# SECTION 26 05 41
# UNDERGROUND ELECTRICAL CONSTRUCTION

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. This section specifies the furnishing, installation and connection of manholes, handholes and ducts to form a complete underground raceway system.

B. “Duct” and “conduit”, and “rigid metal conduit” and “rigid steel conduit are used interchangeably in this specification and have the same meaning.

### 1.2 RELATED WORK

A. Section 31 20 00, EARTH MOVING: Trenching, backfill and compaction.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.

C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings and boxes for raceway systems.

D. 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.

### 1.3 SUBMITTALS

A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. Shop Drawings:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
2. Include manholes, handholes, duct materials, and hardware. Proposed deviations from details on the drawings shall be clearly marked on the submittals. If necessary to locate manholes or handholes at locations other than shown on the drawings, show the proposed locations accurately on scaled site drawings, and submit four copies to the COR for approval prior to construction.
3. Reinforcement shop drawings for precast manholes prepared in accordance with ACI-SP-66.
4. Precast manholes and handholes: Submit plans on elevation showing openings, pulling irons cable supports, sump and other details.

Also, submit detail drawings and design calculations for approval prior to installation. Submittal shall bear the seal of a registered structural engineer.

C. Certifications: Two weeks prior to final inspection, submit four copies of the following to the COR:
   1. Certification that the materials are in accordance with the drawings and specifications.
   2. Certification, by the Contractor, that the complete installation has been properly installed and tested.

**1.4 APPLICABLE PUBLICATIONS**

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 the basic designation only.

A. American Concrete Institute (ACI):
   Building Code Requirements for Structural Concrete
   318/318M-2005.....Building Code Requirements for Structural Concrete & Commentary
   SP-66-04.....ACI Detailing Manual

B. American Society for Testing and Materials (ASTM):
   C478/C478M 2006(b).....Standard Specification for Precast Reinforced Concrete Manhole Sections
   C990 REV A 2003 .....Standard Specification for joints concrete pipe, Manholes and Precast Box using performed flexible Joint sealants.

C. Institute of Electrical and Electronic Engineers (IEEE):
   C2-2002 .....National Electrical Safety Code

D. National Electrical Manufacturers Association (NEMA):
   RNI 2005.....Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
   TC 2 2003.....Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
   TC 3-2004.....PVC Fittings for Use with Rigid PVC Conduit and Tubing
   TC 6 & 8 2003.....PVC Plastic Utilities Duct For Underground Installations

TC 9-2004.....Fittings for PVC Plastic Utilities Duct for Underground Installation

E. National Fire Protection Association (NFPA):

70 2005.....National Electrical Code (NEC)

F. Underwriters Laboratories, Inc. (UL):

6-2004.....Electrical Rigid Metal Conduit-Steel

467-2004.....Standard for Grounding and Bonding Equipment

651-2005.....Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings

651A-2003.....Type EB and A Rigid PVC Conduit and HDPE Conduit, (RTRC)

651B-2002.....Continuous Length HDPE Conduit

G. U.S. General Services Administration (GSA):

A-A-60005-1998.....Frames, Covers, Gratings, Steps, Sump and Catch Basin, Manhole

SS-S-210A-1981.....Sealing Compound, Preformed Plastic for Expansion joints And Pipe Joints

**PART 2 - PRODUCTS**

**2.1 CONCRETE MANHOLES AND HARDWARE**

A. Reinforced Concrete: ACI 318, 20MPA (3000 psi) minimum 28-day compressive strength.

B. Reinforcing Steel: Number 4 minimum.

C. Manhole Hardware:

1. Frames and covers (traffic type):
   a. GSA A-A-60005 Type III.
   b. Frames: Style A, size 30A.
   c. Covers, Type D, size 30A, marked "POWER" or "SIGNAL" as applicable.
   d. Refer to details on plans.
2. Sump frames and gratings:
   a. GSA A-A-60005.
   b. Frames, Type VII.
   c. Gratings, Type I.
   d. Refer to details on plans.
3. Pulling Irons: 22 mm (7/8-inch) diameter hot-dipped galvanized steel bar with exposed triangular shaped opening.

4. Cable supports:
   a. Cable stanchions, hot rolled, heavy duty, hot-dipped galvanized "T" section steel 56 mm (2-1/4 inches) by 6 mm (1/4-inch) in size and punched with 14 holes on 38 mm (1-1/2 inch) centers for attaching cable arms.
   b. Cable arms, 5 mm (3/16-inch) gage, hot rolled, hot-dipped galvanized sheet steel pressed to channel shape. Arms shall be approximately 63 mm (2-1/2 inches) wide and 350 mm (14 inches) long.
   c. Insulators for cable supports, high glazed, wet process porcelain.
   d. Spares: Equip each cable stanchion with two spare cable arms and six spare insulators for future use.
   e. Miscellaneous hardware, hot-dipped galvanized steel.
5. Manhole Ladders:
   a. Manhole Ladders: Aluminum with 400 mm (16 inch) rung spacing.

D. Handhole Hardware:
1. Frames and covers configuration as shown on the drawings. Cast the words “Electric” and “Telephone” in the top face of the power and telephone manhole covers respectively.
2. Pulling irons, 22 mm (7/8-inch) diameter galvanized steel bar with exposed triangular shaped opening.
3. Cable supports are not required.

E. Ground Rod Sleeve: Provide a 75 mm (3 inches) PVC sleeve in manhole floors so that a driven ground rod may be installed.

F. In lieu of poured-in-place manholes and handholes, the Contractor may provide precast units. Units shall comply with ASTM C478, C478M.
1. Size: Plan area and clear height shall be not less than that shown on the drawings for poured-in-place type.
2. Accessories, hardware, and facilities shall be the same as required for poured-in-place type.
3. Assume ground water level 900 mm (3 feet) below ground surface unless a higher water table is shown in the boring logs and adjust design accordingly.
4. Construction:
   a. Units, precast monolithically or of assembled sections. Base and first riser shall be monolithic.

b. Provide tongue-and-groove joints to firmly interlock adjoining components. Seal joints watertight using preformed plastic or rubber materials conforming to ASTM C990 or GSA SS-S-210A. Install sealing material in strict accordance with the sealant manufacturers' printed instructions.
c. Provide lifting devices cast into units.
d. Identify all structures with manufacturer's name embedded in, or otherwise permanently attached to an interior wall face.
e. Provide a sleeve in manhole floors so that a driven ground rod may be installed.

**2.2. DUCTS:**

A. Number and sizes shall be as shown on drawings.
B. Ducts (concrete encased):
1. Plastic Duct:
a. UL 651 and 651A Schedule 80 PVC.
b. Duct shall be suitable for use with 90 degree C rated conductors.
2. Conduit Spacers: Prefabricated plastic.
C. Ducts (direct burial):
1. Plastic duct:
a. NEMA TC2 and TC3
b. UL 651, 651A and 651B, Schedule 80 PVC.
c. Duct shall be suitable for use with 75 degree C rated conductors.
2. Rigid metal conduit, PVC-coated: UL6 and NEMA RN1 galvanized rigid steel, threaded type, coated with PVC sheath bonded to the galvanized exterior surface, nominal 1 mm (0.040 inch) thick.

**2.3 GROUNDING**

A. Rods: Per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS and UL 467
B. Ground Wire: Stranded bare copper 16 $mm^2$ (6 AWG) minimum.

**2.4 WARNING TAPE:**

A. Standard 4-mil polyethylene 76 mm (3 inch) wide tape, detectable type, red with black letters, imprinted with “CAUTION BURIED ELECTRIC CABLE BELOW”.

**2.5 PULL ROPE:**

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

**PART 3 - EXECUTION**

**3.1 MANHOLE AND HANDHOLE CONSTRUCTION AND INSTALLATION**

A. General Requirements:

1. Construct manholes of reinforced concrete.
2. Locate manholes and handholes at the approximate locations shown on the drawings with due consideration given to the location of other utilities, grades, and paving.
3. Steel reinforcing concrete cover, not less than 50 mm (2 inches) thick for exterior surfaces, 38 mm (1 1/2 inches) thick for interior surfaces, and 25 mm (1 inch) thick for the bottom surfaces of the top slabs.
4. Walls, floors, and top:
   a. Construct monolithic walls and floors with window openings in walls for ducts.
   b. Provide sump pits in the floor of manholes for drainage.
   c. Provide manhole with a circular opening suitable for the installation of the frame and cover. Provide water stops at framed cold joints.
5. Duct terminations: Provide windows at duct bank terminations and fill with concrete after duct placement. Terminations shall be sealed watertight.
6. Pulling irons:
   a. Provide pulling irons opposite each duct entrance.
   b. Cast pulling irons in the walls opposite duct windows approximately 152mm (6 inches) above the top of the window.

B. Manhole Access:

1. Manhole chimney shall consist of a sufficient number of brick and mortar courses between top of manhole and manhole frame to reach the required level. Grout the manhole frame to the chimney.
2. The top of frames and covers shall be flush type, with the finish flush with finished grade in paved and unpaved areas.
3. Frames and covers in roadways and paved areas shall be traffic type. In unpaved areas frames and covers may be non-traffic type.

C. Access for Handholes: Make the top of frames and covers flush with finished grade.

D. Manhole Cable Racks:

1. Provide cable racks with porcelain insulator supports in each manhole.
2. Cable support intervals shall not exceed 900mm (36 inches).
3. Install racks at the above spacing on all walls for not less than one cable, whether or not the racks will be used for cables. Install additional racks as required for the cables.
4. Each rack shall include cable support insulators.

E. Ground Rods and Grounding in Manholes:

1. Ground rods:
   a. Rods shall protrude approximately 100 mm (4 inches) above the manhole floor.
   b. Poured-in-place manholes: Drive a ground rod into the earth, before the floor is placed, at a convenient point close to the manhole wall.
   c. Precast manholes: Drive a ground rod into the earth, through the floor sleeve, after the manhole is set in place. Fill the sleeve with a sealant to make a watertight seal.
   d. Locate all utilities in area and be certain that no conduits and/or piping are in path of ground rod being driven.
2. Grounding Conductors:
   a. Install a 141 $mm^2$ (4/0 AWG) bare copper ring grounding conductor around the inside perimeter of the manhole and anchor to the walls with metallic cable clips.
   b. Connect the ring grounding conductor to the ground rod by an exothermic welding process.
   c. 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 16 $mm^2$ (6 AWG) bare copper jumper.

F. Precast Units:

1. Precast units shall have the same accessories and facilities as specified above.
2. Assembly and installation of precast components shall follow the printed instructions and recommendations of the manufacturer of the units.
3. Units shall be installed on a 300 mm (12 inch) level bed of 90% compacted granular fill, well-graded from the 25 mm (1 inch) sieve

to the No. 4 sieve. Granular fill shall be compacted with a minimum of four passes with a plate compactor.

4. Seal duct terminations watertight.

G. Ladders: Provide securely mounted ladder for every manhole over 1200 mm (4 feet) deep.

**3.2 TRENCHING**

A. Refer to Section 31 20 00, EARTH MOVING for trenching back-filling, and compaction.

B. Work with extreme care near existing ducts, conduits, cables, and other utilities to avoid damaging them.

C. Cut the trenches neatly and uniformly.

D. For Concrete Encased Ducts:

1. After excavation of the trench, stakes shall be driven in the bottom of the trench at 1200 mm (4 foot) intervals to establish the grade and route of the duct bank.
2. Pitch the trenches uniformly towards manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching the ducts towards 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 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, with appropriate warning tape attached.

E. Conduits to be installed under existing paved areas, roads, and railroad tracks that are not to be disturbed shall be jacked into place. Conduits shall be PVC-coated rigid metal.

**3.3 DUCT INSTALLATION**

A. General Requirements:

1. Ducts shall be in accordance with the NEC and IEEE C2, as shown on the drawings, and as specified.
2. Slope ducts to drain towards manholes and handholes, and away from building and equipment entrances. Pitch not less than 100 mm (4 inches) in 30 M (100 feet).

3. Underground conduit stub-ups and sweeps to equipment inside of buildings shall be PVC-coated galvanized rigid steel, and shall extend a minimum of 1500 mm (5 feet) outside of building foundation.
4. Stub-ups, sweeps, and risers to equipment mounted on outdoor concrete slabs shall be PVC-coated galvanized rigid steel, and shall extend a minimum of 1500 mm (5 feet) away from edge of slab.
5. Install insulated grounding bushings on the terminations.
6. PVC-coated rigid steel conduits shall be coupled to the ducts with suitable adapters, and the whole encased with 75 mm (3 inches) of concrete.
7. PVC coated rigid steel conduit turns of direction for all duct lines shall have minimum 1200 mm (4 feet) radius in the horizontal and vertical directions. PVC conduit sweeps for all duct lines shall have a minimum 12000 mm (40 feet) radius in the horizontal and 1200 mm (4 feet) in the vertical directions. Where a 12000 mm (40 feet) radius is not possible, horizontal turns of direction shall be rigid steel.
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 bottom of trench during the concrete pour. Spacer spacing shall not exceed 1500 mm (5 feet).
9. Duct lines shall be installed no less than 300 mm (12 inches) from other utility systems, such as water, sewer, and chilled water.
10. Clearances between individual ducts:
    a. For like services, not less than 75 mm (3 inches).
    b. For power and signal services, not less than 150 mm (6 inches).
    c. Provide plastic spacers to maintain clearances.
    d. Provide nonferrous tie wires to prevent displacement of the ducts during pouring of concrete. Tie wires shall not act as substitute for spacers.
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 insure maximum strength and rigidity of the duct bank.
13. Keep ducts clean of earth, sand, or gravel during construction, and seal with tapered plugs upon completion of each portion of the work.

B. Concrete Encased Ducts and Conduits:

1. Install concrete encased ducts for medium and high voltage systems, low voltage systems, and signal systems unless otherwise shown on the drawings.
2. Duct lines shall consist of 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. Conduits crossing under grade slab construction joints shall be installed a minimum of 1200 mm (4 feet) below slab.
   d. Conduits and duct banks which due to existing conditions or conflicts with other duct banks, piping, water mains, sewer piping, man holes, valves or similar equipment cannot be 24" below grade shall have concrete cover on all sides increased from 75 mm (3 inches) to 127 mm (5 inches) and have #4 rebar cages around duct bank, perpendicular to duct bank run, on 457 mm (18 inches) centers. Cages shall have a minimum cover of three inches of concrete.
4. Extend the concrete envelope encasing the ducts not less than 75 mm (3 inches) beyond the outside walls of the outer ducts and conduits.
5. Within 3000 mm (10 feet) of building, manhole and handhole 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, conduits, and concrete envelopes are to be joined to existing manholes, handholes, ducts, conduits, and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to insure smooth durable transitions.
8. Conduit joints in concrete may be placed side by side horizontally but shall be staggered at least 150 mm (6 inches) vertically.

9. Duct Bank Markers:
   a. Duct bank markers, where required, shall be located at the ends of duct banks except at manholes or handholes at approximately every 60 meter (200 feet) along the duct run and at each change in direction of the duct run. Markers shall be placed 600 mm (2 feet) to the right of the duct bank, facing the longitudinal axis of the run in the direction of the electrical load.
   b. The letter ”D” with two arrows shall be impressed or cast on top of the marker. One arrow shall be located below the letter and shall point toward the ducts. Second arrow shall be located adjacent to the letter and shall point in a direction parallel to the ducts. The letter and arrow adjacent to it shall each be approximately 75 mm (2-inches) long. The letter and arrows shall be V-shaped, and shall have a width of stroke at least 6 mm (¼ inch) at the top and a depth of 6 mm (1/4 inch).
   c. In paved areas, the top of the duct markers shall be flush with the finished surface of the paving.
   d. Where the duct bank changes direction, the arrow located adjacent to the letter shall be cast or impressed with an angle in the arrow the same as the angular change of the duct bank.

C. Concrete-Encased and Direct Burial Duct and Conduit Identification: Place continuous strip of warning tape approximately 300 mm (12 inches) above ducts or conduits before backfilling trenches. Warning tape shall be preprinted with proper identification.

D. Spare Ducts and Conduits: 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.

E. Duct and Conduit Cleaning:
   1. Upon completion of the duct bank installation or installation of direct buried ducts, a standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material left in the line. The mandrel shall be not less than 3600 mm (12 inches) long, and shall have a diameter not less than 13 mm (1/2 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.

2. Mandrel pulls shall be witnessed by the COR.

F. Duct and Conduit Sealing: Seal the ducts and conduits at building entrances, and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of moisture and gases.

G. Connections to Manholes: Duct bank envelopes connecting to underground structures shall be flared to have enlarged cross-section at the manhole entrance 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 underground structure shall be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

H. Connections to Existing Manholes: For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve 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.

I. Connections to Existing Ducts: Where connections to existing duct banks are indicated, excavate around the duct banks as necessary. Cut off the duct banks and remove loose concrete from the conduits before installing new concrete-encased ducts. Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks.

J. Partially Completed Duct Banks: 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 conduit plugs. Fit concrete envelope of a partially completed duct bank 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 (1 foot) apart. Restrain reinforcing assembly from moving during pouring of concrete.

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