

**SECTION 26 05 41
UNDERGROUND ELECTRICAL CONSTRUCTION**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of underground ducts and raceways, and precast manholes and pullboxes to form a complete underground electrical raceway system.
- B. The terms “duct” and “conduit” are used interchangeably in this section.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- B. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- C. Section 31 20 11, EARTH MOVING (SHORT FORM): Trenching, backfill, and compaction.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Coordinate layout and installation of ducts, manholes, and pullboxes with final arrangement of other utilities, site grading, and surface features.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit information on manholes, pullboxes, ducts, and hardware. Submit manhole plan and elevation drawings, showing openings, pulling irons, cable supports, cover, ladder, sump, and other accessories.
 - c. Proposed deviations from the drawings shall be clearly marked on the submittals. If it is necessary to locate manholes, pullboxes, or duct banks at locations other than shown on the drawings, show the proposed locations accurately on scaled site drawings, and submit to the Resident Engineer for approval prior to construction.
 - 2. Certifications: Two weeks prior to the final inspection, submit the following.
 - a. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the materials have been properly installed, connected, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Concrete Institute (ACI):
 Building Code Requirements for Structural Concrete
 318-11/318M-11 Building Code Requirements for Structural Concrete &
 Commentary
 SP-66-04 ACI Detailing Manual
- C. American National Standards Institute (ANSI):
 77-10 Underground Enclosure Integrity
- D. American Society for Testing and Materials (ASTM):
 C478-12 Standard Specification for Precast Reinforced Concrete Manhole
 Sections
 C858-10e1 Underground Precast Concrete Utility Structures
 C990-09 Joints for Concrete Pipe, Manholes and Precast Box Sections
 Using Preformed Flexible Joint Sealants.
- E. National Electrical Manufacturers Association (NEMA):
 TC 2-03 Electrical Polyvinyl Chloride (PVC) Conduit
 TC 3-04 Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC
 Conduit And Tubing
 TC 6 & 8-03 Polyvinyl Chloride (PVC) Plastic Utilities Duct For Underground
 Installations
 TC 9-04 Fittings For Polyvinyl Chloride (PVC) Plastic Utilities Duct For
 Underground Installation
- F. National Fire Protection Association (NFPA):
 70-11 National Electrical Code (NEC)
 70E-12 National Electrical Safety Code
- G. Underwriters Laboratories, Inc. (UL):
 6-07 Electrical Rigid Metal Conduit-Steel
 467-07 Grounding and Bonding Equipment
 651-11 Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
 651A-11 Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit
 651B-07 Continuous Length HDPE Conduit

PART 2 - PRODUCTS

2.1 PRE-CAST CONCRETE MANHOLES AND HARDWARE

- A. Structure: Factory-fabricated, reinforced-concrete, monolithically-poured walls and bottom. Frame and cover shall form top of manhole.
- B. Cable Supports:
 - 1. Cable stanchions shall be hot-rolled, heavy duty, hot-dipped galvanized "T" section steel, 56 mm (2.25 inches) x 6 mm (0.25 inch) in size, and punched with 14 holes on 38 mm (1.5 inches) centers for attaching cable arms.
 - 2. Cable arms shall be 5 mm (0.1875 inch) gauge, hot-rolled, hot-dipped galvanized sheet steel, pressed to channel shape. Arms shall be approximately 63 mm (2.5 inches) wide x 350 mm (14 inches) long.
 - 3. Insulators for cable supports shall be porcelain, and shall be saddle type or type that completely encircles the cable.
 - 4. Equip each cable stanchion with one spare cable arm, with three spare insulators for future use.
- C. Ladder: Fiberglass with 400 mm (16 inches) rung spacing. Provide securely-mounted ladder for every manhole over 1.2 M (4 feet) deep.
- D. Ground Rod Sleeve: Provide a 75 mm (3 inches) PVC sleeve in manhole floors so that a driven ground rod may be installed.
- E. Sump: Provide 305 mm x 305 mm (12 inches x 12 inches) covered sump frame and grated cover.

2.2 PULLBOXES

- A. General: Size as indicated on the drawings. Provide pullboxes with weatherproof, non-skid covers with recessed hook eyes, secured with corrosion- and tamper-resistant hardware. Cover material shall be identical to pullbox material. Covers shall have molded lettering, ELECTRIC or SIGNAL as applicable. Pullboxes shall comply with the requirements of ANSI 77 Tier 15 loading. Provide pulling irons, 22 mm (0.875 inch) diameter galvanized steel bar with exposed triangular-shaped opening.
- B. Polymer Concrete Pullboxes: Shall be molded of sand, aggregate, and polymer resin, and reinforced with steel, fiberglass, or both. Pullbox shall have open bottom
- C. Fiberglass Pullboxes: Shall be sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
- D. Concrete Pullboxes: Shall be monolithically-poured reinforced concrete.

2.3 DUCTS

- A. Number and sizes shall be as shown on the drawings.
- B. Ducts (concrete-encased):
 - 1. Plastic Duct:

- a. NEMA TC6 & 8 and TC9 plastic utilities duct UL 651 and 651A Schedule 40 PVC conduit.
- b. Duct shall be suitable for use with 90° C (194° F) rated conductors.
- 2. Conduit Spacers: Prefabricated plastic.
- C. Ducts (direct-burial):
 - 1. Plastic duct:
 - a. Schedule 40 PVC or HDPE conduit
 - b. Duct shall be suitable for use with 75° C (167° F) rated conductors.
 - 2. Rigid metal conduit: UL6 and NEMA RN1 galvanized rigid metal, half-lap wrapped with 10 mil PVC tape.

2.4 GROUNDING

- A. Ground Rods and Ground Wire: Per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

2.5 WARNING TAPE

- A. 4-mil polyethylene 75 mm (3 inches) wide detectable tape, red with black letters, imprinted with "CAUTION - BURIED ELECTRIC CABLE BELOW" or similar.

2.6 PULL ROPE FOR SPARE DUCTS

- A. Plastic with 890 N (200 lb) minimum tensile strength.

PART 3 - EXECUTION

3.1 MANHOLE AND PULLBOX INSTALLATION

- A. Assembly and installation shall be per the requirements of the manufacturer.
 - 1. Install manholes and pullboxes level and plumb.
 - 2. Units shall be installed on a 300 mm (12 inches) thick level bed of 90% compacted granular fill, well-graded from the 25 mm (1 inches) sieve to the No. 4 sieve. Granular fill shall be compacted with a minimum of four passes with a plate compactor.
- B. Access: Ensure the top of frames and covers are flush with finished grade.
- C. Grounding in Manholes:
 - 1. Ground Rods in Manholes: Drive a ground rod into the earth, through the floor sleeve, after the manhole is set in place. Fill the sleeve with sealant to make a watertight seal. Rods shall protrude approximately 100 mm (4 inches) above the manhole floor.
 - 2. Install a No. 3/0 AWG bare copper ring grounding conductor around the inside perimeter of the manhole and anchor to the walls with metallic cable clips.
 - 3. Connect the ring grounding conductor to the ground rod by an exothermic welding process.
 - 4. Bond the ring grounding conductor to the duct bank equipment grounding conductors, the exposed non-current carrying metal parts of racks, sump covers, and like items in the manholes with a minimum No. 6 AWG bare copper jumper using an exothermic welding process.

- D. Manhole Lighting: Provide NEMA 3R lighting switch mounted no more than 600 mm (2 feet) from top of ladder and a 27 W compact fluorescent wet location light fixture in manhole. Provide dedicated 20 mm (0.75 inch) direct-buried conduit and conductors to nearest electrical panelboard.
- E. Sump Pump: Provide 120V cord and plug connected sump pump complete with float switch, thermal overload protection, and GFCI receptacle mounted in NEMA 3R boxes in manhole. Provide dedicated 20 mm (0.75 inch) direct-buried conduit and conductors to nearest electrical panelboard.

3.2 TRENCHING

- A. Refer to Section 31 20 11 EARTH MOVING (SHORT FORM) for trenching, backfilling, and compaction.
- B. Before performing trenching work at existing facilities, a Ground Penetrating Radar Survey shall be carefully performed by a certified technician to reveal all existing underground ducts, conduits, cables, and other utility systems.
- C. Work with extreme care near existing ducts, conduits, and other utilities to avoid damaging them.
- D. Cut the trenches neatly and uniformly.
- E. For Concrete-Encased Ducts:
 - 1. After excavation of the trench, stakes shall be driven in the bottom of the trench at 1.2 M (4 foot) intervals to establish the grade and route of the duct bank.
 - 2. Pitch the trenches uniformly toward manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching the ducts toward buildings wherever possible.
 - 3. The walls of the trench may be used to form the side walls of the duct bank, provided that the soil is self-supporting and that the concrete envelope can be poured without soil inclusions. Forms are required where the soil is not self-supporting.
 - 4. After the concrete-encased duct has sufficiently cured, the trench shall be backfilled to grade with earth, and appropriate warning tape installed.
- F. Individual conduits to be installed under existing paved areas and roads that cannot be disturbed shall be jacked into place using rigid metal conduit, or bored using plastic utilities duct or PVC conduit, as approved by the Resident Engineer.

3.3 DUCT INSTALLATION

- A. General Requirements:
 - 1. Ducts shall be in accordance with the NEC, as shown on the drawings, and as specified.
 - 2. Join and terminate ducts with fittings recommended by the manufacturer.
 - 3. Slope ducts to drain towards manholes and pullboxes, and away from building and equipment entrances. Pitch not less than 100 mm (4 inch) in 30 M (100 feet).

4. Underground conduit stub-ups and sweeps to equipment inside of buildings shall be galvanized rigid metal conduit half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) outside the building foundation. Tops of conduits below building slab shall be minimum 610 mm (24 inches) below bottom of slab.
5. Stub-ups and sweeps to equipment mounted on outdoor concrete slabs shall be galvanized rigid metal conduit half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) away from the edge of slab.
6. Install insulated grounding bushings on the conduit terminations.
7. Radius for sweeps shall be sufficient to accomplish pulls without damage. Minimum radius shall be six times conduit diameter.
8. All multiple conduit runs shall have conduit spacers. Spacers shall securely support and maintain uniform spacing of the duct assembly a minimum of 75 mm (3 inches) above the bottom of the trench during the concrete pour. Spacer spacing shall not exceed 1.5 M (5 feet). Secure spacers to ducts and earth to prevent floating during concrete pour. Provide nonferrous tie wires to prevent displacement of the ducts during concrete pour. Tie wires shall not act as substitute for spacers.
9. Duct lines shall be installed no less than 300 mm (12 inches) from other utility systems, such as water, sewer, chilled water.
10. Clearances between individual ducts:
 - a. For similar services, not less than 75 mm (3 inches).
 - b. For power and signal services, not less than 150 mm (6 inches).
11. Duct lines shall terminate at window openings in manhole walls as shown on the drawings. All ducts shall be fitted with end bells.
12. Couple the ducts with proper couplings. Stagger couplings in rows and layers to ensure maximum strength and rigidity of the duct bank.
13. Keep ducts clean of earth, sand, or gravel, and seal with tapered plugs upon completion of each portion of the work.
14. Spare Ducts: Where spare ducts are shown, they shall have a nylon pull rope installed. They shall be capped at each end and labeled as to location of the other end.
15. Duct Identification: Place continuous strip of warning tape approximately 300 mm (12 inches) above ducts before backfilling trenches. Warning tape shall be preprinted with proper identification.
16. Duct Sealing: Seal ducts, including spare ducts, at building entrances and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of foreign objects and material, moisture, and gases.
17. Use plastic ties to secure cables to insulators on cable arms. Use minimum two ties per cable per insulator.

B. Concrete-Encased Ducts:

1. Install concrete-encased ducts for medium-voltage systems, low-voltage systems, and signal systems, unless otherwise shown on the drawings.
2. Duct banks shall be single or multiple duct assemblies encased in concrete. Ducts shall be uniform in size and material throughout the installation.
3. Tops of concrete-encased ducts shall be:
 - a. Not less than 600 mm (24 inches) and not less than shown on the drawings, below finished grade.
 - b. Not less than 750 mm (30 inches) and not less than shown on the drawings, below roads and other paved surfaces.
 - c. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
 - d. Conduits crossing under grade slab construction joints shall be installed a minimum of 1.2 M (4 feet) below slab.
4. Extend the concrete envelope encasing the ducts not less than 75 mm (3 inches) beyond the outside walls of the outer ducts.
5. Within 3 M (10 feet) of building and manhole wall penetrations, install reinforcing steel bars at the top and bottom of each concrete envelope to provide protection against vertical shearing.
6. Install reinforcing steel bars at the top and bottom of each concrete envelope of all ducts underneath roadways and parking areas.
7. Where new ducts and concrete envelopes are to be joined to existing manholes, pullboxes, ducts, and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions.
8. Duct joints in concrete may be placed side by side horizontally, but shall be staggered at least 150 mm (6 inches) vertically.
9. Pour each run of concrete envelope between manholes or other terminations in one continuous pour. If more than one pour is necessary, terminate each pour in a vertical plane and install 19 mm (0.75 inch) reinforcing rod dowels extending 450 mm (18 inches) into concrete on both sides of joint near corners of envelope.
10. Pour concrete so that open spaces are uniformly filled. Do not agitate with power equipment unless approved by the Resident Engineer.

C. Direct-Burial Ducts:

1. Install direct-burial ducts only where shown on the drawings. Provide direct-burial ducts only for low-voltage power and lighting branch circuits.
2. Tops of ducts shall be:
 - a. Not less than 600 mm (24 inches) and not less than shown on the drawings, below finished grade.

- b. Not less than 750 mm (30 inches) and not less than shown on the drawings, below roads and other paved surfaces.
 - c. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
3. Do not kink the ducts. Compaction shall not deform the ducts.
- D. Connections to Manholes: Ducts connecting to manholes shall be flared to have an enlarged cross-section to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 300 mm (12 inches) in each direction. Perimeter of the duct bank opening in the manhole shall be flared toward the inside or keyed to provide a positive interlock between the duct and the wall of the manhole. Use vibrators when this portion of the encasement is poured to ensure a seal between the envelope and the wall of the structure.
 - E. Connections to Existing Manholes: For duct connections to existing manholes, break the structure wall out to the dimensions required and preserve the steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.
 - F. Connections to Existing Ducts: Where connections to existing ducts are indicated, excavate around the ducts as necessary. Cut off the ducts and remove loose concrete from inside before installing new ducts. Provide a reinforced-concrete collar, poured monolithically with the new ducts, to take the shear at the joint of the duct banks.
 - G. Partially-Completed Ducts: During construction, wherever a construction joint is necessary in a duct bank, prevent debris such as mud and dirt from entering ducts by providing suitable plugs. Fit concrete envelope of a partially completed ducts with reinforcing steel extending a minimum of 600 mm (2 feet) back into the envelope and a minimum of 600 mm (2 feet) beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm (3 inches) from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 300 mm (12 inches) apart. Restrain reinforcing assembly from moving during pouring of concrete.

3.4 ACCEPTANCE CHECKS AND TESTS

- A. Duct Testing and Cleaning:
 - 1. Upon completion of the duct installation, a standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material left in the duct, and to test for out-of-round conditions.
 - 2. The mandrel shall be not less than 300 mm (12 inches) long, and shall have a diameter not less than 13 mm (0.5 inch) less than the inside diameter of the duct. A brush with stiff bristles shall then be pulled through each duct to remove the loosened particles. The diameter of the brush shall be the same as, or slightly larger than, the diameter of the duct.

3. If testing reveals obstructions or out-of-round conditions, the Contractor shall replace affected section(s) of duct and retest to the satisfaction of the Resident Engineer at no cost to the Government.
4. Mandrel pulls shall be witnessed by the Resident Engineer.

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