

SECTION 26 05 00

ELECTRICAL MATERIALS

PART 1: GENERAL

1.1 WORK INCLUDED

- A. Furnish and install all conduit, conduit fittings and boxes to complete the installation of all electrically operated equipment as specified herein, in other Owner Specifications and as required.
- B. Furnish and install all wires and cables for power, lighting, instrumentation, and control as required to complete the electrical installation.
- C. Furnish and install lighting switches and receptacles as shown on the Drawings.

1.2 EQUIPMENT LOCATION

- A. Contractor shall install conduits and appurtenances in such a manner as to avoid all interferences.

1.3 DELIVERY, STORAGE AND HANDLING

- A. Protect conduit and accessories from corrosion and entrance of debris by storing above grade. Provide appropriate covering. Protect PVC conduit and fittings from sunlight.

PART 2: PRODUCTS

2.1 CONDUIT

- A. Conform to requirements of ANSI/NFPA 70, National Electric Code (NEC).
- B. General - The minimum size conduit permitted is $\frac{3}{4}$ -inch unless otherwise specified or indicated on the Drawing. Minimum size conduit permitted is $\frac{1}{2}$ -inch for lighting circuit applications only. Conduits smaller than $\frac{1}{2}$ -inch are not permitted.
- C. Rigid nonmetallic conduit may be used for underground service entrance, underground feeders, and underground branch circuits with the following specific requirements:
 - 1. Conduit shall be Schedule 80 PVC
 - 2. The conduit shall be embedded in soil below the aggregate and shall be at least 12-inches below floor surface. External to structures, such conduits shall be minimum of 24-inch below finished grade.

3. PVC conduits shall not be used in suspended floor slabs.
 4. All conduit bends subjected to physical damage and turning up through the floor shall be galvanized rigid steel.
- D. Outdoor and Process Building Locations: Use rigid galvanized steel conduit. These areas also include interior below-grade locations and wall locations which are water bearing or noted as “wet and corrosive”. It shall also be used in exterior and interior above-grade locations.
- E. In wet and corrosive locations, all seals and all fittings shall be liquid tight, non-metallic.
- F. Conduits shall be installed as shown below:
1. Rigid Conduit -----Article 346, NEC
 2. Rigid Nonmetallic----- Article 347, NEC
- G. A grounding conductor shall be installed in each conduit. Conduit shall not be used as a grounding conductor.

2.2 CONDUIT FITTINGS, PULLBOXES, JUNCTION BOXES, ETC.

- A. Indoor Use - All junction boxes and pull boxes for indoor use shall be of galvanized steel and provided with rubber or neoprene gasketed screwed-on covers of the same gauge as the box being provided unless otherwise specified or indicated on the Drawing.
- B. Outdoor Use - All junction boxes and pull boxes for outdoor use shall be of stainless steel Type 304 and 316, NEMA Type 4X construction. Covers shall be same material as box and shall be hinged. Screws and all metal parts shall be stainless steel. Use of expandable junction boxes and pull boxes is not permitted.
- C. Switch/Receptacle Boxes - All cast fittings or sheet metal boxes containing wiring devices such as receptacles and switches shall be of the deep type. All device boxes used in the process area shall be cast type except those shown as recessed.
- D. Cast fittings shall be non-ferrous metal or malleable iron thoroughly coated inside and outside with metallic zinc or cadmium after all machining has been completed. Cast fittings shall be provided with heavy threaded hubs to fit the conduit required. Covers shall be of the same material as the fittings to which they are attached and shall be screwed on with rubber or neoprene gasket between the covers and fittings.

2.3 CONDUCTORS AND INSULATION

- E. Each coil or reel of insulated wire and cable furnished shall bear a tag at regular intervals on the outer covering containing the UL approval stamp (providing cable is of a class inspected by said laboratory), name of manufacturer, trade designation, voltage rating, size, grade of insulation, month and year of manufacture; and in no case shall be more than six months old, unless otherwise acceptable to the Owner.
- F. All wire and cable shall meet the requirements of the latest edition of the NEC and shall be soft drawn copper unless otherwise noted. All wires and cables used on the project shall be new.
- G. Wire and cable shall not be stored in the weather, and shall meet all requirements of the ICEA.
- H. Furnish and install all conductors, consisting of ninety-eight percent (98%) conductivity copper. All power wires shall be stranded and shall not be less than No. 12 AWG. All control wires shall be stranded and shall be not less than No. 14 AWG. All conductors shall be at least 600 V rated. All power and lighting feeder wire and cable shall be identified by color coding in all hand holes, motor control centers, panel boards, pull boxes and junctions boxes. All signal carrying cable shall be twisted shielded pairs or three (3) wire twisted with shield.
- I. Each conductor and the neutral conductor shall be factory color coded with a separate color for each. The color code indicated below shall be used consistently throughout the electrical system installation, unless otherwise specified:

Phase	480 V	208 V
A	Brown	Black
B	Orange	Red
C	Yellow	Blue
N	Gray w/ Purple Tape	White
G	Green	Green

- J. All wiring #2 or larger shall be THW -2 stranded copper, 600 V rated insulation and suitable for wet location.
- K. All wiring #4 or smaller shall be THHN/THWN, stranded copper, 600 V rated insulation and suitable for wet locations.

2.4 CONNECTORS

- A. All wiring between various pieces of equipment shall be continuous, without splices.

- B. When field conductors are terminated to equipment conductors such as lighting fixtures, motors, etc., non-insulated ring connectors shall be bolted together, wrapped in rubber tape, and then electrical tape.
- C. Splice caps and wire nuts are prohibited.
- D. All motor conductors shall be 'meggered' before terminating.
- E. All conductors 1/0 and larger shall have each bare conductor end treated with an oxidation inhibitor such as Pentrox before connecting a crimp-on lug to it or connecting under a mechanical lug. Crimp-on lugs with an oxidation inhibitor already in the barrel of the lug are acceptable.

2.5 WIRING DEVICES

- A. General: Products of a single manufacturer shall be used for all receptacles and switches. All devices shall be UL listed.
- B. Provide wiring devices of the type, color, and electrical rating for the service indicated.
- C. Lighting Switches
 - 1. Single-pole, 20 amp, 125V
 - 2. 3-way, 20 amp, 125V
 - 3. 4-way, 20 amp, 125V
- D. Receptacles
 - 1. General Duty Duplex: Duplex general duty type receptacles shall be two-pole, 3 wire grounding with green hexagonal equipment ground screw, ground terminal internally connected to mounting yoke, 20 ampere, 125 V, with metal plaster ears, side wiring only, NEMA configuration type 5-20R unless and except where otherwise indicated. All receptacles shall be ivory colored, style 5362.
 - 2. Weatherproof Receptacles: Weatherproof receptacles shall consist of the receptacle type indicated, mounted in a box with a gasketed, weatherproof, cast metal cover plate and separate cap over each receptacle opening. The cap shall be permanently attached to the cover plate by a spring hinged flap. The weatherproof integrity shall not be affected when heavy duty specification attachment plugs are inserted. Cover plates on outlet boxes mounted flush in the wall shall be gasketed to the wall in a watertight manner.

3. GFI Receptacles: Ground fault interrupter receptacles shall be feed-through type capable of protecting connected downstream receptacles on single circuit, ivory, grounding type, UL rated Class A, Group 1, 20 ampere rating, 125 V with solid state ground fault sensing and signaling, with 5 milli-ampere ground fault trip level, equipped with 20 ampere plug configuration, NEMA type 5-20R.
 4. All other receptacles shall be of the appropriate type and voltage.
- E. Device Plates
1. Device plates shall be one piece type, single or multiple gang switch and duplex outlet wall plates for wiring devices. Device plates shall be provided with metal screws for securing plates to devices. Screws shall be stainless steel. All wall plates shall be stainless steel possessing the additional features as indicated on the Drawing.
- F. Weather-protected cover plates
1. Outdoor locations – “in-use” type receptacle covers
 2. Indoor locations – “in-use” receptacle covers
 3. Indoor locations - flush-mount cover

2.6 PANELBOARDS

- A. General: All devices shall be UL listed.
- B. Panel boards shall be appropriately rated for this project. Each panel board shall consist of the required one-pole, two-pole, and three-pole branches of the ratings shown on the Drawing. It shall be dead front construction equivalent to the types shown in the panel board schedule. Panel boards shall be equipped with copper bussing; aluminum is not acceptable.
- C. All circuits controlled out of a panel board or by a breaker shall be identified. A directory holder with a neatly typed directory card and covered with a clear plastic protective plate shall be affixed to each panel board.
- D. Panel boards and circuit breakers shall comply with all pertinent sections of the NEC. Panel board enclosures shall be fitted with hinged doors having a combination lock and latch, with all locks keyed alike. Enclosures shall be painted with a baked light gray enamel or lacquer finish over a suitable prime coat.
- E. Circuit breakers shall be UL listed. All multiple circuit breakers, individual or in panel boards shall be common trip. Twin, tandem and half-size single-pole breakers will not be acceptable.

2.7 DISCONNECT SWITCHES

- A. The disconnect switches shall be 3 blade switches or as shown on the Drawing. For single-phase motors and other devices rated 120 V, disconnect switches shall be rated 240 V. For all devices rated 240 V and higher, switches shall be rated 600 V. Disconnect switches shall be capable of interrupting the full load current of the device to which they are attached. Switches shall have a withstand rating equal or greater the equipment supplying the switch.
- B. Switches shall be housed in NEMA Type 1 or NEMA Type 4X general purpose enclosures as required based on the project requirements or as shown on the Drawing. All switches shall be heavy duty industrial type and be capable of being locked in either the "ON" or "OFF" position. Toggle type single-pole manual starters in NEMA Type 1 enclosure are permitted to be used in lieu of disconnect switches for HVAC applications such as exhaust fans. For manual starters, the Contractor shall supply properly sized thermal overload units.

PART 3: EXECUTION

3.1 CONDUITS

- A. Connections to equipment. Connections from rigid conduit to motors, pressure switches, solenoid valves, level controls, etc., shall be made with short lengths of liquid-tight metal flexible conduit. These lengths shall be provided with appropriate connectors with devices which will provide an excellent electrical connection between equipment and the rigid conduit for the flow of ground current.
- B. Installation procedure. Each piece of conduit installed shall be free from blisters and other defects.
 - 1. Conduit systems shall be continuous from outlet to outlet, from outlets to cabinets and pull or junction boxes. They shall be rigid steel and rigid nonmetallic PVC electrical conduit as specified herein or as indicated on the Drawing. Lock nuts and bushings shall secure the system in such a way as to be electrically continuous throughout. Conduit ends shall be capped to prevent entrance of foreign materials during construction.
 - 2. Conduits shall be run parallel to building lines and long sweep bends shall be utilized. All exposed conduit shall be installed, either parallel or perpendicular to structural members, unless impractical, and shall be grouped wherever possible. Conduit shall be attached to structural components with approved supports spaced a maximum of eight (8) feet apart and shall form a neat rigid installation.
 - 3. Each piece installed shall be cut square, taper reamed, and a coat of conductive sealing compound applied to threads.

4. Conduit connections shall be screwed tight with only incomplete threads exposed. All conduit joints shall be made with standard couplings and the ends of the conduit shall butt tightly into the couplings. In exposed work only, where standard couplings cannot be used, only union type couplings are permitted.
5. Conduit threaded in the field shall have standard sizes and lengths.
6. If No. 4 or larger conductors enter a cabinet, pull box, junction box or auxiliary gutter, the conductors shall be protected by a bushing. Also, on all conduits one and one-fourth inches (1-¹/₄") and larger, insulated bushings shall be utilized.
7. Ropes shall be installed in all empty or spare conduits to facilitate the pulling of future conductors.
8. No single conduit run shall have more than the equivalent of four 90-degree bends. Bending radii shall comply with NEC Article 346-10. Factory bent elbows or field bent elbows with approved tools may be used. Heating of conduit to facilitate bending is prohibited. Only bending methods approved by the PVC conduit manufacturer shall be used for this type of conduit.
9. Conduit supports from building walls shall be installed with at least a 1/4-inch clearance from the walls to prevent the accumulation of dirt and moisture behind the conduit. Conduit and/or conduit fittings shall not be welded together or to any steel structure; however, conduit supports may be welded to flanges of steel beams, columns, etc., in accordance with approved welding techniques and engineering practice.
10. Contractor shall provide sleeves and inserts, correctly located in the structure, as required to complete the Work.
 - a. Inserts shall be steel and of proper size for loads encountered.
 - b. Sleeves shall be provided for all conduits passing through concrete or masonry walls, partitions, concrete slabs or beams. Install during construction to avoid later cutting. Sleeves placed horizontally in walls or in any position in beams shall be standard weight ASTM A53 steel pipe or length equal to thickness of wall or beam. Those placed vertically in non-waterproof floors shall be 20-gauge galvanized sheet steel of length equal to thickness of slab, flared and nailed to the form, or fastened to reinforcing fabric and filled with sand during pouring to prevent deformation. Sleeves in floors with waterproof membrane shall be provided with flanges or flashing rings and shall be clamped or flashed into the membrane. All sleeves shall be of sufficient diameter to clear conduit by ¹/₄-inch all around except sleeves on lines subject to movement by expansion shall clear the conduit by at least 1-inch all around.

- c. Sleeves around conduit through exterior walls shall be caulked watertight with oakum and plastic cement.
11. Approved conduit expansion joints shall be provided wherever conduit crosses a structural expansion joint, is attached between two separate structures, and wherever the conduit run is 100 feet or more in a single straight length.
12. All conduit extending through the floor behind panels or into control centers or similar equipment shall extend a minimum of 6-inches above the floor elevations, with no couplings at floor elevations.
13. Horizontal conduit runs not in the floor slab shall be run above the ceiling wherever practical.
14. Conduit runs shall be installed in such locations as to avoid water pipes. A minimum separation of three (3) feet shall be maintained where conduit crosses or parallels water pipes. A minimum of 12 feet shall be maintained where conduit crosses or parallels hot water piping.
15. The cutting of walls or floors for conduit or other electrical equipment shall be kept to a minimum. Where such cutting is absolutely necessary, care must be taken so as not to weaken the wall or floor involved. Beams or other structural supports shall not be cut under any condition. All cutting, channeling and drilling of holes through walls, floors and ceilings, required for the correct installation of the electrical work, shall be done by and repaired by the Electrical Contractor. The cost of cutting and patching shall be borne by the Contractor. All work shall be finish painted (prime coat and two (2) finish coats) to match the existing finishes. All equipment fastenings to columns, steel beams, and trusses shall be by beam clamps or welded. No holes shall be drilled in the steel. All holes in hung ceilings for support rods, conduits and other equipment shall be made adjacent to bars where possible, to facilitate removal of ceiling panels.
16. Conduit shall be protected immediately after installation by installing flat non-corrosive metallic discs and steel bushings, designed for this purpose, at each end. Discs shall not be removed until it is necessary to clean the conduit and pull wire and cable. Before wire or cable is pulled, insulated bushings shall be installed at each end of the conduit. Prior to pulling in wire and cables, each conduit shall be thoroughly cleaned inside, by the use of compressed air, to remove all sand and other foreign matter.
17. Where used, transition from PVC coated rigid galvanized steel conduit to PVC schedule 80 conduit shall be not less than 6-inches from the outside surface.

18. Conduit buried in the earth (grade) shall be a minimum of 24-inches below grade. Trenching and backfilling shall be provided by the Contractor in accordance with Owner Specifications.

3.2 CONDUIT FITTINGS, PULL BOXES, JUNCTION BOXES, ETC.

- A. Pull boxes and junction boxes shall be installed and located as indicated on the Drawing. The size of boxes shall comply with NEC Section 314.16.
- B. Where nipples are used between fittings and electrical equipment, they shall be so installed that no threads are exposed.
- C. All junction boxes, pull boxes, cabinets, lighting panels, switches, and similar devices shall be solidly attached to structural members prior to installation of conduit. These devices shall be set true and plumb. Wooden plugs are not permitted for securing equipment or conduit to concrete.
- D. Conduits shall be attached to all electrical equipment, such as sheet metal steel junction boxes, pull boxes, switches, etc., using watertight conduit hubs with threaded insulated throat. Stainless steel channels shall be used in chemical room. All hardware shall be stainless steel only.
- E. Where control wires must be interconnected in a junction box, terminal boards consisting of an adequate number of screw type terminals shall be installed. Terminal board current carrying parts must be of ample size to carry the full load current of the circuits connected thereto. Approximately 20 percent of the total number of terminals provided shall consist of spare terminals. Terminals shall be labeled to conform with Drawings and approved shop drawings.
- F. Mounting heights from the finished floor to the centerline of the various boxes and equipment shall be as follows except as otherwise indicated on the Drawing:
 1. Pushbutton Stations, Lighting Switches, etc., 4 ft. 6 in.
 2. Power Receptacles 1 ft. 6 in.
 3. Power Receptacles in Process Area 4 ft. 6 in.

3.3 INSTALLATION OF WIRE & CABLE

- A. The best of care shall be exercised while installing wire and cable so as not to injure the conductor or insulation. Oils, grease, or compounds other than powdered soapstone, or as recommended by the cable manufacturer, shall not be used for pulling in any conductor.
- B. All grouping or bundling of control and circuit wiring in cabinets, panels, pull boxes and junction boxes shall be neatly trained and held with suitable cable

ties. Where control or circuit baling is clamped or fastened in cabinets or other equipment, non-metallic cable clamps and mounting brackets shall be installed.

- C. All wiring shall be tagged at each end and at all junction points with suitable wire markers displaying unique identifying numbers.
- D. Connection of cable clamps or lugs shall be as follows: contact areas of bars, plates, and lugs shall be cleaned with steel wool, emery cloth or buffing machine, in such a manner as to leave the surfaces bright, clean, flat and/or parallel. Care shall be taken so that edges and corners are not rounded. Areas shall then be wiped with a clean cloth to remove all particles of abrasive matter, dust, and dirt. Each cleaned area shall then be completely covered with a thin layer of Vaseline, or other material approved for this purpose by the Owner; the parts tightly drawn together with bolts and locknuts and excess grease wiped off.
- E. Contractor shall be responsible for maintaining the proper electrical phasing of all equipment being installed. Where modifications are required to improperly phased equipment, the Contractor shall do the rewiring at no expense to Owner. The Contractor shall replace or repair any equipment damaged because of improper phasing at no cost to Owner.
- F. Grounding of signal cable shield shall be done only at the power source end. The opposite end shall be protected against accidental contact with ground by bending the drain wire back along the outer cable insulation and sleeving over the drain wire with heat shrink tubing. The insulated conductors of signal cable stripped from their outer insulation and shield shall be as short as practical at their termination points.
- G. Where long pulls are necessary, a messenger shall be pulled with the signal cable to relieve the stress of pulling on the cable.
- H. Contractor shall test wiring devices to ensure electrical continuity of grounding connections, after energizing circuitry, demonstrate compliance with requirements of the project. Contractor shall test each receptacle for proper polarization and ground continuity.

3.4 SPLICING OF CONDUCTORS

- A. Splicing shall be kept to a minimum. Splicing to extend the length of a wire is not permitted. If a wire is found to be too short, it shall be removed and a wire of adequate length installed. Under no circumstances shall signal wire be spliced. Splices shall not be made in cast fittings such as "Tee" or "L" types, but shall be made in junction boxes of adequate size. All splices shall be made via terminal connections to terminal strips in a junction box. Wire nuts are permitted for lighting and receptacle circuits only.

3.5 IDENTIFICATION OF CONDUCTORS

- A. Nameplates and labels shall be engraved on three-layer of laminated plastic with white letters on black background. Nameplates and labels shall be installed on each electrical distribution and control panel, communication cabinet, instrument and transmitter and device controller. Lettering size of $\frac{1}{8}$ -inch shall be used for identifying individual equipment and loads. Lettering size of $\frac{1}{4}$ -inch shall be used for identifying grouped equipment and loads
- B. Wire markers shall be of split sleeve or tubing type and located on each conductor in panel board gutter, pull boxes and junction boxes, terminal strips and each load connection. Wire markers shall show the following:
 - 1. Power and lighting loads: branch circuit or feeder number indicated on Drawing.
 - 2. Control circuits: control wire number indicated on schematics and interconnection diagrams indicated on Drawings and approved shop drawings.
- C. Conduit markers shall be stainless steel with conduit run number embossed on the marker as indicated on Drawings and approved shop drawings. Conduit markers shall be installed on conduits longer than 6 feet, with spacing of 20 feet on center.
- D. Underground warning tape shall be 4" yellow plastic with suitable warning legend describing buried electrical lines.
- E. All nameplates and labels shall be installed on degreased and clean surfaces. Nameplates and labels shall be parallel to the equipment lines and secured with stainless steel screws in recessed finished locations. Underground warning tape shall be installed at 3-inch below finish grade, one per trench.

3.6 INSTALLATION OF PANELBOARDS, DISCONNECT SWITCHES AND OTHER DEVICES

- A. All devices shall be mounted true and plumb in accordance with the manufacturer's recommendation at the locations shown on the Drawing. Devices shall be located so as to be accessible once equipment is in place. Receptacles shall be arranged so as not to present a tripping hazard or interfere with the removal or normal service of equipment.
- B. The power distribution and lighting panel boards shall be installed in accordance with the manufacturer's requirements. The power distribution and panel boards shall be wall-mounted where shown on the Drawing. All power panels shall have an engraved label securely attached to the front cover. Individual breakers shall be clearly marked indicating the equipment being served. Labels shall be typed or printed. Handwritten labels will not be accepted.

- C. The disconnect switches shall be installed in accordance with the manufacturer's requirements. The disconnect switch shall be mounted true and plumb as shown on the Drawing and as described herein. Disconnects shall be permanently labeled with plastic laminated labels. Labels shall be attached in such a way as to resist heat and moisture.

3.7 ABBREVIATIONS

- A. ANSI – AMERICAN NATIONAL STANDARDS INSTITUTE
- B. ASTM – AMERICAN SOCIETY for TESTING and MATERIALS
- C. AWG – AMERICAN WIRE GAUGE
- D. ICEA – INSULATED CABLE ENGINEERS ASSOCIATION
- E. IEEE – INSTITUTE of ELECTRICAL and ELECTRONICS ENGINEERS
- F. MCC – MOTOR CONTROL CENTER
- G. NEC – NATIONAL ELECTRIC CODE
- H. NEMA – NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
- I. NFPA – NATIONAL FIRE PROTECTION ASSOCIATION
- J. NRTL- NATIONALLY RECOGNIZED TESTING LABORATORY
- K. OSHA – OCCUPATIONAL SAFETY and HEALTH ADMINISTRATION
- L. PVC – POLYVINYL CHLORIDE
- M. UL- UNDERWRITERS LABORATORIES
- N. VFD – VARIABLE FREQUENCY DRIVE

END OF SECTION 26 05 00