. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- N. Metallic Fences: Comply with requirements of IEEE C2.
 - 1. Grounding Conductor: Bare copper, not less than No. 2/0 AWG.
 - 2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
 - 3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.5 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
- D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- E. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
- B. Upon completion of installation of electrical grounding and bonding systems, test ground resistance with ground resistance tester using the 3-point fall of potential method. Testing shall be performed during normal dry weather conditions with at least 5 non-rain days elapsing prior to test. Where tests show resistance-to-ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms or less by driving additional ground rods; then retest to demonstrate compliance.
- C. Test ground paths for continuity by applying a low DC voltage source of current, capable of furnishing up to 100 amps, between electrical equipment grounds and ground grid. Grounding path must conduct a 100-amp current at a resistance of 0.010 ohms or less as calculated from circuit voltage.

END OF SECTION

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.2 ACTION SUBMITTALS

A. Product Data: Steel slotted support systems.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Steel slotted channel systems.
2. Include product data for components.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. Killark Electric Mfg. Co.
 - d. O-Z/Gedney.
 - e. Thomas & Betts Corporation.

26 05 29 - 1

- f. Unistrut; Tyco International, Ltd.
- 3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
- 4. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: Comply with NEC.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following (Contractor to verify fastener is appropriate for building material):
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

- 5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Pipe Sleeves: Provide a waterstop on pipe sleeves. Provide pipe sleeves of 2 standard sizes larger than conduit/pipe passing through it and of one of the following:
 1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gauge metal for sleeve diameter noted:
 - a. 3-inch and smaller: 20-gauge.
 - b. 4-inch to 6-inch: 16-gauge.
 - c. Over 6-inch: 14-gauge.
 2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
 3. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

**SECTION 26 05 33
RACEWAYS AND BOXES**

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Boxes, enclosures, and cabinets.
4. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.2 ACTION SUBMITTALS

A. Product Data: For surface raceways, fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: Raceways, fittings, floor boxes, enclosures and cabinets.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. GRC: Comply with ANSI C80.1 and UL 6.

C. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

D. Expansion fittings: Comply with NEMA FB 1 and UL 514B.

1. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions were installed, and including flexible external bonding jumper.
- E. Joint Compound for IMC, or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

- A. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- C. LFNC: Comply with UL 1660.
- D. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- E. Fittings for LFNC: Comply with UL 514B.

2.3 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- C. Floor Boxes:
 1. Material: Steel with steel or brass cover.
 2. Type: Fully adjustable.
 3. Shape: Rectangular.
 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Poke-through Floor Outlets: Provide with fire rating equal to floor fire rating.

- E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- F. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
- G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- H. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- I. Ganged boxes are prohibited.
- J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 4 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Fiberglass.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- K. Cabinets:
 - 1. NEMA 250, Type 12 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
1. Standard: Comply with SCTE 77.
 2. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, "ELECTRIC.".
 6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed Conduit: PVC or aluminum conduit and fittings.
 2. Concealed Conduit, Aboveground: Aluminum metal conduit and fittings.
 3. Underground Direct Buried Conduit: PVC conduit and fittings.
 4. Underground Concrete Encased Conduit: Fiberglass-reinforced conduit or rigid nonmetallic conduit if the conductors are used for power or 120 VAC; otherwise, use rigid metal conduit.

5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 6. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated.
1. Inside Areas (non-chemical and non-admin)
 - a. Rigid Galvanized Steel Conduit (RGS)
 - b. Flexible Metal, Liquid-Tight Conduit (3 feet max)
 2. Inside Areas (Chemical)
 - a. PVC Schedule 40 Conduit
 - b. Flexible, Nonmetallic, Liquid-Tight Conduit (3 feet max)
 3. Inside Areas (Administration, below suspended ceiling)
 - a. Rigid Galvanized Steel Conduit (RGS)
 - b. Flexible Metal, Liquid-Tight Conduit (3 feet max)
 4. Inside Areas (Administration, above suspended ceiling)
 - a. Above 50 Volts
 - 1) Electro Metallic Tubing (EMT) with compression fittings
 - 2) Flexible Metal, Liquid-Tight Conduit (3 feet max)
 - b. Below 50 Volts
 - 1) Free air, in bridle rings/j-hooks with clips
 5. Damp or Wet Locations: PVC or aluminum.
 6. Boxes and Enclosures: Cast metal style in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. EMT: Compression fittings no set-screw
 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
 4. Aluminum Conduit: aluminum fittings and boxes

- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Keep raceways at least 6 inches away from parallel runs of radiant heaters and 6 inches above.
- C. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- D. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- E. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- F. Support conduit within 12 inches of enclosures to which attached.
- G. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from building structure.
- H. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box and tighten the chase nipples so no threads are exposed.
- I. Complete installation of electrical raceways before starting installation of conductors within raceways and prevent foreign matter from entering raceways by using temporary closure protection. Cap spare conduit. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bends is not visible above the finished slab.
- J. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.

2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
 4. Do not embed threadless fittings in concrete unless specifically approved by Engineer for each specific location.
- K. Threaded Conduit Joints: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions. At a minimum, make threaded conduit joints watertight by coating threaded portions with a spray-on or brush-on zinc-bearing paint. Provide paint containing 90 percent minimum by weight of metallic zinc powder in the dried film.
- L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on conduits that contain above 400VAC power conductors.
- O. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- P. Seal the interior of all raceways at the following points:
1. Where an underground raceway enters a building or structure.
 2. Where otherwise required by NFPA 70.
- Q. Expansion-Joint Fittings:
1. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 2. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for

conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

- R. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires; maximum of 36 inches of flexible conduit for all other equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - 1. Use LFMC in damp or wet locations subject to severe physical damage.
 - 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- S. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- T. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.
- U. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- V. Locate boxes so that cover or plate will not span different building finishes.
- W. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- X. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- Y. Set metal floor boxes level and flush with finished floor surface.

3.3 INSTALLATION OF CONCEALED RACEWAYS

- A. Raceways embedded in slabs shall be installed in the middle third of the slab thickness where practical and leave at least 1-inch concrete cover. Tie raceways to reinforcing rods or otherwise secure them to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in the concrete. Run 1-inch and smaller raceways with a minimum of bends in the shortest practical distance. Run larger conduit parallel with or at right angles to the main reinforcement; where at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab. Where nonmetallic conduit or fiberglass-reinforced conduit is used, raceways must be converted to PVC or rigid metal conduit before rising above floor.

3.4 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom for pipe less than 6 inches in nominal diameter.
2. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction.
3. Install manufactured duct elbows for stub-up at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
4. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.5 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes with bottom below frost line or provide gravel bed to 6 inches below frost line.

- E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of concrete floor slabs, exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 05 43
UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Direct-buried conduit, ducts, and duct accessories.
2. Concrete-encased conduit, ducts, and duct accessories.
3. Manholes.

1.2 ACTION SUBMITTALS

A. Product Data: For ducts and conduits, duct-bank materials, manholes, handholes, and boxes, and their accessories.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:
 - a. Include plans, elevations, sections, details, attachments to other work, and accessories.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include reinforcement and joint details, frame and cover design, and manhole frame support rings.
2. Factory-Fabricated Handholes and Boxes:
 - a. Include dimensioned plans, sections, elevations, accessory locations, and fabrication and installation details.
 - b. Include duct entry provisions, including locations and duct sizes.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

- A. Comply with ANSI C2.

2.2 CONDUIT

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
- B. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.3 NONMETALLIC DUCTS AND DUCT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Beck Manufacturing.
 - 2. Cantex, Inc.
 - 3. CertainTeed Corporation.
 - 4. Condux International, Inc.
 - 5. IPEX Inc.
 - 6. Lamson & Sessions; Carlon Electrical Products.
 - 7. Spiraduct/AFC Cable Systems, Inc.
- B. Underground Plastic Utilities Duct: NEMA TC 2, UL 651, ASTM F 512, Type EPC-80, with matching fittings complying with NEMA TC 3 by same manufacturer as the duct.
- C. Duct Accessories:
 - 1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers.
 - 2. Warning Tape: Underground-line warning tape specified in Section 26 05 53 "Identification for Electrical Systems."
 - 3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi red concrete and labeled "ELECTRIC."

2.4 PRECAST MANHOLES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Advance Concrete.
 - 2. Oldcastle Precast Group.
 - 3. Utility Concrete Products, LLC.
 - 4. Wausau Tile Inc.
- B. Comply with ASTM C 858.
- C. Structural Design Loading: Comply with requirements in Section 33 05 16 "Precast Concrete Utility Structures".
- D. Concrete Knockout Panels: 1-1/2 to 2 inches thick, for future conduit entrance and sleeve for ground rod.
- E. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.5 CAST-IN-PLACE MANHOLES

- A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.
- B. Materials: Comply with ASTM C 858 and with Section 03 30 00 "Cast-in-Place Concrete."
- C. Structural Design Loading: As specified in "Underground Enclosure Application" Article.

2.6 UTILITY STRUCTURE ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Neenah Foundry Company.
 - 2. Oldcastle Precast Group.
 - 3. Quazite:Hubbell Power Systems, Inc.
 - 4. Utility Concrete Products, LLC.

26 05 43 - 3

5. Wausau Tile Inc.
- B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
1. Frame and Cover: Weatherproof, with nonskid finish and milled cover-to-frame bearing surfaces; diameter, 29 inches.
 2. Cover Legend: Cast in. Selected to suit system.
 3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening. Seal with mortar or preformed plastic or rubber seals.
- C. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- diameter eye, rated 13,000-lbf minimum tension, and 1-by-4-inch bolt.
- D. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.
- E. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.
1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
- F. Ground Rod Sleeve: 3-inch, PVC conduit sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.
- G. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
1. Stanchions: Nominal 36 inches high by 4 inches wide, with minimum of nine holes for arm attachment.
 2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450-lb minimum capacity to 20 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.

- H. Portable Manhole Ladders: UL-listed, heavy-duty fiberglass specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches. One required.
- I. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two required.

PART 3 - EXECUTION

3.1 CONCRETE ENCASED DUCT BANK

- A. Ducts for Electrical Cables More than 600 V: RNC, NEMA Type EPC-80-PVC, in concrete-encased duct bank unless otherwise indicated.
- B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.
- C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.

3.2 UNDERGROUND DUCT APPLICATION

- A. Underground Ducts Crossing Driveways and/or Roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:
 - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-20 structural load rating.
 - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
 - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 structural load rating.
 - 4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
 - 5. Cover design load shall not exceed the design load of the handhole or box.

- B. Manholes: Precast or cast-in-place concrete.
 - 1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
 - 2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.4 DUCT INSTALLATION

- A. Install ducts according to NEMA TCB 2.
- B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.
- C. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 12.5 feet, both horizontally and vertically, at other locations unless otherwise indicated.
- D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- E. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
 - 2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct banks with calculated expansion of more than 3/4 inch.
 - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- F. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet outside the building wall, without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

- G. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- H. Pulling Cord: Install 100-lbf- test nylon cord in empty ducts.
- I. Concrete-Encased Ducts: Support ducts on duct separators.
 - 1. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms for pipes less than 6 inches in nominal diameter.
 - 2. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
 - 3. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
 - 4. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than five spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - 5. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
 - 6. Elbows: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
 - 7. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.

8. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
9. Concrete Cover: Install a minimum of 3 inches of concrete cover at top and bottom, and a minimum of 2 inches on each side of duct bank.
10. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03 30 00 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

J. Direct-Buried Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct bank
2. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
3. Space separators close enough to prevent sagging and deforming of ducts, with not less than five spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
4. Depth: Install top of duct bank at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

8. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction.
 - a. Place minimum 3 inches of sand as a bed for duct bank. Place sand to a minimum of 6 inches above top level of duct bank.
- K. Warning Planks: Bury warning planks approximately 12 inches above direct-buried ducts and duct banks, placing them 24 inches o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.
- L. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
2. Comply with requirements in Section 03 30 00 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

B. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Install handholes with bottom below frost line, 18 inches below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

F. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation shall be Elastomeric sheet style. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

G. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

I. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
- D. Install handholes and boxes with bottom below frost line, 18 inches below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.7 GROUNDING

- A. Ground underground ducts and utility structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
 - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 6-inch- long mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
 - 3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground

resistance as specified in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION

SECTION 26 05 44
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

B. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Emerson Industrial Automation.
 - b. Engineer Approved Equal
 - 2. WSK or WDP style Compression System

2.3 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

END OF SECTION

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.2 ACTION SUBMITTALS

- A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

- A. Comply with ANSI A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.2 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.3 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.4 FLOOR MARKING TAPE

- A. 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.5 UNDERGROUND-LINE WARNING TAPE

- A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

2.6 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs (Outdoors):

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 7 by 10 inches.

D. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
3. Arc-flash Warning: provide OSHA compliant signage.

4. Lockout/Tagout Warning: provide OSHA compliant signage (see drawing detail).

2.7 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.
 1. Engraved legend with black letters on white face.
 2. Punched or drilled for mechanical fasteners.
 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 EQUIPMENT IDENTIFICATION LABELS

- A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Apply identification devices to surfaces that require finish after completing finish work.
- C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

- E. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
- F. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Install labels at 30-foot maximum intervals.
- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. Emergency Power.
 - 2. Power.
 - 3. UPS.
- C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
 - 1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.
 - a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
 - b. Colors for 240/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Neutral: White.
 - c. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.

- d. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - 4) Neutral: Gray.
- e. Motor Leads, Control Cabinets/MCC
 - 1) Black, numbered L1-T1, etc.
- f. Control Wiring:
 - 1) BLACK – Ungrounded ac and dc power conductors
 - 2) RED – Ungrounded ac control conductors
 - 3) BLUE – Ungrounded dc control conductors
 - 4) ORANGE – Ungrounded conductors that remain energized when the main supply circuit disconnecting means is in the off position
 - 5) WHITE with BLUE stripe – Grounded (current-carrying) dc circuit conductor
 - 6) WHITE with ORANGE stripe – Grounded (current-carrying) ac circuit conductor, which remains energized when the main supply circuit disconnecting means is in the off position
 - 7) GREEN – Equipment grounding conductor
 - 8) Violet – DC Power
- D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- E. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.
- F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
- G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
 2. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
1. Comply with 29 CFR 1910.145.
 2. Identify system voltage with black letters on an orange background.
 3. Apply to exterior of door, cover, or other access.
 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
- J. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- K. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer (main-tie-main), load shedding, and generator use.
- L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:

- a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
- b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
- c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
- d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

END OF SECTION

SECTION 26 05 73.16
OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1.2 ACTION SUBMITTALS

- A. Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
 - 1. Coordination-study input data, including completed computer program input data sheets.
 - 2. Study and equipment evaluation reports.
 - 3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Engineer for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Coordination Study Specialist and Field Adjusting Agency.
- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

- a. The following parts from the Protective Device Coordination Study Report:
 - 1) One-line diagram.
 - 2) Protective device coordination study.
 - 3) Time-current coordination curves.
- b. Power system data.

1.5 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- C. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Software Developers: Subject to compliance with requirements, provide software by the following:
 - 1. Operation Technology, Inc.
 - 2. SKM Systems Analysis, Inc.
- B. Comply with IEEE 242 and IEEE 399.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Short-Circuit Study:
 - 1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Equivalent impedance.
 - 2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

E. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
 - a. Phase and Ground Relays:
 - 1) Device tag.
 - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - 3) Recommendations on improved relaying systems, if applicable.
 - b. Circuit Breakers:
 - 1) Adjustable pickups and time delays (long time, short time, ground).
 - 2) Adjustable time-current characteristic.
 - 3) Adjustable instantaneous pickup.
 - 4) Recommendations on improved trip systems, if applicable.
 - c. Fuses: Show current rating, voltage, and class.

- F. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching

schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
 - a. Power utility's overcurrent protective device.
 - b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - d. Transformer full-load current, magnetizing inrush current.
 - e. Ground-fault protective devices.
 - f. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. The study shall be based on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 - 2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. The calculations shall include the ac fault-current decay from induction motors. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
 - 1. Electric utility's supply termination point.
 - 2. Switchgear.
 - 3. Low-voltage switchgear.
 - 4. Motor-control centers.
 - 5. Standby generators and automatic transfer switches.
 - 6. Branch circuit panelboards.

7. Variable Frequency Drives.

I. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Engineer.
2. Use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.

9. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
10. Motor horsepower and NEMA MG 1 code letter designation.
11. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
12. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Ratings, types, and settings of utility company's overcurrent protective devices.
 - c. Special overcurrent protective device settings or types stipulated by utility company.
 - d. Time-current-characteristic curves of devices indicated to be coordinated.
 - e. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - f. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - g. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.

3.4 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
- C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.