***** THIS STANDARD REPLACES FORMER TDMIS-1013 *****

3000. GENERAL

The following standard is to be followed when designing and installing direct buried (DB) conduit systems. This standard shall apply to primary and secondary systems installed by both DOP and/or customers.

3001. APPLICATION

Schedule 40 PVC conduit is to be used where ducts are to be direct buried or encased in concrete. The amount of ducts should provide for present and future planned installations by DOP and need to include spare ducts (unoccupied and designated as a spare for emergency replacements). The minimum number of ducts shall be two.

Routes through unstable materials such as mud, shifting soils, etc., or through highly corrosive soils, shall be avoided. If construction in these soils cannot be avoided, the conduit system shall be constructed in such a manner as to minimize movement and/or corrosion.

3002. TYPE

Ducts are to be purchased in 10 foot lengths. They are to have a bell end or coupling on one end. See Table 3002-1.

Type	Size	TDMIS Item
Schedule 40 PVC	2”	UK6A2
	3”	UK6A3
	4”	UK6A4
	5”	UK6A5
	6”	UK6A6

Table 3002-1: TDMIS Items for Conduit

3003. BENDING

3003.1. Bends within a Duct Bank Section

PVC conduit has the ability to be bent without any heating of the material. Therefore hot bending will not be used for the installation of conduits. The degree of cold bending will be a function of temperature. Bends that exceed the cold bending availability will be made with 5 degree couplings. The minimum length of duct segments between single 5 degree couplings is 40 inches. This construction yields a 40 foot radius of curvature, which is the minimum requirement for any size conduit.

3003.2. Sweeps at Equipment

Sweeps needed at equipment locations (e.g. pad-mount transformers) shall be made using manufactured sweeps. Acceptable sweeps are listed in Table 3005-1. The radius of the sweep shall be a minimum of 24 inches for 2 inch conduit, 36 inches for 3 to 5 inch conduit and 48 inches for 6 inch conduit. Ninety-degree conduit elbows shall not be used; the radius of these bends are not adequate and will cause damage to cable insulation.

3004. SPACING

3004.1. Ductbanks

Spacers must provide a 1½ inch minimum separation between ducts (except 6 inch ducts which require 2 inches of separation) and 3 inches between the ducts and the surface of the ductbank. Spacers lock vertically and horizontally. Intermediate spacers shall be used as a cap on the top tier of a duct back to prevent floating during encased burial installations. Spacers shall be placed at 5 – 8 foot intervals and shall be placed at each coupling. See Table 2 for duct bank dimensions and Table 3 for spacer information. See Figure 3004-4 for typical ductbank configurations.

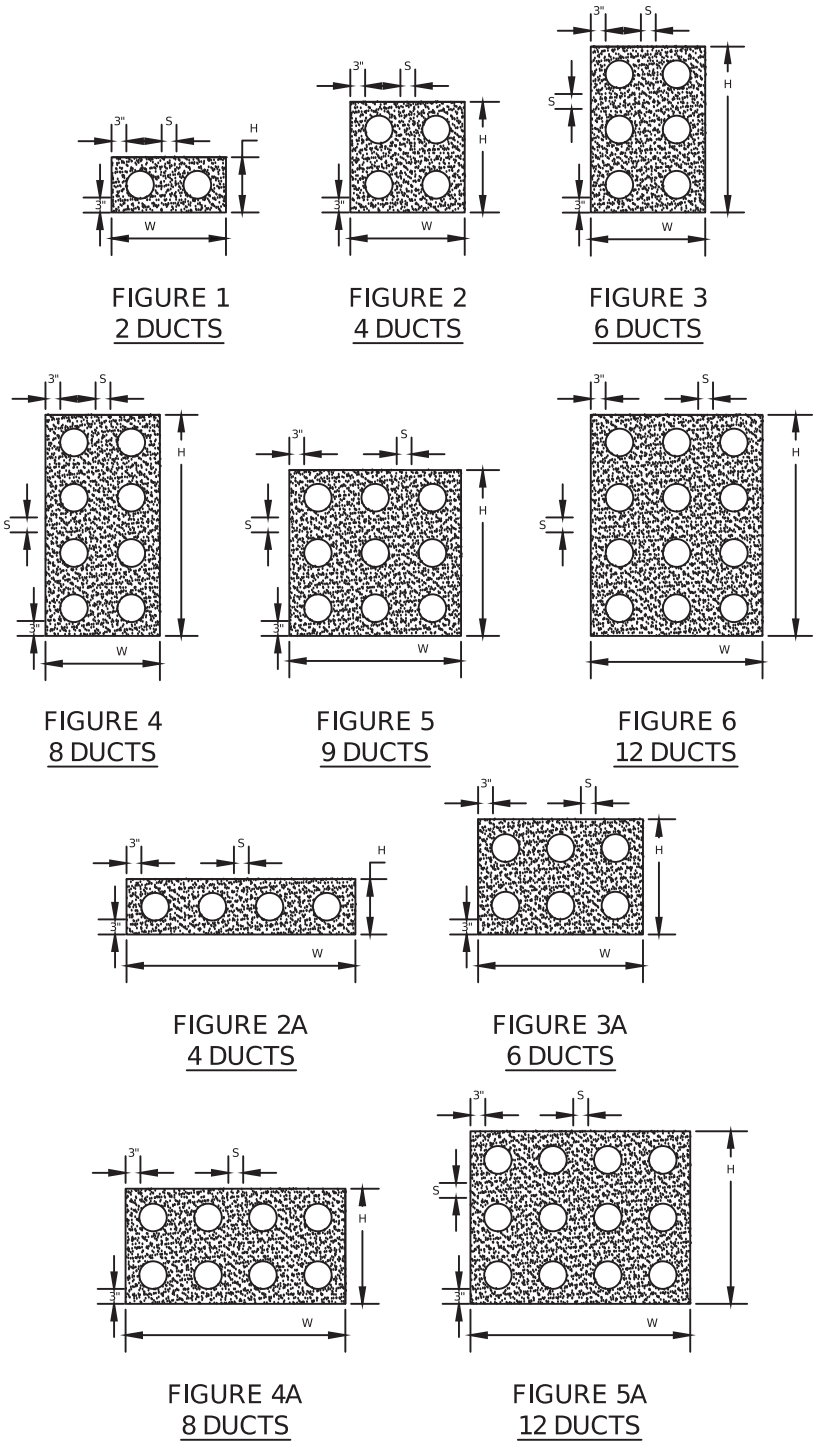


Figure 3004-1: Typical Duct Bank Configurations

Dimensions in Inches									
Figure	4" Duct			5" Duct			6" Duct		
	W	H	S	W	H	S	W	H	S
1	16 ½	10 ½	1 ½	18 ¾	11 ¾	1 ½	21 ¼	12 ¾	2
2	16 ½	16 ½	1 ½	18 ¾	18 ¾	1 ½	21 ¼	21 ¼	2
2A	28 ½	10 ½	1 ½	32 ¾	11 ¾	1 ½	38 ½	12 ¾	2
3	16 ½	22 ½	1 ½	18 ¾	25 ¾	1 ½	21 ¼	30	2
3A	22 ½	16 ½	1 ½	25 ¾	18 ¾	1 ½	30	21 ¼	2
4	16 ½	28 ½	1 ½	18 ¾	32 ¾	1 ½	21 ¼	38 ½	2
4A	28 ½	16 ½	1 ½	32 ¾	18 ¾	1 ½	38 ½	21 ¼	2
5	22 ½	22 ½	1 ½	25 ¾	25 ¾	1 ½	30	30	2
5A	28 ½	22 ½	1 ½	32 ¾	25 ¾	1 ½	38 ½	30	2
6	22 ½	28 ½	1 ½	25 ¾	32 ¾	1 ½	30	38 ½	2

Table 3004-1: Duct Bank Spacing

Size	Intermediate	Base
3"	UK5B	UK4B
4"	UK5C	UK4C
5"	UK5D	UK4D
6"	UK5E	UK4E

Table 3004-2: Conduit Spacer TDMIS Items

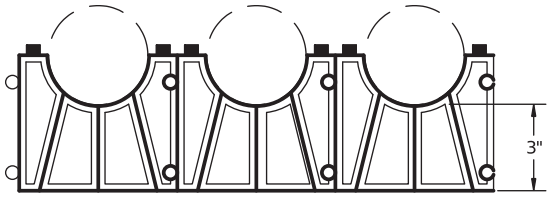


Figure 3004-2: Base Spacer

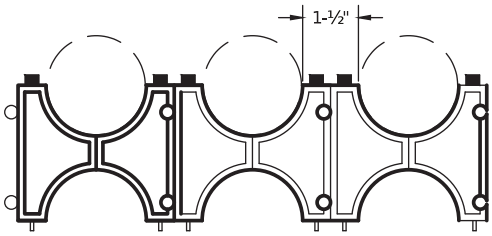
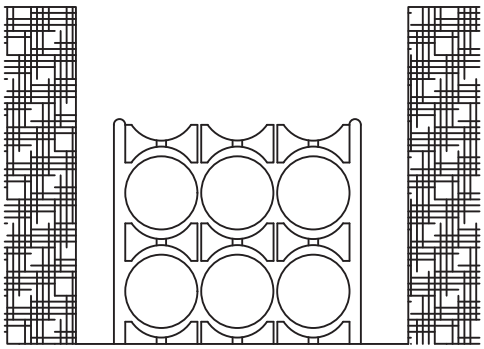


Figure 3004-3: Intermediate Spacer



6- Duct Banks (Example)

Spacers Required:
3 - Bases
6 - Intermediates

Figure 3004-4: 6-Way Duct Bank Example

3004.2. Ductbank Face (in Manholes)

The spacing is increased at the manhole face to allow the cables within the ducts to enter the manhole freely without being too close to the cables from the adjacent ducts and to allow for the use of bell end conduit.

Use the following table and Figure 3004-5 as a guideline for installing ducts at the manhole face.

Dimension	Conduit Size		
	4”	5”	6”
Spacing between conduits (S)	8”	9”	9”
Spacing between conduit and edge of ductbank (E)	6”	6”	6”

Table 3004-3: Conduit Spacer TDMIS Items

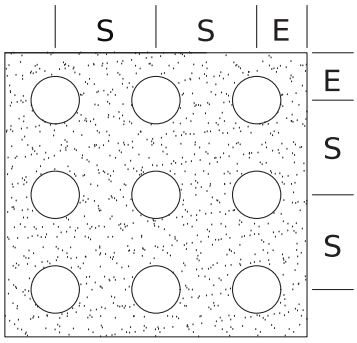


Figure 3004-5: Ductbank Face

3005. FITTINGS

Fittings and accessories will be joined with PVC cement (TDMIS Item UK6S).

Description	2”	4”	5”	6”
Adapter – Female (Threaded)	UK6F2	UK6F4	UK6F5	UK6F6
Adapter – Male (Threaded)	UK7M2	UK7M4	UK7M5	UK7M6
Bend – 90° [1]	UK6B2B	UK6B4C	UK6B4C	--
Bend – 90°, 48” R	--	UK6B4D	UK6B5D	UK6B6D
Bell End	UK6E2	UK6E4	UK6E5	UK6E6
Coupling – Straight	UK6C2	UK6C4	UK6C5	UK6C6
Coupling – 5° Female x Male	UK6D2S	UK6D4S	UK6D5S	UK6D6S
Coupling – 5° Female x Female	UKD2	UK6D4	UK6D5	UKD6
Coupling – Repair Sleeve	UK7CC2	UK7CC4	UK7CC5	UK7CC6
Duct – Split	UK7S2	UK7S4	UK7S5	UK7S6
Plug	UK6G2	UK6G4	UK6G5	UK6G6
Reducer – Male x Male (Large End)	--	UK7E4	UK7E5	UK7E6
Split Duct Repair Kit	UK7T2	UK7T4	UK7T5	UK7T6

Table 3005-1: Conduit Fittings TDMIS Items

3006. PITCH

Ducts are to pitch toward manholes and have a minimum slope of no less than 3 inches per 100 feet.

[1] Minimum radius for 2 inch is 24 inches; for 3 inch, 4 inch and 5 inch is 36 inches; and for 6 inch is 48 inches.

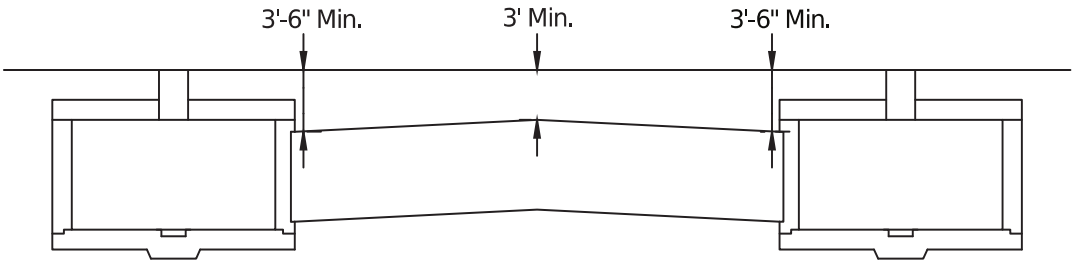


Figure 3006-1

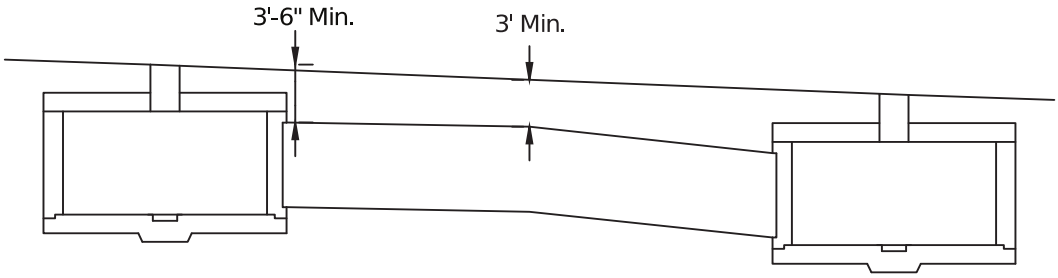


Figure 3006-2

3007. BURIAL DEPTHS

The minimum burial depth between the top of the completed conduit, conduit bank or direct buried cable and grade is 36 inches.

If these minimum burial depths cannot be achieved due to ledge or solid rock conditions, supplemental protection is required to prevent potential damage, both in public ways and private property. The concrete envelope is to be a minimum of 3 inches thick in all directions around the conduit. Minimum cover over the concrete encasement shall not be less than 12 inches.

3008. CLEARANCES

In general, clearances between the conduit envelope and major subsurface pipes or structures shall be 12 inches. This applies to all other utilities including communications, natural gas, sewers, sanitary, storm, and water. However, this clearance may be reduced with approval from DOP Engineering. The standard clearance to communications lines may be substituted for 3 inches of concrete.

Clearances to services and laterals shall be a minimum of 2 inches. Electric conduit crossing above other utilities must have suitable support under the electric conduit, on each side of the other utility line, to maintain the minimum clearance if the other utility's facilities ever have to be dug out.

3009. EXCAVATION

Excavation for an entire run shall be completed prior to conduit installation to preclude encountering unexpected obstructions. The trench shall be excavated and trimmed in such a way that backfill is not required to establish the proper line of grade.

The trench bottom shall be solid, undisturbed earth. Earth showing extensive signs of peat, cinders, rubble, frozen material, or any conditions not suitable for a stable foundation, shall be reported to DOP Engineering for recommendation. Small pockets (up to 1 cubic yard) of unsuitable soil shall be excavated and replaced with compacted gravel (maximum 2 inches of stone).

Where the earth walls of the trench are firm enough to sustain themselves, and all OSHA requirements are met, they may be used as the forms for concrete encasement. The walls of these trenches shall be carefully trimmed to allow the proper thickness (minimum 3 inches) of concrete around the outside conduits, but shall not be so wide as to require an excessive amount of concrete to fill the trench. If shoring and/or sheeting are necessary, they shall be placed as required to maintain the excavation and shall be removed prior to concrete encasement and/or as the backfilling progresses so that all shoring is removed as the job is completed.

Excess excavation material shall be removed from the job site as soon as possible.

3010. INSPECTION

DOP or City inspectors shall perform on-site inspection of the installation after the duct sections are compete and prior to pouring concrete or backfilling any portion of the installation.

3011. CONNECTION OF CONDUIT FITTINGS

Conduit and conduit fittings shall be permanently connected using a medium-bodied clear PVC solvent cement (TDMIS ID UK6S).

3012. CONCRETE

3012.1. Materials

Cement shall be a standard brand of Portland Cement Type II conforming to ASTM C150.

Sand shall be sharp and clean and shall conform to ASTM C33, latest revision.

Coarse aggregate shall be of gravel, crushed gravel or crushed stone and conform to ASTM C33, latest revision.

Water shall be from a potable water supply, assuring it is clean and free from injurious amounts of oil, acids, alkali, organic materials, or other harmful substances.

3012.2. Ready-Mix Concrete

Ready-mix concrete shall be proportioned at the plant. Mixing and delivery shall be in accordance with ASTM C94, latest revision.

Concrete shall have a 3,000 psi 28-day strength minimum with a maximum of #8 aggregate. Slump shall be between 4 and 6 inches.

An air-entraining agent shall be added to concrete mixes in which the surface will be exposed to the elements. Air-entrainment content shall be 5% plus or minus 1%.

3012.3. Delivery and Mixing

In the event that delivery of concrete is called for when the air temperature is below 40 degrees Fahrenheit, the following shall apply:

1. When the air temperature is between 30 degrees Fahrenheit and 40 degrees Fahrenheit, the concrete shall be delivered in excess of 55 degrees Fahrenheit.
2. When the air temperature is between 0 degrees Fahrenheit and 30 degrees Fahrenheit the concrete shall be delivered at a temperature in excess of 60 degrees Fahrenheit.

In hot weather concrete shall be delivered at a temperature which will not cause difficulty from loss of slump, flash set, or cold joints. Discharge of concrete at the job site shall be completed within one hour of adding the mixing water.

3012.4. Forms

Formwork shall be designed and constructed in accordance with the American Concrete Institute's "Recommended Practice for Concrete Formwork", ACI 347, of latest date.

Forms shall be built substantially; true to form, lines, dimensions, and grades shown. They shall be braced and tied to maintain position and shape, without yielding to pressure of fluid concrete or other forces, including those produced by vibratory compaction.

Forms shall be constructed of ¾ inch BB grade plywood supported with 2 x 4 studs on 16 inch centers. Forms shall not exceed a 10 foot pour height and form tie spacing shall not exceed 2 feet. Form ties and accessories shall be used. The forms shall be vertical and symmetrical and in the largest sizes practicable. Sheets showing torn grain, worn edges, hole patches, or other defects, which impairs the texture of the concrete surface, shall not be used.

Forms shall be treated with approved form oil, before erection or reinforcing steel placement, to prevent adhesion of the concrete.

Forms shall be mortar-tight. For surfaces which will be exposed, the form faces shall be smooth and mortar-tight.

Forms shall be removed carefully to avoid damage to the concrete surfaces. The removal time is governed by the concrete's condition, curing temperature, curing time, and the forces the new concrete may be subjected. Under favorable curing conditions, forms may be removed no sooner after placement than 12 hours. If high-early strength concrete is used, this time period may be to six hours.

3012.5. Placement

Concrete shall not be placed until the forms, previously poured concrete surfaces, reinforced steel, and embedded parts have been cleaned of laitance, loose or defective concrete, soil on rock surface, and any other foreign materials.

All concrete placed when the air temperature is above 45 degrees Fahrenheit shall be placed at the coolest temperature as practicable. Concrete placement is not permitted when hot weather conditions prevent proper placement and consolidation. Concrete will not be accepted if its temperature is in excess of 80 degrees Fahrenheit.

When the mean daily temperature falls below 40 degrees Fahrenheit, the minimum concrete temperature shall be 55 degrees Fahrenheit and as close to this minimum as possible.

When the air temperature is below 40 degrees Fahrenheit, provide suitable protection so the concrete can be maintained at a minimum of 50 degrees Fahrenheit throughout the curing period. The protection and heat source, shall maintain the required temperature and moisture conditions without injury due to concentration of heat. All materials which the concrete contacts such as reinforcing, forms, ground, etc., shall be free of frost prior to placement.

Concrete temperature changes during and immediately following the curing period shall be as uniform as possible and shall not exceed 5 degrees Fahrenheit in any one hour, nor 40 degrees Fahrenheit in any 24 hour period. When heaters are used, prevent local surface heating and drying and provide adequate ventilation to prevent carbonation damage to exposed concrete surfaces. Thermostatic temperature controls shall be provided to control the heated enclosures to 50 degrees Fahrenheit. Temperatures exceeding 80 degrees Fahrenheit are to be avoided.

Concrete shall not be allowed to fall from the end of a chute, tube, or bucket more than 5 feet to point of deposit and shall have a fall free from obstructions. Chutes shall be metal or metal-lined.

Pumping equipment, pipelines, procedures, etc., shall be in accordance with ACI 304R, latest revision. Conveying equipment for pumped concrete shall be of suitable kind, without “Y” sections and with adequate pumping capacity. No aluminum pipe shall be used. Placement shall be controlled so there is no

separation in the discharged concrete. The maximum loss of slump in pumping equipment shall be 1½ inches.

Concrete shall be deposited as near to its final position as possible to avoid long flows in the forms. Concrete shall not be moved more than 10 feet from point of deposit. Concrete shall be placed in successive horizontal layers, ranging in thickness from 6–15 inches, maximum.

Concrete shall be placed within 1½ hours after addition of cement to the aggregate. Where conditions make it difficult to place concrete uniformly and perform compaction at the bottom of forms, batches of mortar containing the same proportion of cement to sand as in the concrete mix shall be deposited first and spread over the cleaned surface to a depth of approximately 1 inch.

Segregated, unworkable, and excessive slump concrete shall not be placed or, if placed, shall be removed and wasted as directed. High slump concrete resulting from addition of approved additives is acceptable for placement.

Placement and compaction methods shall ensure homogeneous concrete with maximum consolidation without segregation. Consolidate concrete by internal vibration, spading, or rodding by working it thoroughly around reinforcement, embedded items, and into corners of forms to eliminate all air or stone pockets which cause honeycombing, pitting, or planes of weakness. Concrete contacting all formed surfaces shall be spaded manually to eliminate air bubbles.

Place horizontal construction joints at uniform vertical spacing unless otherwise shown on the drawings. Concrete shall not be placed to a depth of more than 10 feet in any 24 hour period. All concrete placements shall be such as to keep cold joints from forming.

Whenever work is suspended on any section for more than one hour, the horizontal edges of the concrete next to the forms shall be brought to a plane perpendicular to the form face, and treated so no irregular, rough, or feathered edge joints show in the finished work. Before placing the next lift, clean the joint surface and remove all laitance. Immediately before placing new concrete wet the joint surface and remove all standing water.

Unless adequate weather protection is provided, do not place concrete during rain, sleet, or snow.

3012.6. Curing

Protect freshly deposited concrete from premature drying and hot or cold temperatures.

Maintain a constant temperature throughout the curing period without drying.

All exposed concrete surfaces shall be kept continuously moist overnight by ponding, sprinkling, or by use of an approved membrane type curing compound, which conforms to ASTM C309, latest revision, and applied in conformance with the manufacturer's recommendations.

Curing shall continue, using one of the above methods or waterproof paper, for a 7 day period (3 days for high-early strength concrete) maintaining the concrete at a minimum temperature of 50 degrees Fahrenheit as is practical. Protective covering with tarpaulins, hay, straw, etc. shall be provided to retard moisture evaporation during hot weather and to prevent rain damage before hardening. Protective covering shall be available for immediate use at all times.

During the curing period, the concrete shall be protected from damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration.

3012.7. Loading of Concrete

Trenches containing concrete encased duct lines constructed on undisturbed original ground may be backfilled not less than two hours after placement. Compaction by light tamping equipment may proceed immediately. Loading of the backfill by heavy equipment or traffic is not permitted before 12 hours after placement.

3013. BACKFILL

Concrete will be cured for a minimum of 2 hours before backfilling over it. Before any backfill is installed, a DOP employee or City representative shall inspect and approve the duct construction and backfill material. Flowable fill is a viable backfill if available and when deemed necessary.

Backfill within 6 inches of the top of the concrete shall be free of solid material greater than 4 inches maximum dimension, or, with sharp edges likely to cause damage. The

balance of backfill shall be free of solid material greater than 8 inches, maximum dimension. Backfill material shall be adequately compacted in 6 inch lifts. Peat, cinders, rubble and frozen material are not suitable backfill material.

3014. WARNING TAPE

Warning tape (TDMIS Item UT1) shall be installed 12 to 18 inches below finished grade and directly above electric conduit. All buried warning tapes shall be printed on APWA approved colors to meet or exceed industry standards. 5-mil tape shall have a solid aluminum foil backing to make it easy to find underground using a non-ferrous locator. Text shall read: "Warning! Buried Electric Below" in bold capital letters, black on red background. Tape shall be 6" wide minimum. The imprinted warning message shall be "Buried, or Encased" to prevent ink rub-off, and shall be impervious to acids, alkalis and other destructive elements found in soil. The imprint shall allow for total reflectivity. A tape must be visibly seen before it can be read.

3015. MANDREL

An approved flexible mandrel, no less than ¼ inch smaller in diameter than the duct nominal inside diameter, shall be pulled through all completed ducts. 2,500 pound rated pulling tape, often referred to by the trade name "Muletape", shall be left in all conduits.

3016. DUCT SIZING FOR THREE SOLID DIELECTRIC PARALLEL CABLES WITH 600V NEUTRAL

Cables are required to have ¾ inch clearance through the conduit. Also multiple cables might have a possibility of jamming. Table 3016-1 will aid in the selection of the proper conduit size for three parallel conductors with one 600-volt neutral sized per TDMIS-1510. Table 3016-2 includes standard sized cables with concentric neutrals and is provided for reference only. "NO" means the conduit is not suitable for the conductors, "YES" means the conduit is suitable for the conductors.

Acceptable conduit size was selected by determining jamming possibility and a ¾ inch clearance. Jamming was calculated using the formula D/d. Where D = inside diameter of duct and d = single cable nominal OD. If D/d ratio is greater than 2.8 and less than 3.2 there is a possibility that the cables may jam.

Three Cables Parallel Wound with Separate Neutral Conduit Sizing				
Conductor Size	Conduit Size			
	3”	4”	5”	6”
#2 AWG	Yes	Yes	Yes	Yes
2/0 AWG	No	Yes	Yes	Yes
350 MCM	No	No	Yes*	Yes
500 MCM	No	No	Yes	Yes
750 MCM	No	No	No	Yes
1000 MCM	No	No	No	Yes

Table 3016-1: Appropriate Conduit Size for Use with Standard Tape Shield Cables

Three Cables Parallel Wound with Concentric Neutral Conduit Sizing				
Conductor Size	Conduit Size			
	3”	4”	5”	6”
#2 AWG	Yes*	Yes	Yes	Yes
4/0 AWG	No	Yes*	Yes	Yes
500 MCM Compact	No	Yes*	Yes	Yes
500 MCM	No	No	Yes*	Yes
750 MCM	No	No	No	Yes*
1000 MCM	No	No	No	Yes

Table 3016-2: Appropriate Conduit Size for Use with Concentric Neutral Cables

*Cable may jam.

3017. MEASUREMENT AND PAYMENT

3017.1. Method of Measurement

The method of measurement shall be the linear foot length of completed and operational duct bank on center line from point to point. Duct banks that terminate with a transition to a riser, such as a riser pole shall be measured point to point including the transition, i.e., pole to pole, pole to vault or manhole, pole to pad etc. When conduits of different sizes are contained within the same duct bank, the measurement shall assume and be based on all conduits are the same size as the largest conduit.

3017.2. Basis of Payment

Items	Unit	Description
TDMIS-3000	linear feet	Operational and proof-tested ___-inch *[number of ducts]*-way concrete-encased duct bank