Underground Services for Electrical Systems

Scope

This guideline defines the requirements and standards for design of underground electrical and telecommunication pathway systems.

The guideline covers concrete encased duct banks and manholes for primary (medium voltage) power distribution cables and telecommunications cables.

Also included are direct buried ducts for secondary power cables, site lighting cables, and dedicated telecommunications circuits.

Related Sections

U-M Design Guideline Sections:
6.3 DG 260526 - Grounding and Bonding for Electrical
6.3 DG 260533 – Electrical Materials and Methods
6.3 DG 261000 – Medium Voltage Electrical Distribution
6.3 DG 265600 - Exterior Lighting

U-M Master Specification Sections:(A digitally accessible version is pending; please email AEC-Digital Accessibility Support if assistance is needed)
7.1 MS 033053 - Miscellaneous Cast-in-Place Concrete

U-M Standard Details:
9.3 Series - Electrical Standard Details

Design Requirements

Use U-M Master Specification 260543, “Underground Services for Electrical Systems” as basis for design and specifying underground electrical and telecommunication pathway systems. Edit the specification and details to make them project specific. When editing the specification, turn on hidden text and follow the Spec Editor notes.

Underground Ducts

Slope duct banks downward, toward manholes, and away from buildings and tunnels, a minimum of 6 inches per 100 feet. Duct banks shall not route water from manholes into buildings or tunnels, or contain traps between manholes where water may accumulate.

Horizontal directional changes and sloping vertical changes in duct banks shall be made with 20’-0” minimum radius bends. Where this radius cannot be accommodated, perform detailed pulling tension and sidewall pressure calculations, to ensure compliance with cable manufacturer's recommendations. Vertical directional changes in duct banks up into buildings shall have a minimum 6’-0 radius.

Duct banks and direct buried ducts shall be supported on undisturbed soil or on piers extending down to undisturbed soil.

Where power and telecommunications duct banks run in parallel, they shall be separated by a minimum of 12 inches of soil or concrete - vertically and/or horizontally. If the services need to be placed one upon the other (vertically stacked), the power ducts shall be above the telecommunications ducts. Where UM duct banks are located within the Right of Way, a minimum separation of 36” from other utilities may be required. Verify with city of Ann Arbor requirements.

Ground primary power duct banks with a No. 4/0 AWG bare stranded copper ground wire that is run within the duct bank and is grounded at both ends. Direct buried ducts shall be grounded by insulated, stranded copper ground wires installed in each duct. Telecommunications duct banks do not require grounding.

Place marker tape approximately 12 inches above duct banks or direct buried ducts for the entire length of the duct run. Marker tape shall be plastic, vinyl, or Mylar, 6 inches wide, red for electrical power and orange for telecommunications, and labeled to indicate the type of circuit buried below.

The contractor shall clean out ducts, using a solid mandrel and a stiff bristled brush, prior to cable pulling (3-1/4” mandrel for 4” ducts and 4” mandrel for 5” ducts). Leave a pulling string in the duct when cleanout is complete. This will serve as the duct identification on both ends of the run.

Concrete Encased Ducts

Specify Type DB PVC conduit for concrete encased duct banks.
PVC conduit for concrete encasement shall be Type DB, 4-inch diameter minimum, UL Labeled for 90 degrees C cables. Fittings shall be Type DB, solvent type, and from the same manufacturer as the conduit.

Primary power duct banks shall include No. 4 steel reinforcing bars. Telecommunications duct banks do not require steel reinforcing.

Prior to concrete encasement, ducts, reinforcing steel and ground wires shall be secured with nonmetallic straps or cable ties to nonmetallic duct spacers at intervals not exceeding 8 feet. Duct spacers shall be sized for the ducts being held, and shall provide the minimum spacing between ducts required for concrete flow and by the NEC. Duct spacers shall be anchored to the ground using nonmetallic bands and stakes.

Duct banks shall have a minimum of 3 inches of concrete cover on all sides. Concrete shall have a minimum strength of 3,000 psi at 28 days.

Always provide spare ducts in concrete encased duct banks.

Direct Buried Ducts

Specify Schedule 40 PVC conduit for direct buried ducts, except where galvanized rigid steel conduit is required for strength or due to inadequate cover.

PVC conduit for direct burial shall be Schedule 40, UL Labeled for 90 degrees C cables. Fittings shall be Schedule 40, solvent type, and from the same manufacturer as the conduit.

Direct buried ducts and fittings shall have bend radii greater than the minimum bend radii of the cables enclosed, and shall not be smaller than the radii of standard manufactured elbows.

Route direct buried ducts at right angles to building lines and site features, and as close to curbs and sidewalks as possible to avoid interferences with future landscaping.

Where direct buried PVC ducts cannot be buried deep enough to meet the NEC minimum cover requirements, rigid steel conduits shall be installed instead, or a concrete cover shall be poured over the ducts.

When installing direct buried ducts under sidewalks, walkways and other paved areas, install at least one additional 6" PVC sleeve for installation of future ducts without the need to re-open the paved area.

Sleeves

Under roadways, driveways, parking lots and sidewalks, and all other paved areas, specify Schedule 40 PVC conduit sleeves to enclose direct buried ducts.

Sleeves shall be Schedule 40 PVC conduit, 6-inch diameter, UL Labeled for 90 degrees C cables. Couplings shall be Schedule 40, solvent type, and from the same manufacturer as the conduit.

Sleeves shall be buried at a minimum depth of 24” to their top. Sleeves shall extend a minimum of 12” beyond the paved areas they pass under.

Spare sleeves shall be taped closed at both ends with duct tape.

Ends of spare sleeves shall be marked with steel stakes, pipes or conduits that are 3’ long minimum, driven vertically down at the sleeve ends to a depth of 6” below grade to their top.

A marker tape shall be buried in the backfill approximately 12 inches above the sleeves for the entire length of the sleeves.

Manholes and Pull Boxes

Specify reinforced concrete manholes where required for the following:

1. Satisfy cable routing needs, to control pulling tensions, and for cable splicing.
2. Keep duct lengths to 400 feet or less on straight runs. Longer runs are acceptable only when calculations are completed showing that pulling tensions and sidewall pressures are not exceeded in the longer pull.
3. Keep the maximum amount of bends between manholes to no more than 180 degrees.
    a. When bends are present, the maximum length of the duct must be appropriately reduced so the limiting (maximum) pulling tension and maximum sidewall pressures of the cables are not exceeded.
    b. The designer shall do sufficient calculations to ensure that the two, above noted, limiting factors are not violated.

Specify pre-cast polymer pull boxes, only in owner-approved locations, where adequate space does not exist for the installation of manholes.

Manholes and pull boxes shall be accessible on at least three sides by trucks, cable reel trailers, and other cable pulling equipment.

Manholes - General

Manholes shall be precast, or cast in place, and shall be steel reinforced as needed, to achieve an MDOT highway loading of H-20.

Provide a cast iron frame with cover, a galvanized steel ladder, and galvanized pulling eyes embedded in the concrete opposite each duct entrance and in the floor beneath the cover.

Provide a sealed depression in the floor offset slightly from the center, for installation of a portable sump pump. Drains shall not be installed in floors.

Manholes placed in 'green-belts' and like areas shall have manhole covers with a lighter duty rating (the manholes themselves and the 'ring', however, are the same as required for the MDOT, H-20 rating)

All duct entries into manholes shall include provisions for bell end fittings and a means to securing the duct bank(s) to the manhole wall

1. Precast, or cast-in-place, manholes shall be delivered (or constructed) with the ducts openings cast in place.
2. Provisions for known future ducts shall have knockouts installed, with the bell end fittings included.
3. When installing multiple new ducts into manholes without proper knockouts, cut an opening in the manhole wall, rework steel reinforcing, and install ducts, all in accordance with the associated U of M standard detail.
4. Alternatively, when installing multiple new ducts into manholes without proper knockouts, the duct openings may be core drilled at the proper locations. The diameter of the corings, however, shall be 2” to 4" larger than the duct being installed. This larger opening will allow proper grouting of the ducts and bell ends into the manhole wall.

Provide bell end fittings on ducts where the ducts enter manholes. Note that the use of a coupling on the end of a length of PVC pipe, is not the equivalent of a bell end fitting - only true 'bell end fittings' shall be used to meet this requirement. The duct(s) and associated bell end fittings shall be securely grouted into the wall of the manhole.

Where duct banks enter manholes or buildings, they shall be constructed as an integral part of the wall. (Do not core-drill the wall and then install end bell fittings to the edge of the core-drilled hole without prior written approval from the U-M Primary Systems Engineer.) Duct bank shall extend to the inside surfaces of the walls, and the duct bank reinforcing shall be integrated with the wall reinforcing.

Ducts shall enter telecommunications manholes on the short sides only. Ducts may enter primary manholes on any side, but should be positioned to permit installation of additional ducts in the future. Ducts should enter as perpendicular to the wall surface as possible.

Ground splices and connections at manholes and pull boxes, where required, shall be exothermic welds, or copper (or bronze) compression ground fittings, or bolted compression ground fittings.

Concrete shall have a minimum strength of 3,000 psi at 28 days.

Electrical Power Manholes

Electric power manholes shall have inside dimensions of 10 feet long by 10 feet wide by 7 feet high. Duct entry points shall be offset from the center of the wall to allow easier training of the cables along the walls of the manhole.

Provide a grounding system for each manhole and connect this to grounds run with power duct banks. Make all grounding system connections using exothermic welds, or copper (or bronze) fittings as manufactured by Burndy Hyground System.

The frame and 36" cover for electrical power manholes shall be East Jordan Iron Works 1580C with lettering, “UM ELEC”.

Electric power manholes shall be equipped with 3 Aickenstrut (non-metallic) stanchions per wall, each bolted to the wall with stainless steel Rawl bolts. Each stanchion shall be fitted with one Aickenstrut (non-metallic) cable support arm.

The typical medium voltage feeder being installed is composed of 3-1/C, 350 kcmil copper, 15kV (ungrounded) cables, with tape shields, and EPR insulation rated for 133% of the 15kV nominal rating.

Ground electric power manholes with four, ¾ inch diameter by 10 foot long, ground rods, one driven inside of the manhole at each corner. Connect the ground rods and any duct bank ground conductors together with a No. 4/0 AWG bare, stranded copper ground wire loop. A No. 2 AWG bare stranded copper pigtail from the ground wire loop shall be used to ground the manhole cover frame, ladder support bracket, any metallic concrete inserts and metallic cable racks, and the shields of any cables that are spliced are to be grounded in the manhole.

Telecommunication Manholes

Telecommunications manholes shall have inside dimensions of 12 feet long by 6 feet wide by 7 feet high. Duct entry points shall be offset from the center of the wall to allow easier training of the cables along the walls of the manhole. Ducts shall only enter on the shorter end walls, not on the long walls. The frame and 27" cover for telecommunications manholes shall be East Jordan Iron Works 1805 with the lettering, “UM TELECOM”.

Telecommunications manholes shall contain seven full height vertical concrete inserts in each long wall, and two in each short wall. Inserts shall be 1-5/8 inch hot dipped galvanized Unistrut type channel or Aickenstrut nonmetallic channel of equal size and strength. Corner inserts shall be equipped with 12 inch corner brackets and side inserts shall be equipped with 3 inch side brackets to support full height perforated cable support racks. Each long wall shall also be equipped with 2 copper ground bus bars, 6 inches long by 2 inches wide by 1/4 inch thick, on 2 inch metal stand-offs bolted to the concrete.

Pull boxes

Pull boxes and covers shall be precast polymer concrete or polymer foam, heavy-duty rated, bottomless, with a single piece cover. Pull boxes shall be one size larger than required to loop cables out of the opening and back in again without exceeding the minimum bend radii of the cables. Covers shall be engraved “UM ELECTRIC”, “UM TELEPHONE”, or “UM OUTSIDE LIGHTING” as applicable, and attached with pentahead stainless steel bolts.

Pull boxes shall be located in mulched areas wherever possible and shall be level with the existing grade.

Provide barriers in pull boxes containing circuits of two different voltages, or containing both power and telecommunications circuits.

Excavation and Backfill

Miss Dig shall be contacted at (800) 482-7171 before performing any excavation work.

Manholes shall be installed on a base of pea gravel or MDOT Class II sand at least 12 inches deep. Pull boxes shall be installed on a base of pea gravel or MDOT Class II sand at least 6 inches deep.

Provide barricades around open holes and trenches, temporary bridges over trenches cut through major sidewalk routes. Major sidewalk routes shall not be closed to pedestrian traffic.

Trees, shrubs and plantings in the area of excavation shall be removed by the Plant Grounds Department in advance. Provide barriers to protect landscaping adjacent to the excavation area.

Remove rocks, concrete, or other debris encountered during excavation.

Where sidewalk sections must be removed for installation of underground ducts, remove the sidewalk sections (flags) completely from joint to joint.

Cut asphalt to be removed for installation of underground ducts, in two, straight, parallel lines.

Backfill excavations in 6 inch layers and mechanically compact to 98 percent compaction. Excavated materials may be used as backfill only if the backfill is sand or clean dirt that is free of rocks and debris over 3/4 inches in diameter. Dispose of clay, rocks, concrete and other debris, and replace it with MDOT Class II sand.

In landscaped areas, backfill and mechanically compact to a depth of 6 inches below grade. Backfill the last 6 inches with clean topsoil, and reseed affected lawn areas.

Restore concrete sidewalks and asphalt in accordance with University Guidelines.

Quality Assurance

U-M Code Inspection Department (EHS) shall be contacted before pouring concrete and before backfilling excavations.