CHAPTER 7

UNDERGROUND DISTRIBUTION LINES

7-1. General.

Underground lines will be provided only in those areas as established in chapter 5. Underground line installation will be coordinated with the installation master plan to avoid conflict with construction of future facilities. Lines will normally be installed adjacent to roadways in urban, housing, or industrial plant areas, but may be routed as required to meet the project objectives. A careful study will be made of all underground utilities in order to ensure a minimum of interference between electrical lines and other underground utilities, whether existing, being constructed, or proposed as a definite future construction project. Electrical lines will be at least six feet from any steam or hot water lines, except at crossings where a one-foot separation from such lines is adequate.

a. Symbols and codes. For uniformity, symbols will comply with ANSI Y32.9. Installation will comply with the requirements of the NESC and the NEC as required. Where state safety rules are predominantly accepted, such rules may be used provided they are as stringent as those of the NESC.

b. Construction and other conditions. Typical underground construction details are shown later in this chapter. Service conditions are covered in chapter 1. Grounding and surge protection are covered in chapter 9. Other conditions will follow the guidelines established by the NESC, the Rural Electrification Authority (REA), or the local utility as applicable. Underground cable systems may employ manholes or above-ground sectionalizing and pulling cabinets depending on local geological conditions, potential for damage from vehicles and the required design life of the facility.

c. Air Force underground installations.

(1) *Secondary distribution.* All secondary underground cables may be installed in either concrete encased ducts or direct burial type ducts or conduit, or they may be direct burial type cables. Direct burial plastic conduit may be utilized when cable temperature conditions are within the conduit rating and where the conduit is not under large paved areas or building structures. Conductors shall be copper, although aluminum may be used in lieu of copper conductors No. 4 AWG and larger.

(2) *Primary distribution.*

(a) 5,000 volts or less-copper, single or multiple conductor, metallic or non-metallic sheathed. Nonmetallic sheathed cable 2,000 volt to 5,000 volt rating shall be shielded.

(b) Above 5,000 volts-copper, metallic, or non-metallic sheathed, single or multiple conductor, shielded cable.

(c) Aluminum conductors of equivalent ampacities may be used in lieu of No. 4 AWG copper and larger copper conductors.

(d) Aluminum conductors shall be terminated in compression type lugs or connectors tilled with high temperature, oxide inhibitor compound.

(3) *Cable installation.* All primary underground cables shall be installed in concrete encased non-metallic ducts or concrete encased galvanized rigid steel conduits except as follows. Steel conduit, which is not concrete encased, shall be corrosion proof-coated (PVC, etc.) and shall be employed only for short runs between buildings or under paved areas. Direct buried ducts or direct buried cables may be employed for primary distribution (above 600 V) feeders located in areas which are remote to normal pedestrian and vehicle traffic. Consider using a direct buried, flexible polyethylene cable, duct type conduit with self contained cable to allow easier replacement. Concrete markers shall be provided at approximately 200 foot intervals and at each change in direction to indicate the location of underground cable route. Direct buried cable or cable duct, which is not concrete and metallic conduit encased, should be marked with a metallic/magnetic warning tape buried six to twelve inches below the surface and above the cable or duct. Cable warning tape shall be red or orange in color.

7-2. Cable.

Conductor material and insulation type will be specified. Restricting extensions of existing systems to a specific conductor material and insulation type in order to match an existing cable type is permitted only when a need has been established. Neutral cables, where required, will be installed with 600 V insulation unless concentric neutral cable is used. In duct lines, neutrals will be installed in the same conduit with associated phase cables.

a. Conductor material. Since underground conductors are continuously supported, soft-drawn copper or aluminum alloy 5005 provides adequate strength. However, the selection of copper or aluminum will be justified based upon an analysis using life, environmental, and cost factors. The need for mechanical flexibility requires that conducts be stranded, and the NEC makes this mandatory for cables larger than No. 8 AWG installed in raceways. The installation of conductors larger than 500 kcmil is not economical, and such large cables should be used only under exceptional circumstances. Large ampacities can be served by parallel or multiple circuits. Three 15 kV, single-conductor, nonmetallic-jacketed cables larger than No. 4/0 AWG will require use of ducts larger than the standard four-inch size (i.e. three single-conductor cables making up a three-phase circuit and each having individual overall diameters greater than 1.25 inches will need to be installed in a duct larger than four inches). One three-conductor cable is more costly than three single-conductor cables, and use of multiple-conductor cable will be restricted to special conditions. Metallic-armored cable is such a special condition.

b. Insulation and jacket material. The type of insulation used will be dependent upon the voltage level and type of service required. Factors affecting selection will be the effects of the surrounding environment, the importance of the load in regard to operation of the installation, and whether peak loading is continuous or intermittent.

(1) *Medium-voltage cable.* Cable will be specitied as 133 percent insulation level (ungrounded) which allows greater margin for voltage surges, insulation deterioration, and fault clearing time than does the use of the 100 percent insulation level (grounded). When marking guide specifications, refer to NFPA 70, which currently limits the minimum size to No. 1 AWG at 133 percent insulation for 15 kV to 28 kV systems and No. 2 AWG at 133 percent insulation for 8 kV to 15 kV systems. Medium-voltage cable above 3 kV will be shielded.

(a) Nonmetallic-jacketed cable. Nonmetallic-jacketed cable will be used, except where circumstances warrant other coverings. Insulation will be either crosslinked-polyethylene (XLP) for short life requirements, or ethylene-propylene-rubber (EPR) for long life requirements, in accordance with NEMA WC-7 and WC-8. Comparisons of various cable insulations, as shown in table 7-1, indicate the advantages of these two insulations over other types. Coverings (jackets) will be any of the rubber or plastic options covered by NEMA specifications. This option allows the use of cables which are available as stock items in small quantities. In some environments, however, selection of other jacket materials may be necessary because properties of some jacket materials may not provide adequate cable protection. Special shielding or coverings will not be specified, unless the designer has checked that the footage installed for each different cable diameter is large enough for manufacturers to make the special runs required.

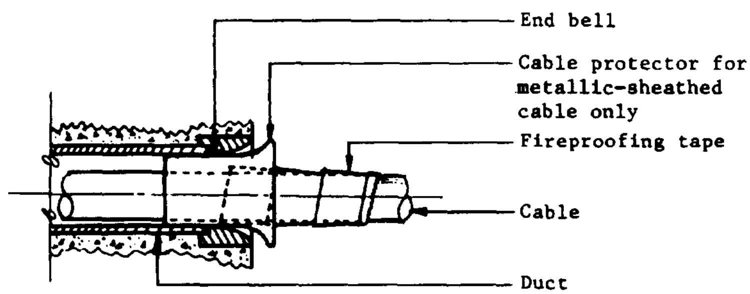
(b) Metallic-armored cable. Armored cable is justified only when cable is installed under water (submarine cables) and sometimes when installed in cable trays or trenches. Armored cable will have XLP or EPR insulation covered with a thermoplastic core covering and then provided with an interlocked-metal tape armor. A nonmetallic jacket is required for underground installations, where corrosion and moisture protection is required, for installations in outdoor cable trays, or for submarine cables. Submarine cable may also require a lead covering. Cable having a steel armor will be three-conductor type to avoid the high hysteresis and eddy current losses which can result when single-conductor cable is used.

(c) Lead-covered cable. Lead-covered cables will not be used, unless extenuating circumstances prevail such as for submarine cable. The lead covering is both more costly and more difficult to handle. The use of laminated insulation such as for paper-insulated-lead-covered (PILC) or for varnished-cambric-lead-covered (VCLC) instead of the solid or extruded dielectrics such as crosslinked-polyethylene (XLP) or ethylenepropylene-rubber (EPR) is not approved. In addition, these cables have lower temperature ratings.

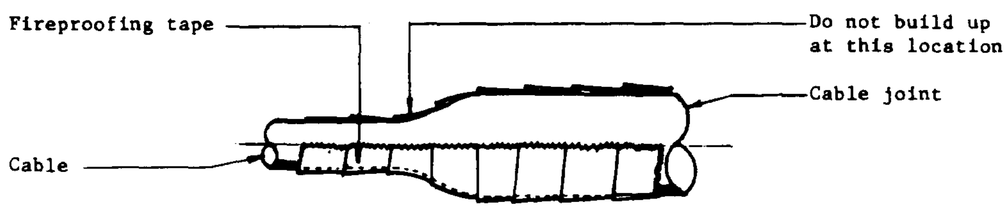
(2) *Low-voltage cables.* Cables suitable for below grade installations are listed in the NEC. Insulation will be either XLP (NEMA WC 7) or EPR (NEMA WC 8) and jackets or other protection will be in accordance with the applicable Underwriter's Laboratories (UL) specification covering that NEC type. Use of metal-clad (MC) cable will be limited as previously discussed for metallic-armored cable. The use of the less expensive Moisture-and-Heat-Resistant Thermoplastic (THWN) or Moisture-and-Heat-Resistant Cross-Linked Synthetic Polymer (XHHW) is not recommended for underground work as their thinner insulation has been designed for interior usage. Moisture-and-Heat Resistant Thermoplastic (THW) wiring does have the same thickness of insulation as Heat-Resistant Rubber (RHH)/Moisture-and-Heat Resistant Rubber (RHW)/Underground Service-Entrance (USE) wire, but polyvinyl-chloride insulation is considered to have only fair electrical and mechanical insulation properties as compared to the excellent properties exhibited by XLP and EPR insulation. UF cable may have a greater insulation thickness, but some sizes have a lower ampacity rating than does USE cable.

c. Cable ampacity. The current carrying capacities of cable will be in accordance with ampacities given in the NEC and IEEE/ICEA publications. There are many factors taken into account in determining these allowable ampacities such as operating temperatures, soil effects, shielding losses, and conductor configurations, but the variables which cause the most concern are circuit loading and location in a duct bank. Because of load diversity, peak demands for cables in a duct bank will not occur concurrently in most cases. This diversity factor will be taken into account when computating expected heat build-up in a duct bank. Heat dissipation from a cable is also influenced by the position occupied by the cable in a duck bank. Cables in duck bank corners dissipate heat more effectively than cables in interior ducts, because of the greater soil dissipating area and the smaller heat contribution from neighboring cables. Calculations of the position effect indicate that, to equalize operating temperatures, full-load ratings of cables appropriate for isolated (one-way) ducts should be decreased for multiple duct banks. For example, in an eight-way-duct bank the recommended full-load percentage decrease for each corner duct is 95 percent and for each interior duct is 83 percent giving an average load percentage decrease of 89 percent. This derating still allows provision for loads in excess of the normal feeder capacity usually found on military installations, as the summation of feeder capacities is generally from three to eight times the overall capacity of a main electric supply station.

d. Power cable joints. A splice which connects cables rated 2.5 kV and above is known as a power cable joint. Cable joints are composed of connectors to join two or more cables for the purpose of providing a continuous electric path plus necessary



DUCT ENTRANCE



CABLE JOINT

REQUIREMENTS

Fireproof only medium-voltage circuits (over 600-volts). Fireproof cables their entire length within the manhole and Into the duct entrance as indicated.

US Army Corps of Engineers

Table 7-1. Rated Conductor Temperatures.

components for maintaining symmetrical stress distribution, minimizing voltage gradients, and maximizing environmental protection.

(1) *Connectors.* Connectors will be of the compression type or the plug-in type. Mechanical connectors of the bolted or screw type or thermal connectors of the soldered, brazed, or welded type will be used only in special cases where the application so warrants. Compression connectors above 5 kV need to be of the tapered-end type, or have semiconducting (semicon) tape or molded construction to give the same effect and thus limit stresses.

(2) *Other necessary joint components.* The other necessary components are contained with the connectors in kits to provide joints which range from the fully field-assembled type (taped) to those kits with mostly factory-formed parts (preformed) which require less installation labor. Factory preformed kits are preferred. The field-assembled kits will not be used unless the Contractor cannot locate the preformed kits, and the Contractor employes a cable splicer approved by the Contracting Officer.

(a) Conventional taped or resin system splice kits. These kits cost the least for materials and are used to make up a significant number of cable joints, but this type requires the most labor to install. Joints are longer and bulkier than other types. Quality is dependent upon the splicer's skill level, so joint workmanship can vary widely. Any kit selected must have splice tapes suitable for the cable insulation. Refer to IEEE Std 141 for details and specifications of cable joints.

(b) Heat-shrinkable splice kits. These kits include factory preformed splices which are heat-treated in the field to fit the conductor. This type is simpler to install than the conventional taped or resin type, and provides a less bulky splice than any of the other types. A kit will fit a range of cable sizes, but kits may not be available for other than solid dielectric single-conductor cables.

(c) Separable insulated connectors. Such connectors are fully factory preformed into the minimum of parts necessary to adapt either the receptacle and plug or the connector and splice body to the cable insulation, shielding, and jacket. Such joints cannot be used for laminated insulations, but provide a waterproof and totally submersible joint for solid or extruded dielectric insulations. These joints are the quickest to install, but the labor savings may be outweighed by the highest initial cost. Greater reliability has been reported by utility and industry records for these joints. Connections do provide disconnectability for future taps or for cable sectionalizing during fault testing. Whenever separable insulated connectors are used for this application, they should be of the loadbreak type. The preformed kit must be suitable for the cable insulation and correctly sized for the cable diameter. Separable insulated connectors will not be used in manholes, except where necessary for reasons of clearance at airfields. Separable insulated connectors will not be used in direct burial applications.

(3) *Choice.* Any of the cable joints discussed may be permitted as a Contractor's option, whose selection is made by balancing labor savings against material costs. Disconnectable loadbreak separable connectors, which are the most expensive type of cable joints, will be used only where the disconnect feature is necessary. Metallic-armored cable splices will be enclosed in compound-filled metal splice boxes. Splice and terminator kits will be selected as recommended by the cable manufacturer.

(4) *Dissimilar material.* Both aluminum-to-copper conductor and nonmetallic-jacketed to lead-covered cable connections are easily made when connectors and splicing materials are correctly utilized and installed. While transitions from one material to another will not be permitted when installing new lines, such transitions between existing and new work are acceptable for extensions and additions.

e. High-voltage cable terminations. A device used for terminating alternating-current power cables having extruded, solid, or laminated insulation which is rated 2.5 kV and above is known as a high-voltage cable termination.

(1) *Provisions.* Such terminations are covered by IEEE Std 48 which requires terminations to be able to provide one or more of the following:

(a) Electric stress control for the cable insulation shield terminus.

(b) Complete external leakage insulation between the cable conductors and ground.

(c) A seal at the end of the cable against the entrance of the external environment which also maintains the pressure, if any, of the cable system.

(2) *Types.* Termination types are defined by IEEE Std 48 as Class 1, which provides all of the above three conditions (and includes potheads, a term now rapidly becoming obsolete), Class 2 which provides the first two conditions, and Class 3 which provides only the first condition. The first two classes include both indoor and outdoor types, but Class 3 can only be used indoors. Protection from direct exposure to solar radiation or precipitation is required for outdoor types.

(3) *Requirements.* Class 2 terminations with their unsealed ends are subject to tracking when

exposed to humidity changes occurring inside outdoor equipment. Class 3 terminations, with their exposed length in addition to the exposed end, can be more difficult to maintain plus more dangerous to maintenance personnel. Since the use of the more expensive Class 1 type causes an almost unnoticable overall cost increase in the provision of a medium-voltage cable installation, only Class 1 terminations will be used. Either taped or preformed Class 1 terminations are acceptable. Use of the next higher BIL rating in contaminated areas is not recommended, as it is preferable to have a cable failure at the termination rather than within the cable length.

f. Fireproofing. High current arcs can cause heat or even flames which can destroy cables adjacent to the arc. To limit damage, cables are often fireproofed in manholes and vaults. Fireproofing should be limited to cables rated above 600 V. Fireproofing methods include wrapping the cable with a fireproofing tape, spraying the cable with a foreproofing coating, or installing fire stops in the manhole. Medium-voltage cables and conductors in manholes that are taped or coated with a fireproofing material will be taped or coated for their entire length on an individual cable basis. Figure 7-1 shows cable fireproofing details for a taped installation. Polymeric elastomer tapes will be used. Asbestos tapes are not permitted. Where cables have been lubricated to enhance pulling into ducts, the lubricant will be removed from cables exposed in the manhole before fireproofing.

g. Insulation tests. Cable testing will be specified to be performed and successfully completed for all medium-voltage cable installations. Cable testing will include the testing of the adequacy of all cable splices and terminations, as applicable. Cables will be disconnected from equipment during the testing process. The first testing of new cables is performed by the cable manufacturer at the

Insulation Type	Max Voltage Temp. (kV)	Max Opr Temp. (°C)	Max OL [2] Temp. (°C)	Max S/C [3] Temp. (°C)
Paper (solid-type) multiconductor and single conductor, shielded	9	95	115	200
	29	90	110	200
	49	80	100	200
	69	65	80	200
Varnished cambric	5	85	100	200
	15	77	85	200
	28	70	72	200
Polyethylene (natural) [4]	5	75	95	150
	35	75	90	150
SBR rubber	2	75	95	200
Butyl rubber	5	90	105	20
	35	85	100	200
Oil-base rubber	35	70	85	200
Polyethylene (crosslinked) [4]	35	90	130	250
EPR rubber [4]	35	90	130	250
Chlorosulfonated polyethylene [4]	2	90	130	250
Polyvinyl chloride	2	60	85	150
	2	75	95	150
	2	90	105	150
Silicone rubber	5	125	150	250
Ethylene tetrafluoroethylene [5]	2	150	200	250

1 Reprinted with permission from IEEE Std 141-1986.
2 Operation at these overload (OL) temperatures shall not exceed 100 h/yr. Such 100 h overload periods shall not exceed five.
3 S/C = short-circuit
4 Cables are available in 69 kV and higher ratings.
5 For example, Tefzel.

Figure 7-1. Fireproofing of Insulated Cables.

factory, and is performed in accordance with industry standards. The designer will specify the field tests in accordance IEEE Std 400. Unless the cable accessory manufacturers indicate higher voltages are acceptable, test voltages will not exceed the recommendations of IEEE Std 404 for cable joints and IEEE Std 48 for cable terminations. Table 7-2 compares the recommendations of various standards regarding test voltages for insulation, terminations, and joints. Test voltages for 28 kV and 35 kV cable insulation should be in accordance with the AEIC standards since ICEA/NEMA standards do not cover 133 percent insulation for these two voltage classes. Tests for cables 600 volts and below will be specified in accordance with IEEE Std 422.

7-3. Duct lines.

Excluding Alaska and other permafrost locations, duct lines will be installed in accordance with the NESC regarding the frost line (i.e., below frost lines or restrained with backfill, concrete encasement, bracing, or other means to maintain its design position under stress of installation procedures, cable pulling operations, settling, or frost uplift). For permafrost locations, designs will incorporate duct line installation methods which are standard for the base, post, or local utility. In clay soil, not less than a three-inch layer of sand will cover the bottom of the duct trench before ducts are placed. Ducts will be covered with not less than a six-inch layer of sand after they are placed. Metallic conduit will not be used when concrete encasement is provided. When tying into an existing asbestos composite duct bank, proper environmental protocol will be followed. The designer will provide terrain profiles for all duct systems utilizing manholes. Systems utilizing above ground sectionalizing and pulling cabinets need profiles only in hilly or congested areas.

Table 7-2. Comparison of DC Test Voltages (kV)

Cable Rated Voltage (kV)	133 Percent Insulation		Terminations	Joints on Extruded Dielectric Cable
Phase to Phase	NEMA WC7 WC8	AEIC CS5 CS6	IEEE No. 48	IEEE No. 404
2.5	25	-	40	-
5.0	25	-	50	25
8.7	35	-	65	35
15	65	-	75	55
25	100	-	105	75
28	-	125	115	85
34.5	-	155	140	100

a. Construction.

(1) *Wall thickness.* Nonmetallic ducts are manufactured with thin-wall (type EB) and thick-wall (type DB) thicknesses. The thin-wall type is designed to be used with an added concrete encasement. The thick-wall type is used without encasement in concrete; this type of duct is installed with an earth fill separating the ducts in a bank, except that under areas used for vehicular traffic concrete encasement is necessary. Guidelines indicating where concrete encasement is necessary are provided in chapter 5.

(2) *Shape.* Most ducts have round exteriors with a round bore; however, octagonal and square exteriors are available, as are square bores. Square or octagonal exteriors may make stacking easier in some cases, but round bores are preferable for cable pulling.

(3) *Number.* Ducts are available in a single raceway configuration. Although some ducts are available in multiple duct units with from two to nine raceways in each length, this type will not be used for electric power cables.

b. Systems. For new projects, duct lines will be provided at the same time for both electric power and communication circuits. See TM 5-811-9 for communications systems requirements. Communication cables will be completely isolated from electric power cables in accordance with ANSI C2, by using separate conduits and access points, such as manholes. Separate electric and communication conduits may be installed in the same duct bank, however. For economy and space conservation, electric power and communication ducts may be installed in the same trench and manholes may be adjacent, when such arrangements suit the communication circuit requirements of the appropriate agency. Power and communication cable separation will be in accordance with ANSI C2. Fiber optic cable (and duct) spacing from power cable will be the same as for conventional cable and duct because of the continued use of hybrid systems, and to provide an increased margin of protection for the fiber optic cable.

c. Sizes. The nominal diameter of raceways for medium-voltage, communication, and other cables in ducts between manholes will be four inches, with larger ducts provided where 15 kV cables larger than No. 4/0 AWG are to be installed. The communication service duct to any building will not be less than three inches in diameter. Low-voltage power ducts supplying building services will be sized in accordance with the NEC. Exterior loads supplied from a building such as multiple lighting, control, or motor loads will be served with not less than l-inch ducts. In general, sizes of underground raceways installed should be the nominal 4-inch, 3-inch, 2-inch, or 1-inch size, except where large numbers of secondary ducts make this uneconomical, such as on tank farms.

d. Spare capacity. A sufficient number of spare ducts will be provided in duct systems between manholes to provide for at least a 25 percent increase in the number of cables. The number of spare ducts will be increased as required for future service to planned expansion. Such spare provisions do not apply to building service ducts, unless there is a definite planned expansion or a planned increase in reliability requires provision for duplicate feeders. Spare ducts should be plugged to prevent entry of debris and rodents.

e. Installation. Installation requirements for concrete-encased duct lines will meet requirements of ANSI C2. Figure 7-2 shows typical contigurations, however, spacing and arrangement will be adapted to ensure adequate conductor ampacities in accordance with the NEC and IEEE/ICEA publications. Additional duct configurations are depicted in the NEC. Figure 7-3 indicates drainage requirements for underground ducts.

(1) *Maximum number of conduits in a duct run.* Electric power cables generate heat dependent upon the cable loading and resistance. Dissipation of this heat is no problem because of diversity of cable loading, as previously noted. More than eight ducts entering at any one point in a manhole provide a cable congestion which makes maintenance time-consuming and costly. Where the use of more than eight ducts in a single run is necessary, the minimum manhole size required, as noted later, will be increased. More than two duct entrances may require larger manhole sizes.

(2) *Configurations.* Arrangements for electric (E) and communication (C) ducts are given below:

4E or 4C . . . . 2 ducts wide by 2 deep
4E and 4C . . . . 4 ducts wide by 2 deep
6E or 6C . . . . 3 ducts wide by 2 deep
6E and 6C . . . . 6 ducts wide by 2 deep

(3) *Miscellaneous.*

(a) Jacking. Where ducts are jacked under existing pavement or used for exposed installations, rigid steel conduit will be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required when conduits are jacked. For crossings of existing railroads and airfield pavements greater than 50 feet in length, the predrilling method or the jack-and-sleeve method will be used.

(b) Duct line markers. Duct line markers will be provided only for duct line stubouts or for other ducts whose locations are indeterminate because of duct curvature or terminations at completely below-grade structures. In addition to markers, 3-inch wide 5-mil brightly colored plastic tape placed approximately 12 inches below finished grade may be used.

7-4. Manholes, Handholes, and Pullboxes.

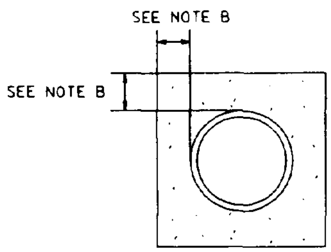
In traffic areas, design will be for a H20 wheel loading as defined by AASHTO HB-13.

a. Manholes. Manholes will normally be located at street intersections and will be spaced otherwise to meet facility needs; to conform to the facility master plan; or as required by the cable pulling calculations.

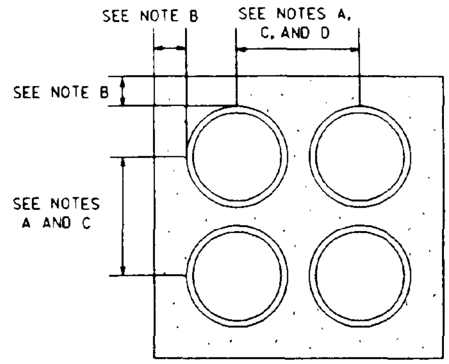
(1) *Criteria for construction.* Manholes will not be less than six feet in depth, by six feet in length, by four feet in width with an access opening to the surface above (outer air) of not less than 30 inches in diameter. Manholes will provide a minimum wall space of six feet on all sides where splices will be racked. Duct entrances into the manhole can be located near one end of long walls so that sharp bends of cables at the duct mouth are avoided, or else sufficient space will be provided for a reverse bend before the cable straightens out on the wall on which the cable is racked. Manhole elevations and elevations of duct lines entering manholes will be shown. For nonmetallic-jacketed cables, the minimum bending radius will be 12 times the overall cable diameter. Metallic-jacketed cable bends will be in accordance with ICEA/NEMA requirements or 12 times the overall cable diameter, whichever is greater. Figure 7-4 shows details of factors which affect lengths of manholes. A scale example of a specific cable size installed in a manhole is shown on figure 7-5.

(2) *Types of manholes.* A combination electric power and communications manhole suitable for use with most electric power and communication duct arrangements is shown on figure 7-6. Other arrangements are acceptable, but minimum inside dimensions and reinforcing will match requirements shown on figure 7-6. Generally, manhole drawings indicate the requirements for a cast-in-place concrete manhole. Precast manholes may be specified as a Contractor's option, when they provide the same inside dimensions, strength, and sealed joints comparable to the monolithic construction of case-in-place manholes. Prefabricated vaults of other than concrete construction will be restricted to direct-burial cable systems.

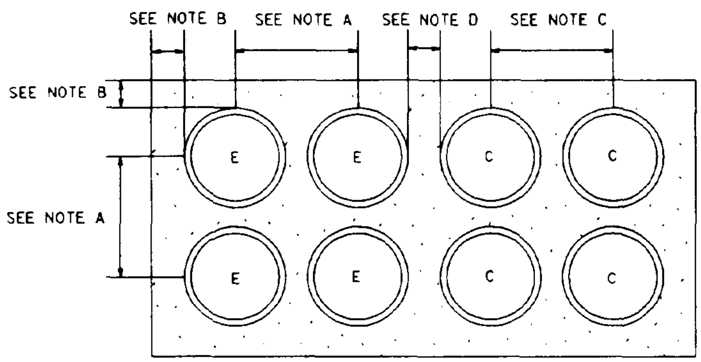
(3) *Prohibited devices.* Electrical equipment such as transformers or switches should not be installed in manholes or underground vaults, except in manholes adjacent to airfields where such installations may be necessary to meet airfield clearance requirements, or as specifically required



SINGLE DUCT



ELECTRIC OR COMMUNICATION DUCT BANK



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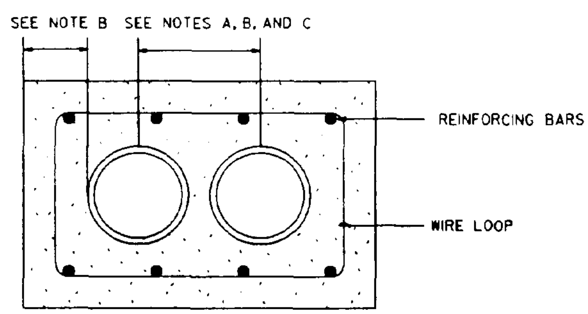


REINFORCED DUCT BANK

NOTES:

A. ELECTRICAL SUPPLY DUCT:
ARRANGEMENTS. SIZES. AND DIMENSIONS SHOWN ABOVE WILL CONFORM TO THE REQUIREMENTS OF NFPA 70.

B. ENCASEMENT DIMENSIONS ARE TO BE DETERMINED BASED ON LOCATION. BURIAL DEPTHS. AND STRENGTH REQUIREMENTS.

C. COMMUNICATIONS SUPPLY DUCT:
SEPARATIONS ARE DEPENDENT ON COMMERCIALLY AVAILABLE DUCT SPACERS FOR THE RESPECTIVE CONDUIT SIZE.

D. ANSI C2 MINUIMUM SEPARATION FOR SUPPLY-COMMUNICATION IS 3 INCHES CONCRETE.

Figure 7-2. Concrete Encased Duct Details by the Using Agency, and then equipment will be of the type which can be submersed. Where the water table is high enough to flood manholes, water will be removed by portable pumps operated on a regular schedule. Permanently connected sump pumps will not be installed, except in special instances. Permanent ladders will not be installed; portable ladders will be used when required.

(4) *Manhole appurtenances.* Ground rods will be installed in one corner of each electric manhole for metallic shield or sheath grounding to reduce induced potential gradients. Dangerous gradients are not induced by communication circuits, so rods will not be installed in communication manholes. Other manhole appurtenances are shown on figure 7-7. Square covers will not be used because of the danger of the cover slipping through the opening. The traffic cover shown on figure 7-7 is suitable for AASHTO H20 wheel loadings. Pulling-in irons will be provided opposite each duct entrance or where there are provisions for future duct entrances. Sufficient cable racks will be installed to properly support cables on both sides of any cable splice and elsewhere as needed. Rack horizontal spacing will be 3 feet to 4-½ feet for electric power cables dependent upon the nature of the cable bends. At least two racks will be located on each wall, except, racks will not be more than 30 inches apart horizontally.

(5) Communication manholes are to be designed in accordance with Army Field Manual 11-486-5, Telecommunications Engineering Outside Plant Telephones, paragraphs 7-17 to 7-30.

b. Other Types of Cable Access Points. Where splicing or pulling of cables requires an access point, but the volume provided by a manhole is unnecessary, handholes or pullboxes will be provided as appropriate.

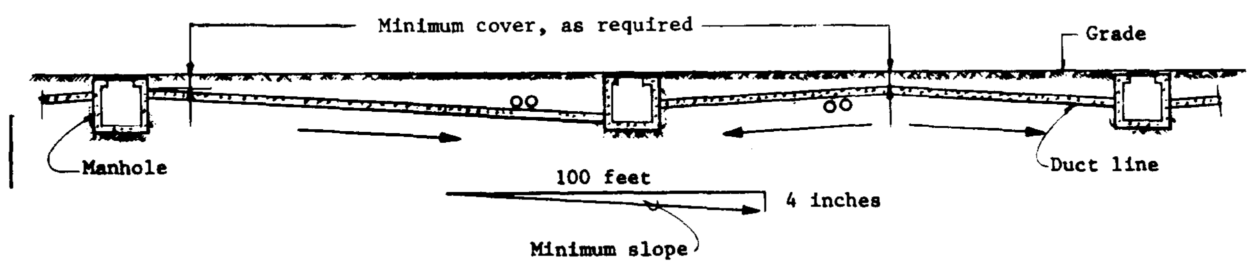
(1) *Handholes.* Handholes are used on laterals from manhole and ductline systems or other sources for low-voltage power and communication supply to building services. A handhole suitable for most electric power or communication usage is shown on figure 7-8. At least four racks will be installed. Where more than two splices occur, a manhole may be more appropriate.

(2) *Pullboxes.* Pullboxes are used for electric circuits supplying low-voltage electric loads which require conductors no larger than No. 1/0 AWG and no more than one 2-inch conduit entrance at each side. Where larger conduits are installed, handholes or manholes will be used. Because pullbox depths are less than two feet, conduits must always slope up into the pullbox. Pullboxes are also suitable for fire alarm, public address, and control circuits. Pullboxes will not be used for telephone circuits without the approval of the appropriate communication agency. Figure 7-9 shows standard sizes of pullboxes used for low-voltage installations. Pullboxes will not be used in areas subject to vehicular traffic. In such areas, handholes will be installed. The use of a pullbox at the base of a lighting pole is unnecessary in most cases.

c. Manholes at Air Force installations.

(1) *General requirements.* Manholes shall be adequately sized, shall comply with applicable requirements of OSHA, and AASHTO, and may be precast or cast-in-place. Openings should be round and not less than 32 inches in diameter.

(2) Manholes for aircraft operating and parking aprons. Electrical manholes in aprons shall be avoided. Cables shall be installed beyond the periphery of aprons. Electrical manholes shall maintain a distance of 50 feet from the edge of paving and 50 feet from any hydrant lateral control pit and 200 feet from a fueling point.



DUCT LINE ELEVATION

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Figure 7-3. Duct Line Drainage.

7-5. Direct-Burial Cable Installations.

Cables will be installed not less than the minimum depth required by the NEC or, excluding Alaska and other permafrost areas, as necessary to be below the frost line, whichever is greater.

a. Protection. In some locations, nonmetallic-jackets may not provide sufficient cable protection. Metal armor provides protection from rodents. Direct-burial cable with concentric neutral, installed in ducts, will incorporate the same overall jacket as that specified for direct burial. Where buried cable warning is required by the using agency, tape manufactured for this purpose will be provided. Where installed under traffic areas or railroads, cables will be installed in concrete-encased ducts for protection. Under railroads and airfield crossings, concrete-encased ducts must be steel-reinforced.

b. Markers. Cable markers will be located near the ends of cable runs, at each cable joint or splice, at approximately every 500 feet along cable runs, and at changes in direction of cable runs. In addition to markers, a 3-inch wide 5-mil, brightly colored plastic tape placed approximately 12 inches below finished grade will be used. Where cable is used for lighting circuits and the lighting poles effectively provide indication of direction changes, markers are not required. Markers will be similar to the one shown on figure 7-10.

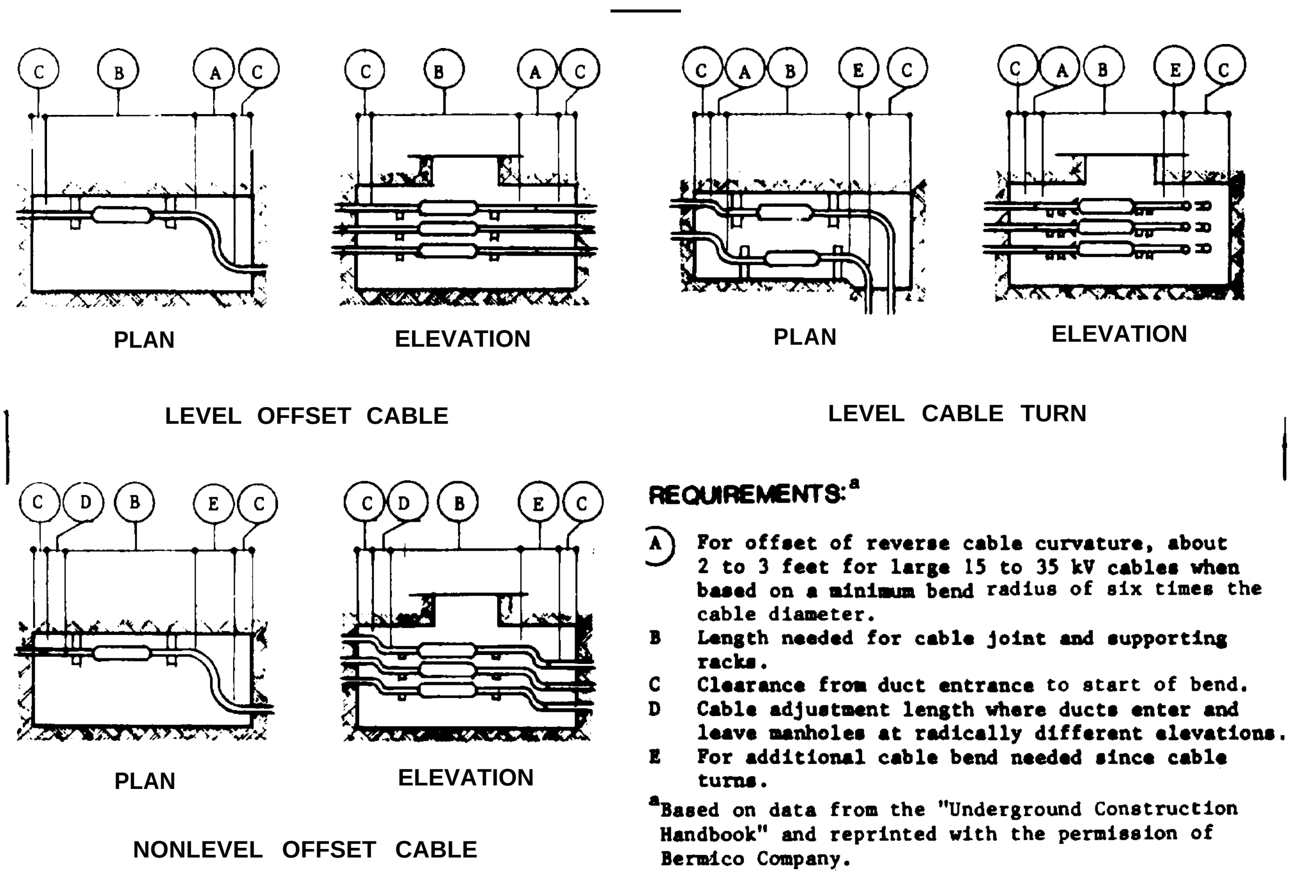

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Figure 7-4. Factors Influencing Manhole Design.

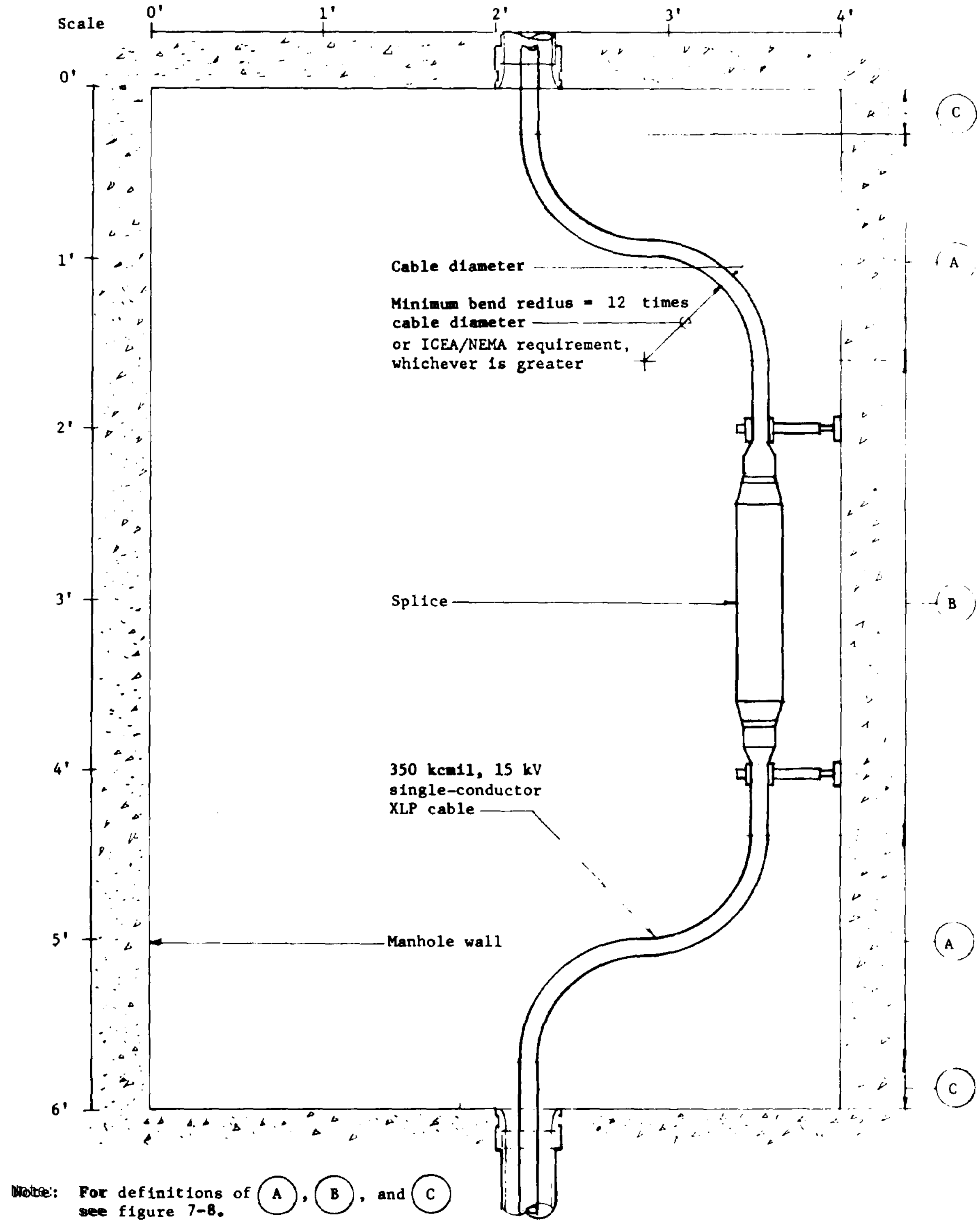

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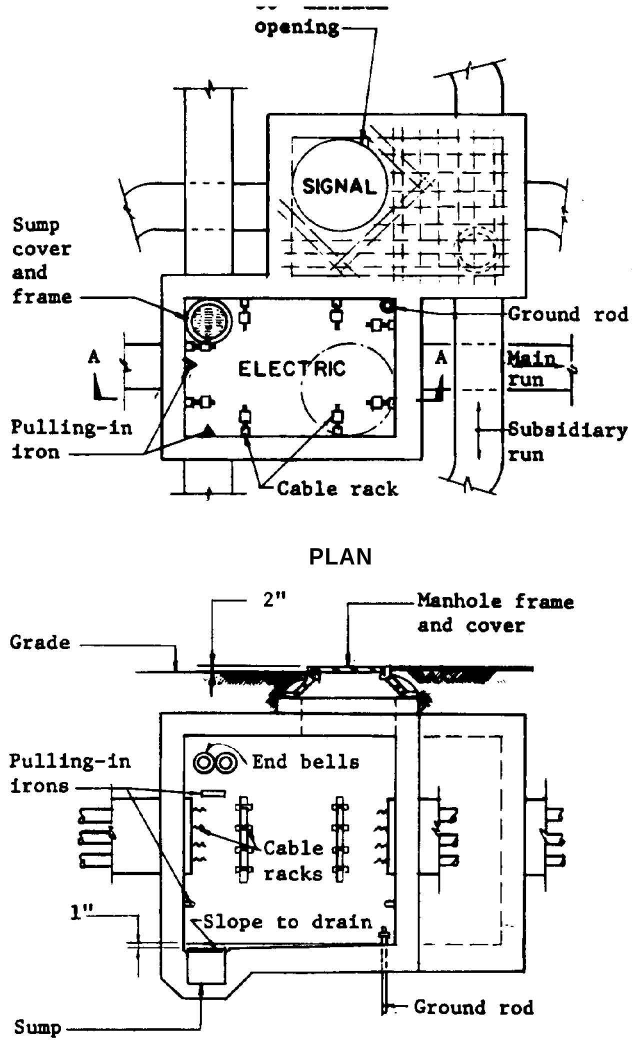
Figure 7-5. A Scale Example of a Cable Installed in a Manhole



SECTION A - A

Construction requirements			
Clear minimum inside dimensions for installation and maintenance purposes			
Height	Length	Width	Sump depth
6 feet	6 feet	4 feet	1 foot
Minimum concrete thickness			
Manhole walls, top, and floor		Sump walls and floor	
8 inches		4 inches	
Minimum reinforcing[a]			

1. Bars will be a minimum of No. 4 round deformed.
2. Walls and floor will have bars at 12 inches minimum on centers with a minimum 12 inch hook at corners and intersections.
3. The top will have bars installed as shown at 4 inches on center minimum laterally and longitudinally as appropriate, except that at openings also provide an additional bar at a two-inch spacing and two diagonal bars, each way at 45° to and located above lateral or longitudinal bars.

[a]Reinforcing will be increased where required to suit actual installation.

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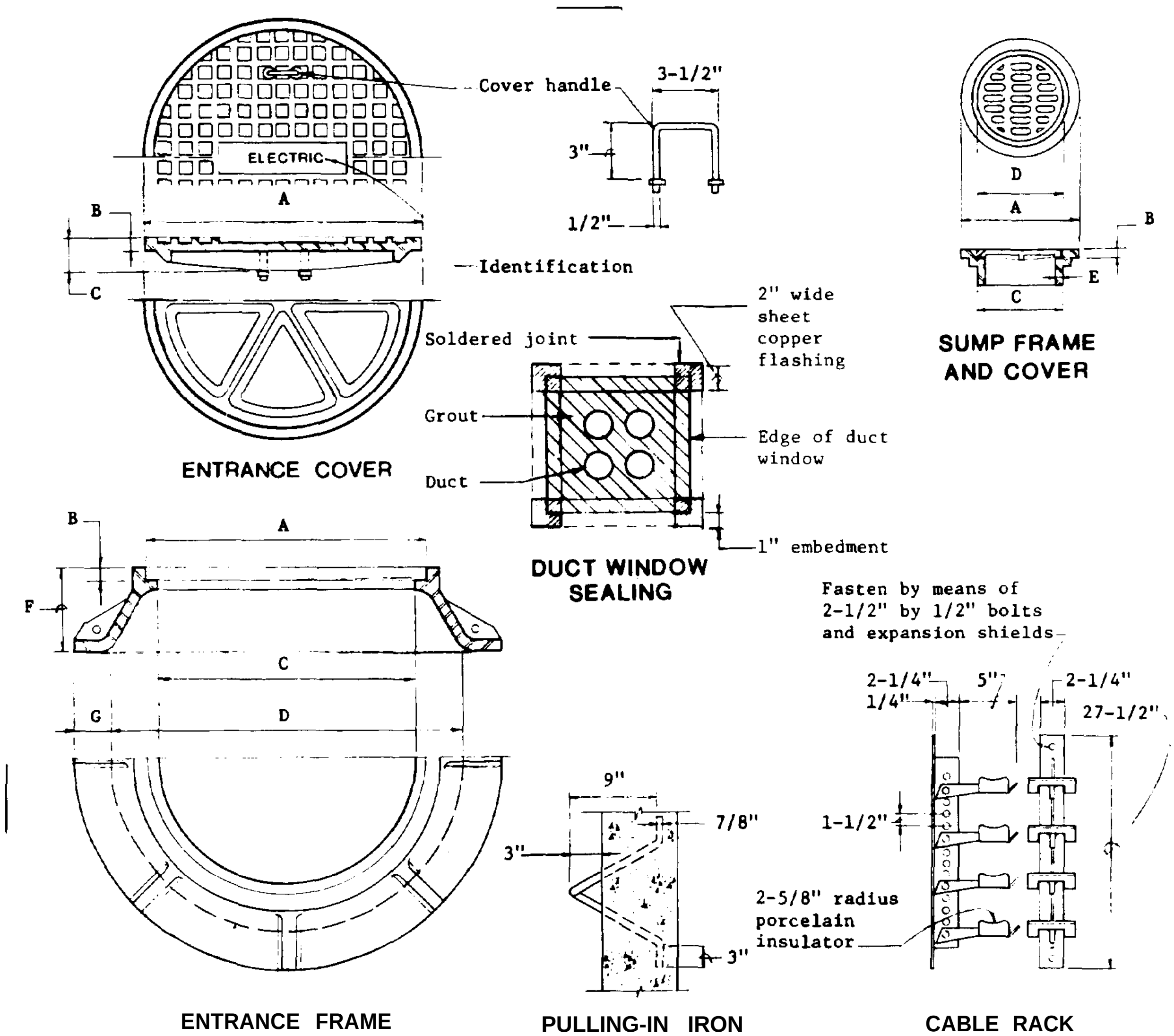
Figure 7-6. Typical Double Manhole.



Appurtenance	Fed. Spec. RR-F-621 classification			Dimensions inches							Remarks
	Type	Style	Size	Nominal	A	B	C	D	E	F	
Manhole frame	III	A	30A 30C	30	32	1-3/8 2	30	41	4	10	Nontraffic Traffic
Manhole cover	D		30A 30B	30	31-7/8	1-3/8 2	2-5/8 3-1/4	-	-	-	Nontraffic Traffic
Handhole frame	III	A	36A 36C	36	38	1-3/8 2	36	47	4	10	Nontraffic Traffic
Handhole cover	D		a	36	37-7/8	1-3/8 2	2-5/8 3-1/4	-	-	-	Nontraffic Traffic
Sump frame	VII	-	-	12	15	1/2	12	13	3/8	-	b
Sump cover	I	-	-	12	-	1/2	-	13	-	-	b

[a]Modified to suit a 36-inch frame.
[b]Circular instead of square shaped.

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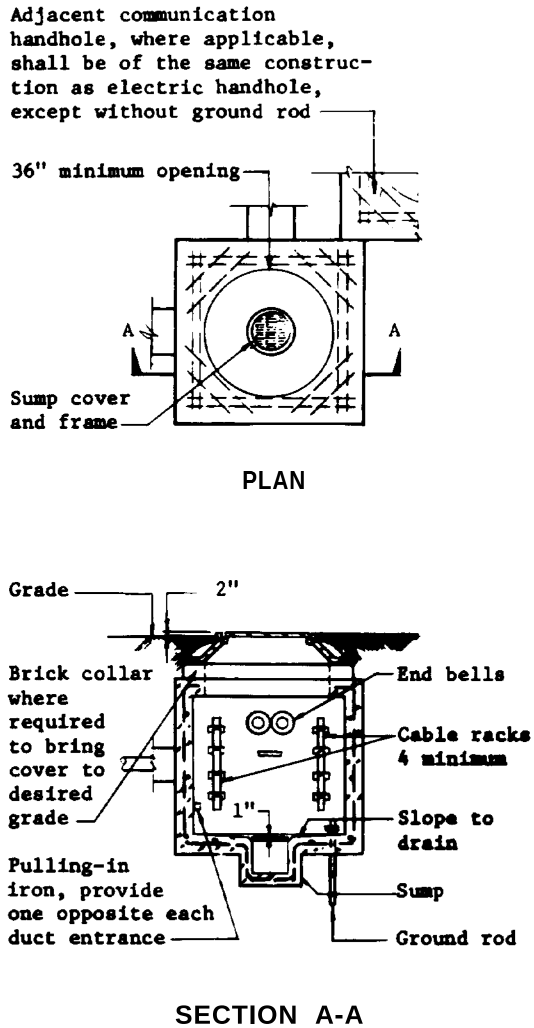
Figure 7-7. Manhole Appurtenances.



Construction requirements			
Clear minimum inside requirements for installation and maintenance purposes			
Height	Length	Width	Sump depth
4 feet	4 feet	4 feet	1 foot
Minimum concrete thickness			
Handhole walls, top, and floor		Sump walls and floor	
6 inches		4 inches	
Minimum reinforcing[a]			
1. Bars will be a minimum of No. 4 round deformed. 2. Walls and floor will have bars at 8 inches maximum on centers with a minimum 12 inch hook at corners and intersections. 3. The top shall have bars installed as shown at a minimum of 2 inches from the opening and with a minimum 4 inches spacing between bars.			

[a]Reinforcing shall be increased where required to suit actual installation. Minimum requirements are for a H20 wheel loading (AASHTO).

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Figure 7-8. Electric or Communication Handhole.

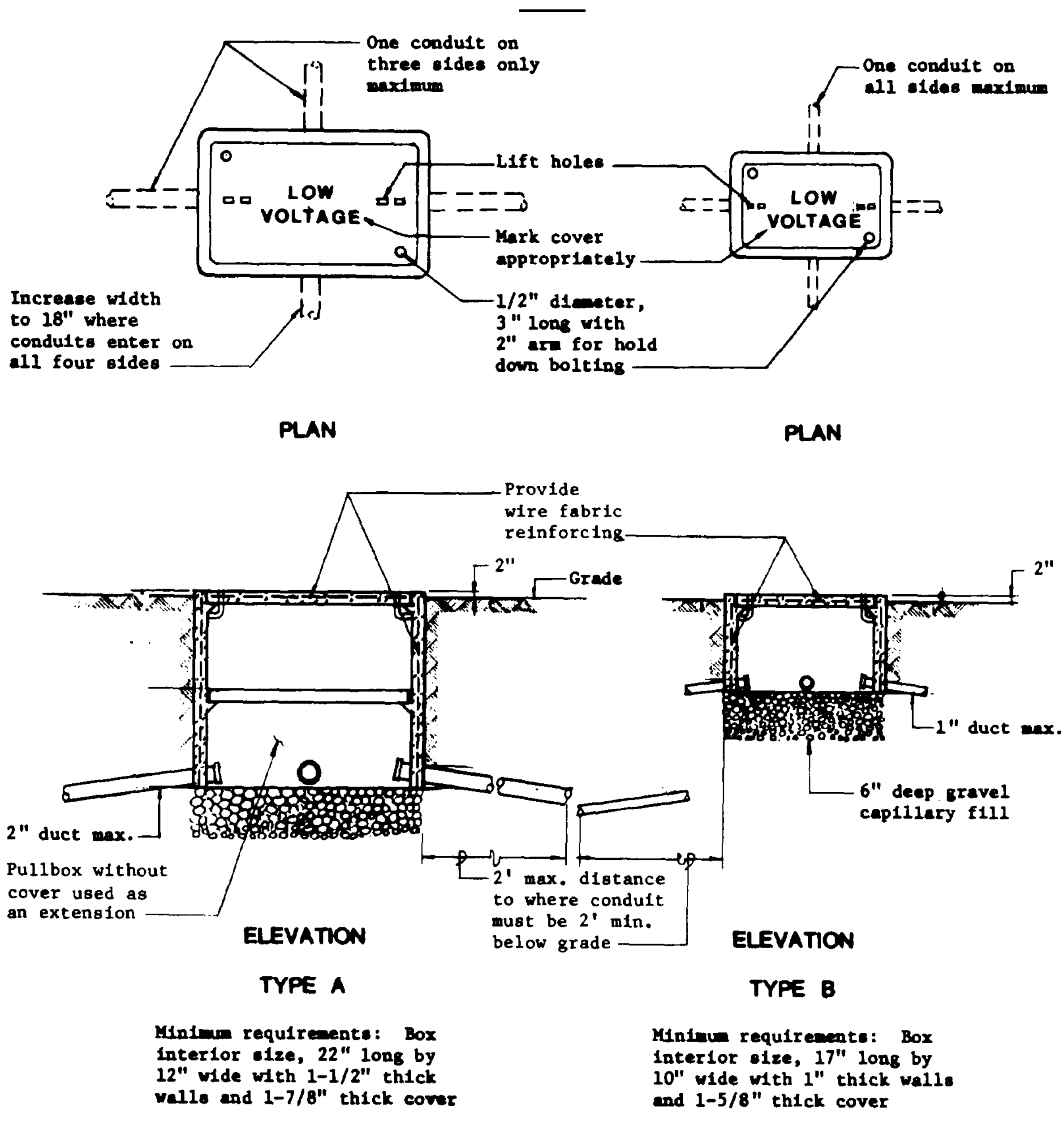

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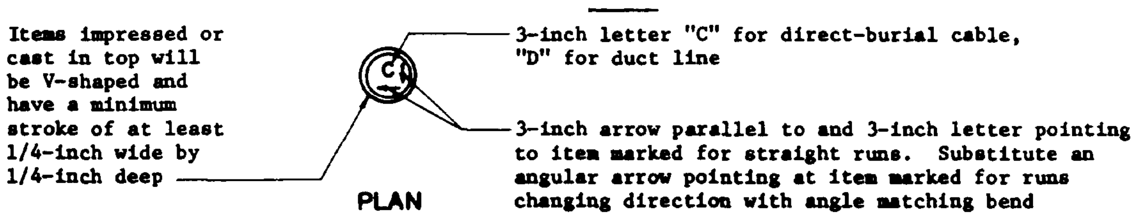
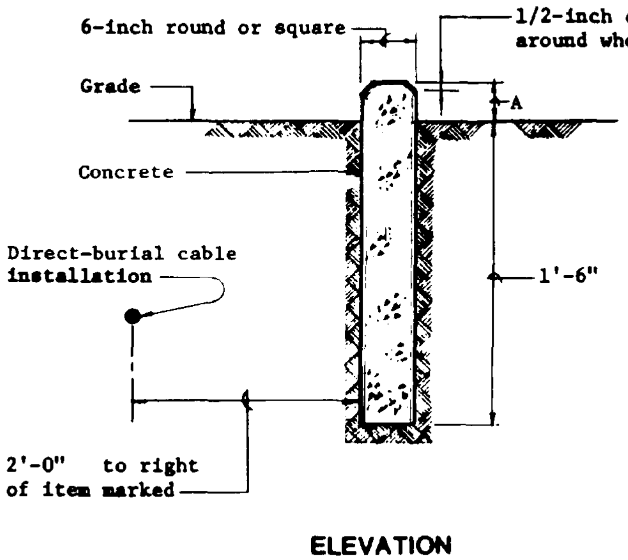
Figure 7-9. Pullbox Installation





Suggested projections	
Dimension A inches	Location
0	Paved areas
1/2"	Grassed areas subject to mowing
1"	Graveled areas
4"	Uncultivated areas

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Figure 7-10. Underground System Marker.