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600 VOLT UNDERGROUND CABLE & CONDUIT SELECTION GUIDE

1.0 INDEX

2.0 PURPOSE

This guide is to provide information necessary for the economical application of underground service cables. The eight tables in Section 5.0 include conduit sizes, number of conduits, required number of cables, and cable ampacities for single and three phase services.

3.0 DISCUSSION

This standard should be utilized to size all underground service cables for residential, commercial and industrial applications. The development of this standard incorporates both economic and physical constraints. *The economic analysis used to develop the cable applications includes all associated materials.* Therefore, the application of this standard will result in the *most economical* and reliable installation for both Liberty and it's Customers. ***All services should be as short as possible to minimize cable losses, especially heavily loaded 3 phase service cables.*** Electric Utility Service Equipment Requirements Committee (EUSERC) specifications for landing lugs and box dimensions were also considered during the development of this standard. The EUSERC requirements dictated some of the cable applications.

4.0 APPLICATION NOTES

A. Secondary or service cables shall be 600 volt XLPE AL in #2, 2/0, 4/0, 350, and 750 kcm sizes. The cable shall be installed in a conventional duct system or in a cable trench. The cable shall be selected and installed to meet expected demands.

Large single phase residential and three phase commercial services, often require parallel runs of cable. Tables 1 through 8 must be used to determine cable ampacity when multiple sets of cable are utilized to minimize cable losses.

B. **Use caution when applying this standard.** *The peak load of large services must be checked against the ampacity of the cable combination given in the table.* If required, the number of cables should be increased to match the demand.

C. Service load is assumed to be 65% of the main panel with respect for load factors of either over/under 75%. The under 75% LF cable loading should be utilized for most customers. **Panels with exposed riser conduits must use the 100% LF data.**

D. Conduit should always be sized according to panel size, regardless of estimated load at the time service is provided. This allows for the future economical addition of cables if the customer's load grows.

E. *Evaluation of flicker/voltage drop is necessary for applications involving long distance or heavily loaded cables.*

5.0 TABLES

TABLE 1

SINGLE PHASE - THREE WIRE SERVICES

Customer Main Panel Rating (Amps)	Estimated Peak Load (65%) (Amps)	Required Conductor Size (al XLPE)	Cable Stock Number	Thermal Ampacity of Service @ 100% LF	Conduit Number - Size
100	65	#2 Triplex	8800-230265	115	1-3" (1)
200	130	2/0 Triplex	8800-230520	175	1-3" (2)
200	130	4/0 Triplex	8800-230665	235	1-3" (2)
320/400	260	350 Triplex	8800-230783	330	1-3"
600	390	2-350 Triplex	8800-230783	627	2-3"
800	520	2-350 Triplex	8800-230783	627	2-3"
1000 (4)	650	2-350 Triplex	8800-230783	627	3-3"
1200 (5)	780	2-750 Triplex (3)	4-8800-230895 2-8800-230781	985	2-4"

NOTES: TABLE 1

1. Conduit size will vary depending upon local requirements and construction practices. Consult the local LU district prior to construction, for the correct conduit size.
2. **750 kcm is not available in triplex configuration.** Use Two-750 KCM (8800-230895) and One-350 KCM (8800-230781) XLPE conductors.
3. 1000A is the maximum single phase panel size, larger loads will require a three phase panel.
4. 1200A - reference only.

TABLE 2

THREE PHASE - FOUR WIRE SERVICES
(60' maximum service cable length)

Customer Main Panel Rating (Amps)	Estimated Peak Load 65% (Amps)	Required Conductor Size (al XLPE)	Cable Stock Number	Thermal Ampacity of Service @ 100% / 75% LF		Number of Conduits and Size (1)
100	65	1-#2 str Quadruplex	8800-230270	110	120	1-3"
200	130	4/0 Quadruplex	8800-230670	215	240	1-3"
400	260	1-350 Quadruplex	8800-230784	305	326	1-4"
600	390	1-750 kcm per phase with 1-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	480	520	1-4"
800	520	2-750 kcm per phase with 2-350 kcm neutrals	750 - 8800-230895 350 - 8800-230781	860	940	2-4"
1000 (1)	650	2-750 kcm per phase with 2-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	860	940	2-4" (3-4")
1200 (1)	780	3-750 kcm per phase with 3-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	1110	1275	3-4" (4-4")
1400 (1)	880	3-750 kcm per phase with 3-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	1110	1275	3-4" (5-4")
1600 (1)	1040	4-750 kcm per phase with 4-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	1320	1520	4-4" (6-4")
2000 (1)	1300	5-750 kcm per phase with 5-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	1525	1780	6-4" (7-4")
2001 - 4000 (2)	See GI0011U, Section 7 - Services					

NOTES: TABLE 2

1. 100% rated panels above 800 amp require the conduits (4-4"), as indicated by the number in the parenthesis.
2. Cable Trench (GI0011U) is required on 2001 amp or larger panel ratings. The number of cable runs and their ampacities are listed in Table 8 of this standard.
3. This table is based on 60' maximum service cable lengths. *For service length exceeding 60 feet,* please refer to table 3.

TABLE 3

THREE PHASE - FOUR WIRE SERVICES
(For service cable lengths over 60')

Customer Main Panel Rating (Amps)	Estimated Peak Load 65% (Amps)	Required Conductor Size (al XLPE)	Cable Stock Number	Thermal Ampacity of Service @ 100% / 75% LF		Number of Conduits and Size (1)
100	65	1-2/0 Quadruplex	8800-230525	160	180	1-3"
200	130	4/0 Quadruplex	8800-230670	215	240	1-3"
400 (1)	260	1-750 kcm per phase with 1-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	480	520	2-4"
600	390	2-750 kcm per phase with 2-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	860	940	2-4"
800	520	3-750 kcm per phase with 3-350 kcm neutrals	750 - 8800-230895 350 - 8800-230781	1110	1275	3-4"
1000	650	3-750 kcm per phase with 3-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	1110	1275	3-4"
1200	780	4-750 kcm per phase with 4-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	1320	1520	4-4"
1400 (2)	880	4-750 kcm per phase with 4-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	1320	1520	4-4" (5-4")
1600 (2)	1040	5-750 kcm per phase with 5-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	1525	1780	5-4" (6-4")
2000 (2)	1300	6-750 kcm per phase with 6-350 kcm neutral	750 - 8800-230895 350 - 8800-230781	1750	2070	6-4" (7-4")
2001 - 4000 (3)	See GI0011U, Section 7 - Services					

NOTES: TABLE 3

1. Consideration should be given to increasing to a 600 amp panel . If a 400 amp is utilized, conduit entrance must be centered in panel bottom under the bus to facilitate cables.
2. 100% rated panels above 1200 amp require the conduits (5-4"), as indicated by the number in parenthesis.
3. Cable Trench (GI0011U) is required on 2001 amp or larger panel ratings. The number of cable runs and their ampacities are listed in Table 8 of this the standard.
4. This table is based on ***service cable lengths being longer than 60'***.

TABLE 4

AMPACITIES OF U/G XLPE ALUMINUM CABLES IN CONDUIT

SINGLE PHASE				THREE PHASE			
# of Runs	Cable	Ampacity		# of Runs	Cable	Ampacity	
		100% LF	50% LF			100% LF	75% LF
1	#2 Triplex	115	140	1	#2 Triplex	110	120
1	2/0 Triplex	175	195	1	2/0 Quad	160	185
1	4/0 Triplex	235	285	1	4/0 Quad	215	240
1	350 Triplex	330	385	1	350 Quad	305	326
1	750 Triplex	520	600	1	750 Quad	480	520
2	4/0 Triplex	470	520	2	350 Quad	550	620
2	350 Triplex	627	710	2	750 Quad	860	940
2	750 Triplex	985	1120	3	350 Quad	720	825
3	350 Triplex	845	990	3	750 Quad	1110	1275
				4	750 Quad	1320	1520
				5	750 Quad	1525	1780
				6	750 Quad	1740	2070
				7	750 Quad	2010	2250
				8 (2)	750 Quad	2230	2420
				10 (2)	750 Quad	2680	2815
				12 (2)	750 Quad	3150	3320
				14 (2)	750 Quad	3640	3800
				16 (2)	750 Quad	4140	4280

NOTES: TABLE 4

1. **750 kcm is not available in Triplex or Quad configuration.**
   Use 2-1/C- 750 kcm (8800-230895) and 1-1/C- 350 km (8800-230781) XLPE conductors or
   Use 3-1/C- 750 kcm (8800-230895) and 1-1/C- 350 km (8800-230781) XLPE conductors.
2. Reference only. See Cable Trench Installation Guide for new construction, GI0011U and Table 8 of this standard show ampacities of cables in cable trench.

TABLE 5

SINGLE PHASE SERVICE OR SECONDARY CABLE
50% LOAD FACTOR - SUMMER

Size (AWG or kcm)	Number of Circuits in Duct Bank			Riser (Exposed)
	One	Two	Three	
	Amps	Amps	Amps	
#2	140	132	125	115
2/0	195	187	180	175
4/0	285	260	250	235
350	385	355	335	330
750	600	555	525	520

TABLE 6

DESIGN LIMITS FOR RESIDENTIAL CABLES
SINGLE CONDUIT RUNS

Size (AWG or kcm)	Number of Circuits in Duct Bank	
	Economic Limits	Thermal Limits
	Amps- Kva	Amps- Kva
#2	80 - 19	140 - 33
2/0	115 - 28	195 - 46
4/0	171 - 41	285 - 68
350	230 - 55	385 - 92
750 (*)	390 - 94	600 - 144

(*) 750kcm shown for reference only - 350 kcm is normally the largest cable used for residential design.

TABLE 7

THREE PHASE SERVICE CABLES
LOAD FACTOR AS SHOWN - SUMMER AMPACITY

Size (AWG or kcm)	Number of Circuits in Duct Bank								
	One			Three		Four		Six	
	75%	100%	Riser (Exposed)	75%	75%	75%	75%	75%	75%
#2	120	110	100	105	95	100	90	92	80
2/0	185	160	150	165	130	150	120	130	110
4/0	240	215	210	206	185	190	160	175	150
350	326	305	295	275	240	250	225	230	200
750	520	480	470	425	370	380	330	345	290

TABLE 8

DESIGN LIMITS FOR RESIDENTIAL CABLES
SINGLE CONDUIT RUNS

Sets of Cables (Wire Size)	4 (750)	5 (750)	6 (750)	7 (750)	8 (750)	9 (750)
24" x 30" (ID) Cable Trench - (GI0011U)	1880	2350	2820	3290	3760	4230

Per GO 128 Rule 33.4
The cable must be racked with the proper clearances to provide the capacities listed in Table 8.

CONDUIT INSTALLATION GUIDE

1.0 INDEX

2.0 PURPOSE

This standard provides placing instructions for plastic conduit and fittings and is adapted from Western Underground Committee Guide #3.4, Plastic Conduit and Fittings Placing Instruction, and NEMA, National Electrical Manufacturers Association Bulletins No. TC- 2, and TC-3 of latest revision.

3.0 BASIC MATERIALS

The plastic conduit and fittings used in this standard are those specified in ANSI/ASTM F51279 smooth-wall polyvinyl chloride (PVC) , Gray (NEMA TC-2) for conduit and (NEMATC-3) for fittings.

4.0 TYPE OF CONDUIT (DUCT)

Type DB PVC with greater pipe stiffness values, designed primarily for direct burial. DB duct may also be concrete encased, either in trenches or in casings or boring, for extra heavy or high dynamic load application.

5.0 TRANSPORTATION

5.1 Generally, duct is shipped in self-supporting framed units designed for mechanical unloading. **Framed units should not be dropped from truck bed**.

5.2 **Abusive handling should be avoided. Care should be exercised when handling duct in temperatures below 32° F**.

6.0 STORAGE

6.1 Framed units should be stored on a level surface. The wood frames should line up, one on top of another, so that the load will be on the wood frames rather than the duct. As a general practice, frames are spaced on 7'-0" centers. Standing height should be limited to 12 feet.

6.2 The most desirable method of stacking loose duct is with all duct parallel (nested). To avoid excessive ovality on the bottom row, the stacking height should be limited to 4 feet for EB (Type I) and 5 feet for DB (Type II). The bottom row of duct should be laid on as level a surface as possible. NOTE: DO NOT place sleepers under the duct as excessive deflections and sagging could result.

7.0 INSTALLATION

7.1 A duct system is considered to be properly installed if the inside diameter of each duct is adequate to allow free passage of the specified mandrel. (See Section 19.0)

7.2 To limit the deflection, the trench bedding, the duct separation, the type of backfill, and the amount of compaction are factors requiring attention.

7.3 Backfill compacted to 80% - 95% of the relative density is required as noted in LU Standards for trenching and excavation (TE0001U) and main trench detail (TE0005U).

7.4 All backfill materials used shall conform to the requirements set forth in LU Material Specification SUB01X.

7.5 Observe all local and federal regulations pertaining to the excavation of open trench. Trenches must be backfilled as soon as the conduit is installed. Refer to LU standard TE0001U for details.

7.6 Make certain that all foreign matter has been wiped from both the conduit and the fittings at the joints.

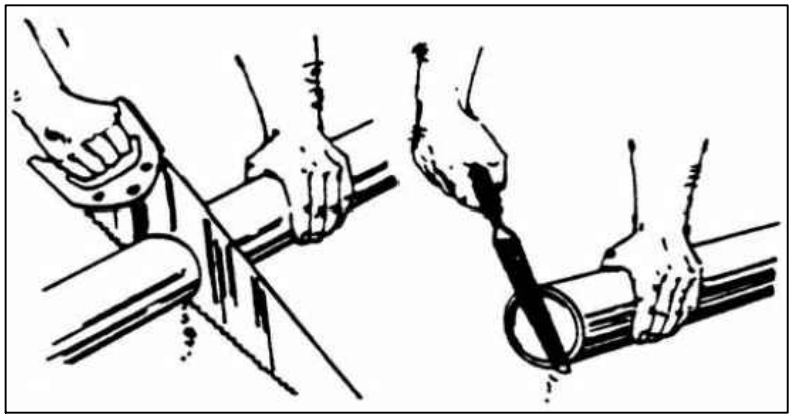
7.7 Changing of **primary or secondary** conduit size is only permitted in vaults, manholes, splice boxes, or pull boxes. *Conduit runs will be one size continuously with no reducers allowed.* The only exception is that a 3"x 2" reducer may be used with service conduit.

7.8 *There must be at least 15' of straight conduit between 'back to back' bends/sweeps*

8.0 CUTTING DUCT

Cutting - Use a fine tooth wood saw to cut conduit 1/2" to 1-1/2" diameter, or crosscut wood saw on sizes over 2" diameter. A hacksaw can be used on all sizes.

Example:



9.0 MECHANICAL DAMAGE MINIMIZATION

9.1 ***Conduit protection (primary/secondary), on property line of private property, will require one of the following applications: concrete cap, a minimum 5' trench depth or replacing PVC with rigid steel.***

9.2 Trenches should be backfilled when conduit is laid. Conduit should not be left exposed in an open trench.

9.3 Provide support for the full length of conduit when transporting long lengths.

9.4 Do not permit unsupported overhangs.

10.0 CONDUIT FITTINGS

10.1 See Conduit Application Guide CD0004U, UNDERGROUND Volume, for complete list of conduit and fittings.

10.2 In general, reducer couplings are not allowed. See Section 7.7.

10.3 Use approved adapter/ coupling to convert to other types of conduit.

11.0 CONDUIT TERMINATION

11.1 A tapered polyethylene plug with attachment eye will be used to temporarily plug conduit ends and terminators. This is to keep debris and foreign material out of the conduit until use. These temporary plugs will be **used on all conduit stubs** and ends in secondary and primary applications. The use of tape as a means of sealing conduit is unacceptable, and will not be allowed.

11.2 Conduit may be terminated in vaults with duct terminators with sand support up to the conduit approach outside of the vault. *Bushing reducer adapters (4"x3") can be used in conjunction with duct terminators to facilitate the proper conduit size and location.* When duct enters a knockout, terminated ends of conduit must be free of support into the manhole for a distance of at least 10 feet. This is to permit alignment of the conduit and the knockouts opening. The conduit will be supported inside the manhole with proper spacing and will be cut to length after the concrete encasement has cured.

12.0 PVC CEMENT/THINNER/PRIMER

12.1 Use only recommended PVC cement from conduit fabricator.

12.2 If the cement being used shows signs of jelling, it shall be discarded. In no case shall thinner be used in an attempt to restore jelled PVC cement.

12.3 Thinner may not be used to change the viscosity of a medium bodied cement.

12.4 In cold weather, under 50° F., use a primer to soften the joining surfaces before applying the cement. Allow longer cure time.

13.0 CEMENTING CONDUIT

13.1 Clean conduit by wiping off all dust, dirt, and moisture from the surfaces to be cemented and then apply a fine abrasive paper or cloth.

13.2 With a non-synthetic bristle brush, apply an even coating of cement to the conduit for the full length of the depth of the socket and apply a uniform coat to sufficiently wet socket of the fitting. Excess cement on the fitting should be avoided as it is wiped into the joint and tends to weaken the pipe.

13.3 **Work quickly!** Join the conduit within 15 seconds of applying the cement.

13.4 Slip the conduit straight into the fitting with a slight twist (1/4 turn) until it bottoms, make sure joint is completely seated. Hold the joint for 15 seconds, (2 minute plus in cold weather, under 50°F.), so that the conduit does not push out of the fitting. Do not twist or drive pipe after insertion is complete.

13.5 The jointed members shall be cured and undisturbed for five minutes or more before they are handled.

13.6 Newly assembled joints should be handled carefully until the cement has cured for the recommended set period. After this initial cure, care must be exercised in handling to prevent twisting or pulling the joint apart. Set periods are related to the ambient temperatures as follows: a) 30 minutes minimum at 60°F. to 100°F., b) 1 hour min. at 40°F. to 60°F., c) 2 hrs min. at 20°F. to 40°F. Conduits can be assembled above ground and allowed to lay undisturbed for the weld to cure before being lowered into the ditch.

13.7 Be sure and wipe off the excess solvent that is left on the outer shoulder of the fitting. Plastic bristle brushes should not be used. On large diameter conduit, the brush should be a minimum of 1 inch wide.

13.8 *Only use small cans of cement since it dries rapidly.* Keep covered when not in use and away from excess heat and flames. Do not use solvent cement thinner for thinning cement which has thickened. See Sections 12.2 and 12.3.

13.9 Another fitting or conduit section can be added to the opposite end within two or three minutes if care is exercised in handling so that strain is not placed on the previous assembly. See section 13.6.

13.10 The plastic joint must be held rigid after insertion for the cure period in cases where a plastic connection is made with the union under stress due to misalignment or other factors. This will relieve stress on the joint until the conduit is backfilled or encased.

14.0 TEMPERATURE

14.1 See Sections 13.4 and 13.6.

14.2 All plastic conduit and fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.

14.3 Precautions - Due to expansion and contraction of plastic duct of 1-1/2" per 100' for every 20°F change in temperature, the following precautions should be taken:

14.3.1 Allow extra conduit footage at each tie-in for contraction when duct temperature is higher than that of earth; or extra room for expansion, if the reverse condition exists.

14.3.2 Backfill from center of ditch toward ends or from one tie-in point toward the other end of duct run.

14.3.3 After ditch is backfilled and compacted and duct temperature is the same as that of surrounding soil, lines may be cut off and matched up to connect to the vault duct terminators installed in vault wall. If conduits enters the concrete knock-outs of vault, during the entry, (to manhole, vault, or handhold), conduits shall be grouted into walls and concrete encased for a minimum distance of 15" outside of walls.

15.0 TRENCHING

See LU Specification TE0001U.

16.0 CONCRETE ENCASED DUCT BANK

16.1 Concrete *may be required* to be dyed red (12 lbs. of dye per yard).

16.2 Concrete requirements may vary depending on installation necessity. A light concrete mix (three bag slurry mix) is all that is generally required in most cases. A 5 bag mix may be required if a more rigid base is identified and requested by an inspector.

16.3 Concrete encasement is required when conduit is installed under ditches (irrigation and drainage), rivers, streams, foundations, slabs & footings. See CD0003U for further requirements. Primary conduits on private property "side or rear" property lines may require concrete cover, see Section 9.0. Concrete encasement is also required in any downtown area. Additionally, 90° sweeps in long conduit runs with multiple

sweeps may require concrete encasement. Contact a LU inspector for information or questions.

16.4 Tie and fasten all conduit to prevent floating. 16.5 Spacers must be utilized with concrete encasement. Spacers shall be placed between 4' and 10' intervals depending on size of conduit (See Section 17).

16.6 Minimum spacing of 1-1/2" between conduits is required.

16.7 Minimum concrete encasement shall be 3" on top, bottom and sides of conduit.

16.8 Backfill will be as specified in this standard after concrete has cured. (See Section 7.3)

16.9 Conduit is subject to temperature rise as concrete cures. Therefore, allow free end to expand. This can be accomplished by pouring concrete from center of run or from one tie-in point.

17.0 CONDUIT SPACERS

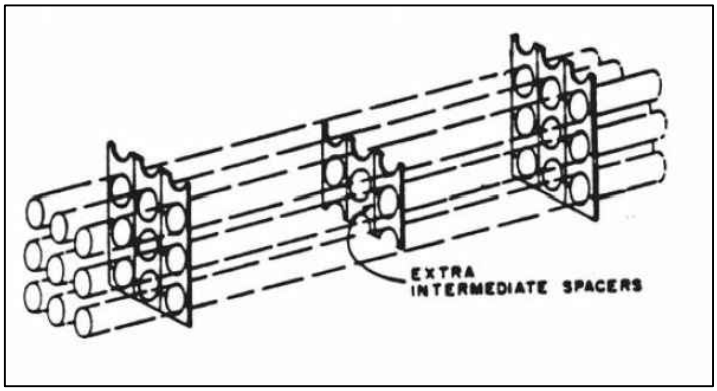
17.1 Duct spacers should be of the type recommended by conduit manufacturer and approved by the utility. Spacers should be of the type with an interlocking device that relieves the conduit of both horizontal and vertical stress. (See LU Stock Material Sheets for approved manufacturers and catalog numbers.)

	DUCT SIZE	SPACING
8800-240750 - 4" base		
8800-240760 - 4" Intermediate	0.5" to 2"	4 - 6 feet
8800-240770 - 6" base	3"	6 - 8 feet
8800-240780 - 6" Intermediate	4" to 6"	8 - 10 feet

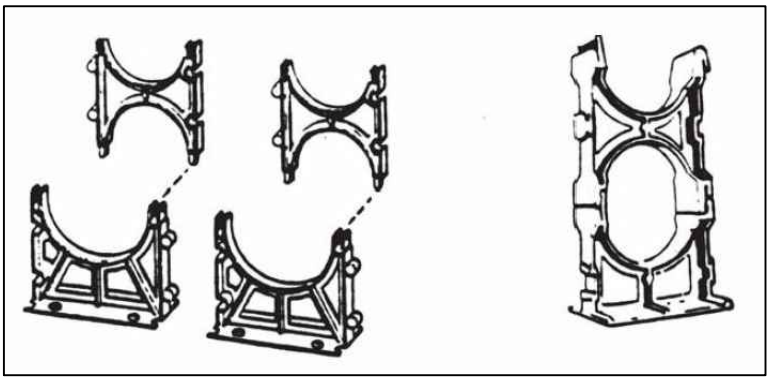
17.1.1 Spacers must be utilized with concrete encasement and will not be required with other types of backfill.

17.1.2 Extra Intermediate Spacers: Due to some distortion of conduit from heat, and/or other means, it may be necessary to install extra intermediate spacers with the duct bank. These extra spacers must be installed within the normal required spacing to maintain the proper horizontal clearance. This horizontal space is required

to allow the proper amount of backfill material and/or concrete to infiltrate vertically among the duct to insure proper compaction and protection.



Base spacers, when used, must be 12 inches or more distance from any coupling or joint. When conduit is assembled above ground, the spacer will be supported in vertical position by use of the interlocking device design.



17.2 Spacers should not be located at the center of a radius bend.

17.2.1 On fabricated bends, locate the spacer in the tangent free of the coupling.

17.2.2 On trench formed radius sweeps, locate the spacer midway between the tangent and center of the bend.

18.0 DUCT BANK INSTALLATION

Install base spacers in position as specified in Section 17.1 of this specification. The base spacer must provide sufficient clearance off the trench floor to permit the specified layer of concrete and/or select backfill to gather at the bottom. The spacers should be consistent with this specification

to prevent excessive deflection from loading or buoyancy forces. The use of bricks or wood are not permitted because these materials may deform the duct wall. Starting at the manhole location, the first lengths of duct are joined to the manhole terminators. When all ducts in bottom tier are terminated to manhole, the second tier of ducts should be terminated in the same manner as the first tier. This procedure is followed until the top tier of the duct bank has been terminated. The next lengths of ducts are attached to the first lengths following the same procedure described above for the full length of the duct run.

19.0 MANDRELLING

After the duct has been installed and backfilled a mandrel shall be passed through the duct in the presence of LU Inspector. If the mandrel fails to pass through the duct being tested, either the duct is obstructed, misaligned, or the curve has too small a radius. **Defective ducts must be exposed and the defect corrected.** After the duct(s) are repaired, repeat the mandrel test in that section of duct. Mandrels are constructed in various sizes, depending upon there use and nature of the section being tested, e.g. duct size. The OD of a test mandrel is normally 80% of the I D of nominal size of the duct. The length of the mandrel will vary depending upon the manufacturer and mandrel type,(testing conduit or removing debris).

20.0 PULL LINE REQUIREMENTS

20.1 Applicant and/or Developer shall supply and install a pull line that meets or exceeds the following requirements in all conduit applications:

a. A minimum 1/4" wide, polyester pull line will be of a flat design,
b. Shall have a minimum breaking strength of 400 lbs,
c. Will have sequential footage markings.
d. Examples of pull lines that meet these requirements (LU stock # 8800-957305):

Neptco "mule tape"	WP400P
Condux International	08096203
Herculine	P400W

20.2 Adequate pull line will be provided at both ends of conduits to facilitate conductor pulling. Extend pull line 3 feet from the conduit end at the service panel, and 5 feet from the conduit at the secondary service box or transformer pad.

21.0 INSPECTION AND PERFORMANCE OF WORK

21.1 Applicant and/or Developer shall, without cost to LU, secure all necessary permits and licenses, pay all fees and deposits, and arrange for all inspections, as

required by all applicable governmental rules, regulations, codes, and ordinances. Work hereunder shall conform to all applicable governmental rules, regulations, codes, and ordinances before work will be accepted by LU.

21.2 Applicant and/or Developer shall inform Inspector at least 24-30 hours in advance before commencing any item of construction or installation of material to enable proper inspection of materials and workmanship. Materials and/or workmanship failing to meet the requirements of this Specification or installed without prior notice to Inspector will be subject to rejection. If required by Inspector, Applicant shall immediately remove same and furnish and install, at his expense, approved material and/or workmanship. No work shall be embedded in concrete, back filled, or otherwise covered or concealed until such time as it has been inspected and approved by Inspector.

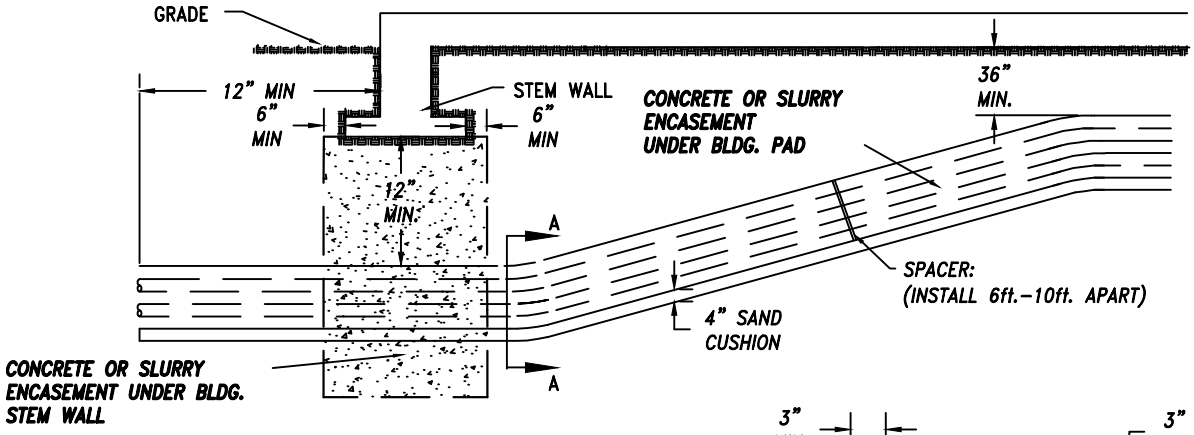
21.3 All materials and workmanship shall be first quality in every respect, plumb and true, and according to the specific requirements of the drawings and this Specification. All work shall be subject to inspection by Inspector, who may exercise such control as is required to safeguard the interests of LU.

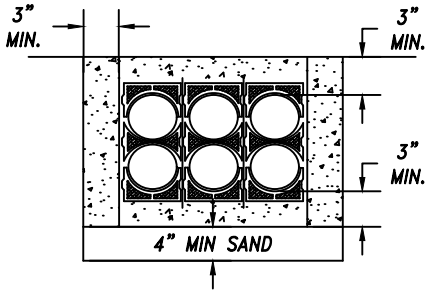
21.4 Any portion of the work which fails to operate to the satisfaction of Inspector, or any defects which are disclosed by testing shall be made good by Applicant and/or Developer at his expense before the work will be accepted by LU.

CONDUIT INSTALLATION BENEATH FOUNDATIONS, AND SLABS

PREFERRED OPTION:

RIGID PLASTIC CONDUIT - CONCRETE ENCASED





1. DB-120 duct bank must rest on sand cushion and be surrounded on all sides with a 3" min. concrete cover. Allow concrete to flow between ducts to assure complete encasement. **Light Concrete or 3 bag slurry mix per inspector approval**.

2. No service conduit is allowed under one building to serve another building.

3. Installation must be **inspected by LU** prior to backfill and concreting.

4. Finish backfill with sand/select material and compact to 90% density.

5. Spacers to be installed on 4 ft. - 10 ft. centers, refer to CD0001U for details.

6. Service conduit installed to internal electrical rooms, will be installed, owned and maintained by customer.

7. Flex Conduit is not permitted.

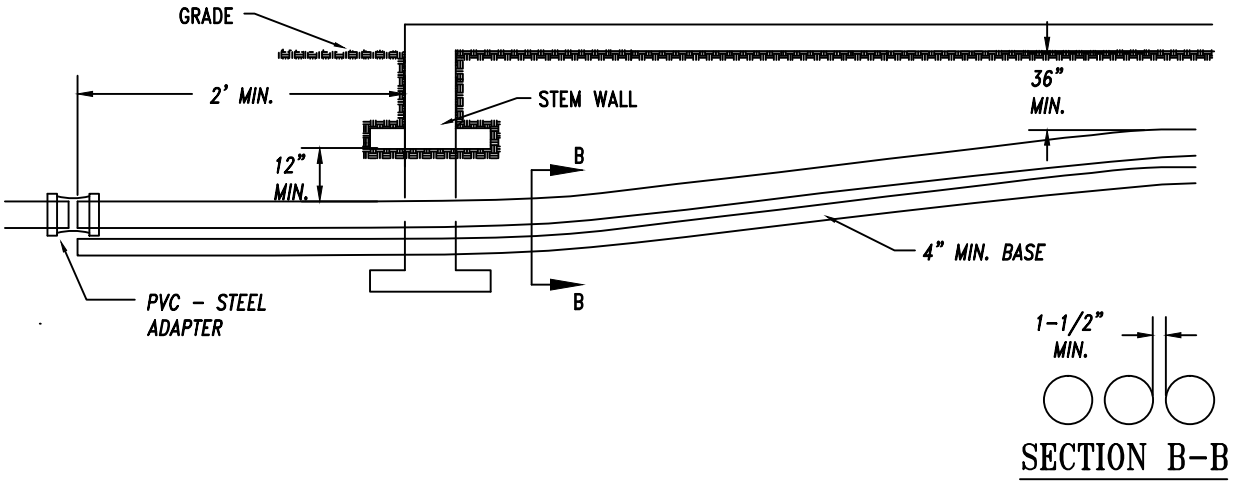
8. Refer to substructure, CB0003U, Tables 1 or 2, for number and size of conduits required.

9. Refer to substructure, CD0001U, Section 16 for other concrete encasement requirements.

CONDUIT INSTALLATION BENEATH FOUNDATIONS, AND SLABS

ALTERNATE OPTION:

RIGID STEEL CONDUIT



1. Conduits must be separated a minimum of 1-1/2".
2. Installation must be inspected by LU prior to backfill.
3. Backfill trench with sand/select material and compact to 90% density.
4. Do not use EMT conduit in place of rigid steel.
5. Service conduit installed to internal electrical rooms will be installed, owned and maintained by customer.
6. Each conduit to contain 1 set of phase wires plus neutral.
7. Refer to substructure, CB0003U, for number and size of conduits.

CONDUIT APPLICATION STANDARD

1.0 INDEX

2.0 PURPOSE

This standard covers approved types of electrical conduits and fittings for either above ground or buried use within Liberty Utilities (LU) service territory.

It also provides a dimensional guide to aid in the design and selection of electrical conduit and fittings used in residential or commercial developments.

LU 'gray' electrical PVC conduit and fittings will meet the following specifications: ANSI/ASTM F512-79 smooth-wall polyvinyl chloride, NEMA TC-2/UL651 for conduit and NEMA TC-3/ UL514b for fittings.

3.0 GENERAL

These electrical conduit requirements are LU approved types and can be replaced with another type only if it exceeds the designated minimum conduit classification requirements. There will be certain cases when a heavier walled or specific type of electrical conduit will be required for a particular installation. When such cases occur, the Utility Design Administrator or Project Engineer will designate the conduit class required. (Refer to Sheet 4.5.23 for approved electrical conduit and applications.)

3.1 All approved electrical conduits and fittings covered in this standard shall meet applicable specifications and their latest revisions.

3.2 These electrical conduits are in compliance with “USA” trade sizes having iron-pipe-size (IPS) outside diameters and special wall thickness. Refer to Sheet 4.5.25 and Sheet 4.5.26 for dimensional information.

4.0 APPROVED CONDUIT TYPES

4.1 **Hot-Dip Galvanized Rigid Steel Conduit (GRS)** - For use as riser conduit.

4.2 **Intermediate Metal Conduit (IMC)** - May be used as a substitute for 'above grade' galvanized rigid steel conduit with **inspector approval**.

4.3 **Type DB-120 PVC 'gray' Conduit** - For underground buried applications only, as direct burial or with concrete encasement.

4.4 **Schedule 40 & 80 PVC 'gray' Conduit** - For use in above-ground exposed locations.

5.0 CONDUIT APPLICATIONS

5.1 **Underground Straight Lengths**
DB-120 rated conduit including sweeps shall be the preferred conduit for buried conduit applications. **No portion of a DB-120 PVC conduit/sweep may be exposed above ground.** Each conduit run shall be one size conduit continuously, no reducers allowed.

5.2 **Radius of Conduit Sweeps**
a. 36" radius sweeps shall be the minimum for 3"and 4" conduits.
b. 48" radius sweeps shall be the minimum for 6" conduit.

NOTE: The larger the radius sweep the better for cable pulling.

5.3 **Pole Risers, Primary/Secondary**
a. **Upper Section:** A minimum conduit classification of Schedule 40 PVC shall be required. No metallic conduits are allowed on this portion of the power pole.
b. **Lower Section:** (1) In traffic areas (exposed to traffic) the first ten-foot (10') length from the base of the power pole and including the sweep, shall be galvanized rigid steel (GRS). (2) In traffic areas (not exposed to traffic) and non-traffic areas, the first ten-foot (10') length from the base of the power pole and including the sweep may be a minimum classification of schedule 80 PVC conduit. **Exception: 6" schedule 80 risers will not be utilized.**
c. Riser conduit and sweep must be of the same type, (PVC-PVC, Steel-Steel).
d. Whenever possible, risers should be installed on the side of the pole opposite traffic flow.
e. When single conductor risers (3-4" C) are utilized for three phase 1000kcm risers, steel must not be used. Schedule 80 is required. (GO 128 33.4-C).

5.4 **Service Entrance**

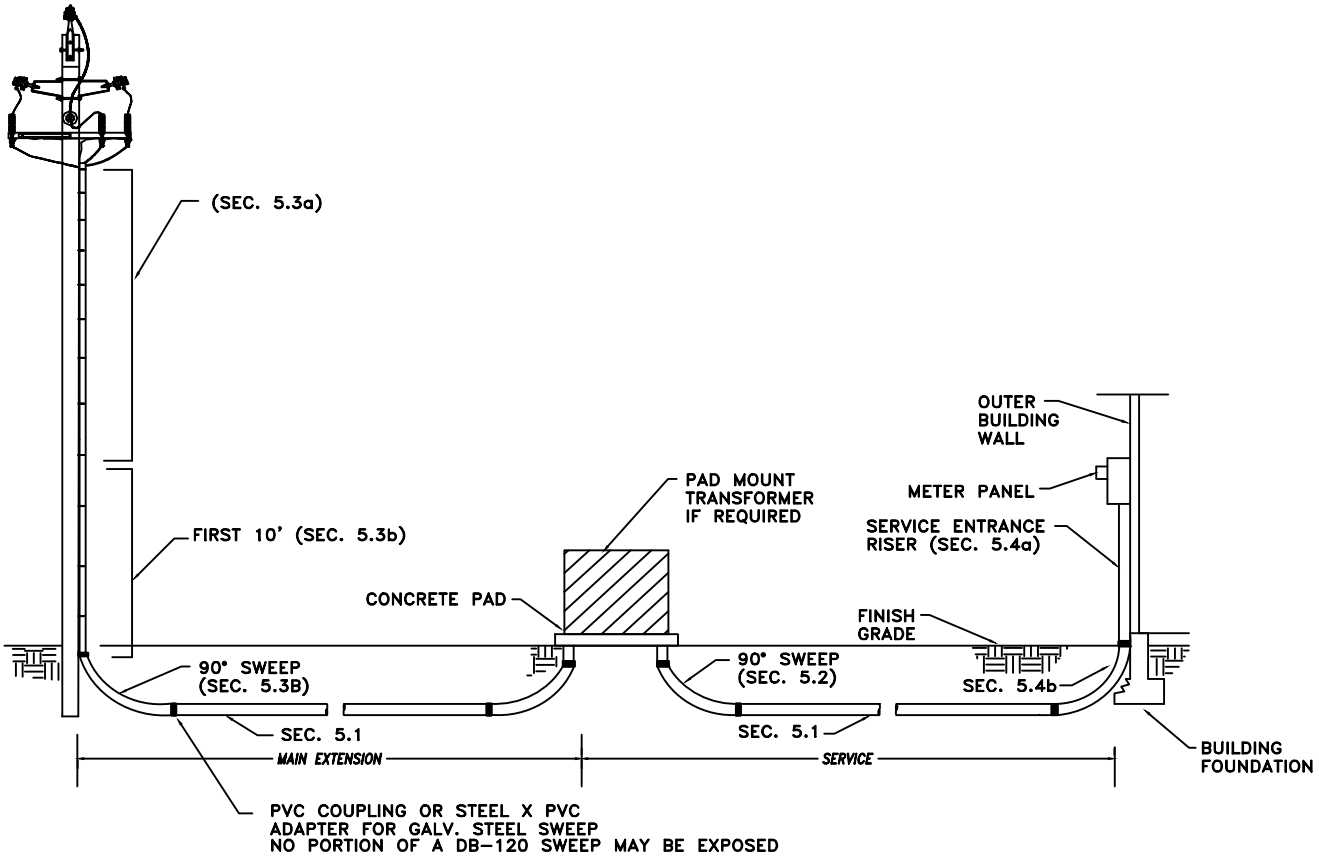
a. **Risers:**

Exposed (outside building wall): A minimum conduit classification of Schedule 80 PVC conduit shall be required.

Recessed (inside building wall): A minimum conduit classification of Schedule 40 PVC conduit shall be required.

b. **Sweeps:**

Conduit sweeps, if exposed will be a minimum schedule 80 when connected to either Schedule 40 or Schedule 80 PVC conduit riser. DB-120



PVC is OK, but no portion of a DB-120 sweep can be exposed above ground.

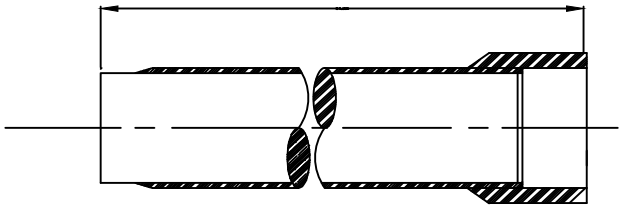
REFERENCES:

Listed below are related LU Standards, substructure, governing installation procedures:

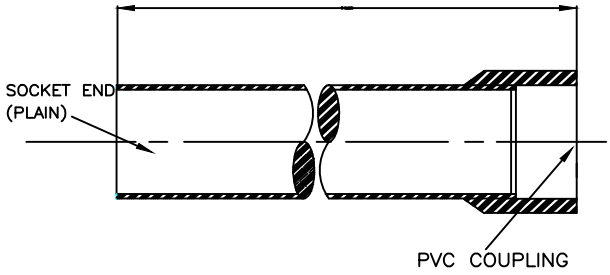
a. **CD0001U** (Conduit Installation Guide)
b. **CI000IM** (Commercial & Industrial Electric Service Requirements)
c. **US0001M** (Underground Electric Residential Service)

STANDARD CONDUIT LENGTHS

GALVANIZED RIGID STEEL (GRS)



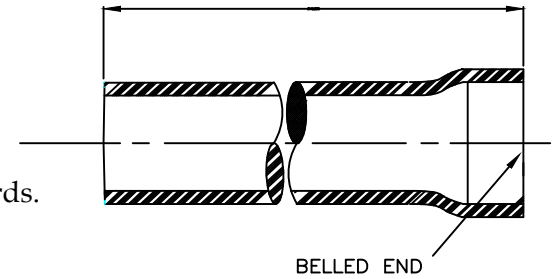
SCHEDULE 40 & 80 PVC CONDUIT



NOTES:

1. All conduit inside diameters (I.D.) are nominal sizes.
2. All conduits shall meet applicable specifications and their latest revisions.
3. Refer to sheet 4.5.26 for coupling standards.

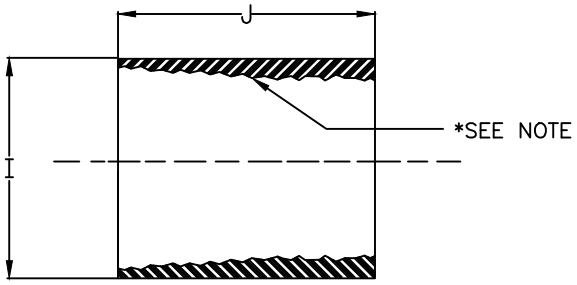
TYPE DB - PVC CONDUIT

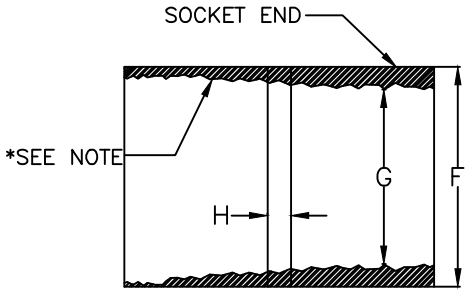


CONDUIT STOCK NUMBERS				
SIZE	**GRS**	**DB-120**	**SCHED. 40**	**SCHED. 80**
2"	8800-240110	8800-240155	8800-240179	8800-240160
3"	8800-240120	8800-240170	---	8800-240180
4"	8800-240130	8800-240200	8800-240190	8800-240191
6"	8800-240140	8800-240210	8800-240220	---

CONDUIT MINIMUM WALL THICKNESS				
SIZE	**GRS**	**DB-120**	**SCHED. 40**	**SCHED. 80**
2"	0.095	0.077	0.154	.218
3"	0.13	0.118	0.216	0.3
4"	0.13	0.154	0.237	0.337
6"	*	0.227	0.28	0.432
*Galvanized rigid steel conduit min. wall thickness is .280"				

STANDARD COUPLINGS



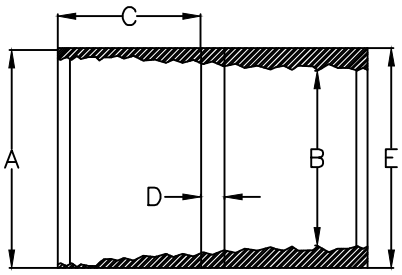


TRANSITION DIMENSIONS

SIZE	I	J
2"	2.73	2.18
3"	4	3.25
4"	5	3.5
6"	7.39	4

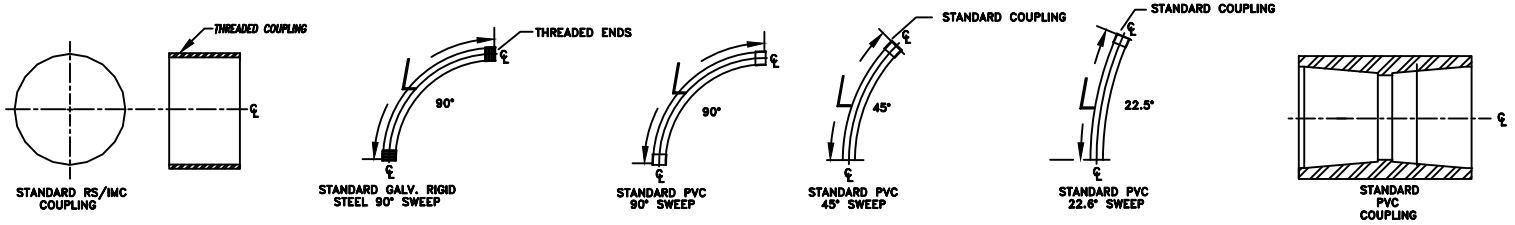
TRANSITION RS//IMC X PVC DIMENSIONS

SIZE	F	G	H
2"	2.844	1.964	0.078
3"	4.047	2.915	0.172
4"	5.109	3.825	0.172
6"	7.516	5.762	.234



PVC COUPLING DIMENSIONS

INTERGRAL COUPLING					
SIZE	A	B	C	D	E
2"	2.393	2.369	1.125	0.094	2.734
3"	3.515	3.492	1.125	0.109	3.969
4"	4.515	4.491	1.75	0.109	5.031
6"	6.658	6.614	2.125	0.141	7.5



CONDUIT AND FITTING CHART

CONDUIT SIZE	CONDUITS				SPACERS		COUPLINGS		ELBOW SWEEPS AND BENDS								BELL ENDS	PLUGS
	STOCK NUMBER				STOCK NUMBER		STOCK NUMBER		BEND	RADUIUS IN INCHES	LENTH IN INCHES	STOCK NUMBER					STOCK NUMBER	STOCK NUMBER
	GALV STL	DB-120	SCHED 40	SCHED 80	INTER-	BASE	PVC-STL	PVC				GALV STL	DB-120	SCHED 40	SCHED 80		PVC	
2"	8800-240110	8800-240155	8800-240179	8800-240160	----	----	8800-240250	8800-240230	90°	24	28.2	----	8800-240840	----	----		8800-240410	8800-240699
									90°	36	42.2	8800-240350	8800-240841	8800-240837	8800-240839			
									45°	36	23.3	----	8800-240910	----	----			
3"	8800-240120	8800-240170	----	8800-240180	----	----	8800-240270	8800-240240	90°	36	78.5	8800-240360	----	----	----		8800-240415	8800-240700
										36	63.3	----	8800-240850	----	8800-240849			
										48	82.2	8800-240370	----	----	----			
										60	101	----	8800-240848	----	----			
									45°	36	35	----	8800-240920	----	----			
										150	124.6	----	8800-240930	----	----			
									22.5°	36	20.9	----	8800-240960	----	----			
									11.25°	150	36.2	----	8800-240990	----	----			
4"	8800-240130	8800-240200	8800-240190	8800-240191	8800-240760	8800-240750	8800-240300	8800-240291	90°	36	79	8800-240380	----	----	8800-240869		8800-240420	8800-240710
										48	83.2	8800-240390	----	----	----			
										36	64.3	----	8800-240870	----	----			
										60	102	----	8800-240868	----	----			
									45°	36	36	----	8800-240940	----	----			
										150	125.5	----	8800-240950	----	----			
									22.5°	36	21.9	----	8800-240970	----	----			
									11.25°	150	37.2	----	8800-241000	----	----			
6"	8800-240140	8800-240210	8800-240220	----	8800-240780	8800-240770	8800-240320	8800-240340	90°	48	101.9	8800-240400	----	----	----		8800-240430	8800-240720
										60	105.2	----	8800-240890	----	----			
									45°	150	128.8	----	8800-240955	----	----			
									11.25°	150	40.5	----	8800-240980	----	----			

DRAWING NUMBER **CD0004U**

SUBSTRUCTURE

4.5.27 OF 30

ENGINEERING AND CONSTRUCTION STANDARD

CONDUIT APPLICATION STANDARD

Liberty Utilities®

DRAWN	DESIGN	SUPR	DATE	REV
JL	MB	DA	08/17	04

MARKING BURIED ELECTRIC FACILITIES

1.0 INDEX

2.0 PURPOSE

This guide is to provide a standard procedure for installing buried markers / indicators for locating underground electric facilities.

3.0 GENERAL

3.1 The applicant will be responsible to supply and install all markers as shown on LU work order drawings. Inspector will field determine additional location(s) as needed.

3.2 Markers, LU Stock Number 8800-253123, are 4 1/2" round.
Approved Manufacturers:
- 3M Model 1402-XR Red
- Omni Model 160

3.3 Markers are provided in **bright red color** for ease of identification as a LU **electric power marker**. Markers for other utilities (facilities) are different colors.

3.4 The marker should be buried over any subsurface item which may require location at some future time.

3.5 The buried markers can be located with any modern locator:

- Radiodetection Omni/EMS
- Antennas, Goldak MLX series locators
- 3M, Scotchmark ® brand locators
- Dynatel ® brand EMS marker locators
- And others, check manufactures specifications

4.0 APPLICATIONS

4.1 The application of markers requires discretion on the part of the Planners and Field Inspectors. These devices are to be applied at equipment that would be difficult to locate for future construction. The marker may be used to mark / locate a wide variety of buried items, with the primary use of marking / locating conduit stub outs and DB cable splices.

4.2 The marker is particularly effective for use in joint trenches due to the fact that each utility will have a designated frequency and color for this type of marker.

5.0 STORAGE AND HANDLING

5.1 The markers should be stored inside their shipping containers until ready for placement in the field. The markers should not be stored in direct sunlight or at temperatures in excess of 100° F for an extended period of time.

5.2 Reasonable care in handling and placement must be taken to prevent damage to the waterproof outer case.

6.0 PLACEMENT AND BURIAL PROCEDURES

6.1 The bottom of the marker may be buried to a maximum depth of 54".

6.2 Burial Procedures:

a. Marker should be buried directly over the installation to be marked and at least 6" above the facility. This minimum separation is necessary to insure maximum radiated signal from the marker to the Detector. Markers must be covered with at least 4" of firm soil to prevent accidental movement and to prevent damage to the marker during backfill. Refer to Figures 1 and 2. ***Do not place Markers within 4" of any buried metal***.

b. Round markers are self leveling based on gravity, therefore no direction is preferred.

6.3 Markers will be buried as shown in Figures 1 and 2 on the following page.

Figure 1. Typical Installation in a 60" deep Trench.
One Single Marker at a Maximum Depth of 54".

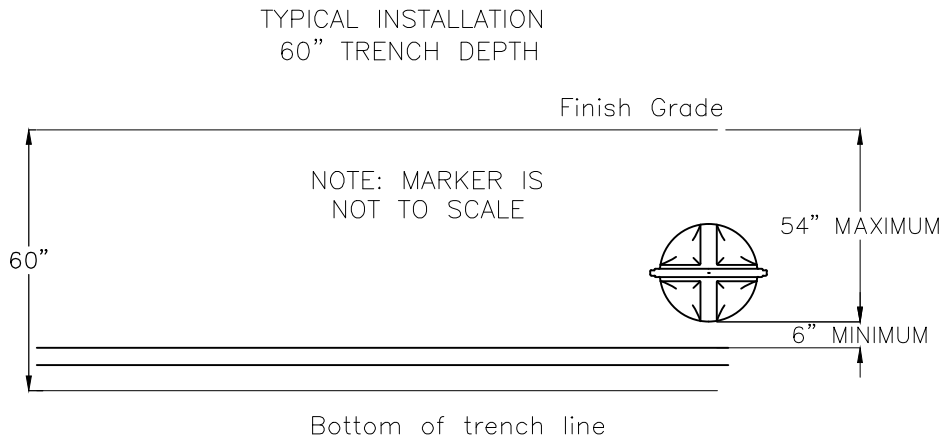


Figure 2. Optional Installation at Extra Depth:
Multiple Markers with a Maximum Spacing of 54" Between Markers.