Designation: F449 – 20

Standard Practice for Subsurface Installation of Corrugated Polyethylene Pipe for Agricultural Drainage or Water Table Control[1]

This standard is issued under the fixed designation F449; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice is recommended for and limited to gravity flow subsurface drainage systems or water table control, but not recommended for sanitary or storm sewer applications. Procedures are outlined to minimize pipe deflection or structural damage during and after the installation process. These installation procedures are in accordance with "flexible conduit" principles.

1.2 This practice applies to all agricultural subsurface drainage or water table control installations using Specification F667, F2648, or other plastic pipe.

NOTE 1—Specific references to the appendix in the body of this practice are for informational purposes.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only, may not be equivalents and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2321 Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

D2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

F412 Terminology Relating to Plastic Piping Systems

F667 Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings

F2648 Specification for 2 to 60 inch [50 to 1500 mm] Annular Corrugated Profile Wall Polyethylene (PE) Pipe and Fittings for Land Drainage Applications

3. Terminology

3.1 Definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise specified.

3.2 *backfill*—materials used to fill the trench following installation of the pipe and bedding.

3.3 *bedding*—material which provides bottom and side support for the pipe.

3.4 *blinding*—the placement of bedding material over and on the sides of the pipe to ensure proper grade, alignment, support, and protection of pipe during backfilling after installation.

3.5 *boot (also shield)*——the protecting apparatus linked to the rear of the installation machine in a manner which allows placement of the pipe on the trench bottom, protection of the workman, or placement of envelope or filter material, or both.

3.6 *cradle*—a structure designed to provide trench bottom support for the pipe.

3.7 *envelope*—porous material placed around the pipe to fill the excavated space.

3.8 *filter*—an envelope of natural or synthetic materials placed completely around the pipe to permit free water movement into pipe perforations and restrict movement of silt and sand into the pipe.

3.8.1 *Discussion*—When crushed stone is used as the filter medium it also provides stabilizing support for the pipe.

3.9 *grade*—the slope of the pipe invert.

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.65 on Land Drainage.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

3.10 *groove support angle*—angle between the radii of the pipe at points of contact with the formed groove of undisturbed soil or a cradle.

3.11 *in-situ*—soil in the natural or original position, undisturbed. Applied to a soil when occurring in the situation in which it was originally formed or deposited.

3.12 *mineral soils*—soil containing (*1*) less than 30 % organic matter by weight provided the mineral fraction is 60 % or more clay, or (*2*) less than 20 % organic matter by weight provided the mineral fraction has no clay, or (*3*) less than a proportional content of organic matter between 20 and 30 % if the clay content of the mineral fraction is between 0 and 60 %.

3.13 *natural granular envelope*—an envelope of granular material, usually highly permeable well-graded sand and gravel.

3.14 *organic soil*—soil containing (*1*) 30 % or more organic matter provided the mineral fraction is 60 % or more clay, or (*2*) 20 % or more organic matter provided the mineral fraction has no clay, or (*3*) a proportional content of organic matter between 20 and 30 % if the clay content of mineral fraction is between 0 and 60 %. (It is a general rule that a soil is classed as an organic soil (histosol) either if more than one half of upper 32 in. (80 mm) of soil is organic or if organic soil material of any thickness rests on rock or on fragmental material having voids filled with organic material.)

3.15 *pipe stiffness*—force per unit length, per unit deflection as defined in Test Method D2412.

3.16 *power feeder*—mechanism that applies force to the pipe as it passes through the boot or shield to reduce stretch during installation.

3.17 *pre-ripping*—the practice of making a pass with the plow without installing pipe to locate rocks and to reduce draft.

3.18 *semi-circular groove*—a rounded trench bottom in native *in-situ* soil that conforms to the outside diameter from the invert to the springline of the pipe (180°).

3.19 *start hole*—a trench sufficiently long and wide to allow working room for placing the boot or shield, blade or cutting mechanism on grade to start the trench and to install connections or pipe.

3.19.1 *Discussion*—Start holes are usually dug with a backhoe or excavator with a flat-bottom trench.

3.20 *springline*—an imaginary horizontal reference line located at mid-height, or halfway point of a pipe.

3.21 *stretch*—the increase in length of the pipe caused by tension forces during installation. It is expressed as a percent increase of the length prior to installation. Stretch differs from elongation in that elongation is a material test and stretch is an installation test.

3.22 *synthetic envelope*—an envelope made of synthetic geotextiles, usually thin synthetic fabrics or thicker fibrous material, or both, often selected to function as a filter.

3.23 *trench depth*—the depth of the trench measured from the bottom of the pipe.

3.24 *trench width*—the width of the trench measured at the top of the pipe.

4. General Requirements

4.1 *Burial*—The maximum and minimum burial depth are affected by the following factors, groove support angle or shape of the trench bottom, bedding, blinding backfill soil density, envelope density, envelope placement, pipe stiffness, the live load expected, desired water table depth, and width of trench.

4.1.1 *Minimum Depth:*

4.1.1.1 *Mineral Soils*—The minimum recommended cover needed to protect the pipe from excessive deflection under live loads beyond what is listed in 5.2 for maximum deflection is 2 ft (0.6 m). Granular bedding or special construction techniques may be used to reduce the cover. The time for consolidation of backfill may be a factor (see 8.1). The minimum cover may have limiting factors other than deflection such as clearance for subsoiling and utility crossing.

4.1.1.2 *Organic Soils*—Subsurface drains should be installed in these soils only after initial subsidence has occurred. To produce initial subsidence open ditches should be constructed in deep organic soils to carry off free water, and the area should be allowed to stand or be partially cultivated for a period of 3 to 5 years before installing pipe. The recommended minimum cover for the pipe in organic soils is 2.5 ft (0.7 m). If water level controls are not provided in the drainage system to hold subsidence to a minimum, the depth of cover should be increased to 3 ft (0.9 m).

NOTE 2—These minimum depths are recommended to prevent excessive deflection of the pipe by normal agricultural vehicle loads beyond what is listed in 5.2 for maximum deflection. Other drainage factors such as those encountered with salinity control in arid irrigated lands may require minimum depths of 6 ft (1.8 m)

4.1.2 *Maximum Depth*—The maximum burial depth is influenced by such factors as degree of compaction, type of bedding, support from the trench bottom, trench width, size of pipe, pipe stiffness, weight of backfill, and live loads imposed. Without an engineering design, maximum buried depths should be limited to those listed in Table 1 or Table 2. For installation at depths greater than those listed in Table 1 or Table 2, specifications of an engineering design should be followed.

4.1.3 *Trench Width*—Increasing the trench width increases the soil load on the pipe. For Table 1 designs, the trench width must be at least 2 in. (50 mm) wider than the pipe on each side for plow installation and 3 to 6 in. (75 to 150 mm) on each side for open trench installation to allow sufficient bedding to support the pipe. If fine material cannot be placed alongside and over the pipe, a wider trench should be considered or special bedding material supplied. Side clearances of more than 6 in. (150 mm) on each side should only be used with an engineering design and special construction. For Table 2 designs, a maximum and minimum trench width is specified to limit excessive deflection and allow a larger amount of soil arching to reduce the load on the pipe. The tile boot or trench box used to construct the semi-circular groove shall conform as closely as possible to the pipe OD and shall be within 1 % or ½ in. (12 mm), whichever is greater, of the pipe OD. The trench width requirements only pertain to the vertical distance from the springline to the top of the pipe. It is permissible for

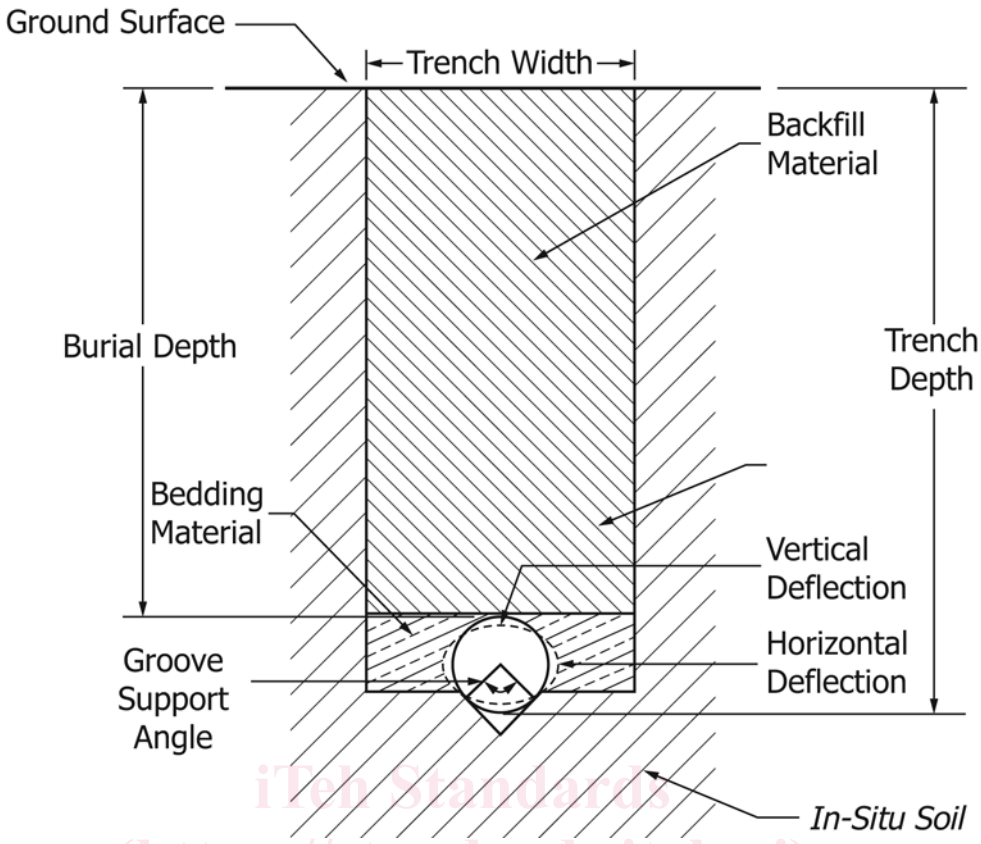

FIG. 1 Terminology for Installation of Plastic Drain Pipe

TABLE 1 Maximum Trench Depths for Pipe Buried in Loose, Fine-Textured Soils, ft (m)[A]

NOTE 1—These depths are based on limited research and should be used with caution. See Appendix X1 for burial depth calculation method. Differences in commercial pipe from several manufacturers, including corrugation design and pipe stiffness, as well as soil conditions, may change the assumptions; and, therefore, maximum depths may be more or less than stated below. Consult the manufacturer for specific recommendations.

Nominal pipe diameter, in. (mm)	Pipe quality (ASTM)	Trench width at top of pipe, m (ft)[A]			
		1 (0.3)	1.3 (0.4)	2 (0.6)	2.6 (0.8) or greater
3 (76)	F667/F2648	9.8 (3.0)	9.8 (3.0)	6.9 (2.1)	6.2 (1.9)
4 (102)	F667/F2648	9.8 (3.0)	9.8 (3.0)	6.9 (2.1)	6.2 (1.9)
5 (127)	F667	9.8 (3.0)	9.8 (3.0)	6.9 (2.1)	6.2 (1.9)
6 (152)	F667/F2648	9.8 (3.0)	9.5 (2.9)	6.6 (2.0)	6.2 (1.9)
8 (203)	F667/F2648	9.8 (3.0)	9.8 (3.0)	6.9 (2.1)	6.2 (1.9)

[A]Maximum trench depth is listed to the right of each size and type of pipe and is dependent on the trench width at the top of the pipe.

the trench width above the top of the pipe to slope to the natural angle of repose of the soil.

NOTE 3—A narrow trench width will result in a greater transfer of loads to the sidefill materials. A semi-circular groove installation in in-situ soils conforming to the outer diameter of the pipe minimizes the impact of poor compaction and provides very good bedding support in addition to reduced dead loads on the pipe.

4.2 *Design Items*—It is particularly important that blinding, bedding, or envelope material be placed as the pipe is installed to ensure uniform continuous support, so that the bedding, blinding, or envelope material can provide lateral restraint against pipe deflection as the backfill settles on the bedding, blinding, or envelope material.

4.3 *Envelopes*—Must be designed to provide adequate support for the pipe, improve the flow of ground water into the pipe, and in some installations, filter flow into the pipe.

4.3.1 *Natural Granular Envelopes*—Shall have a minimum thickness of 75 mm (3 in.) around the pipe.

4.3.2 *Synthetic Envelopes*—Blinding or bedding is needed to support and hold the envelope and pipe in place.

4.4 *Filters*—Are required when ground water can develop velocities sufficient to move sand or silt, or both, into the drain. Filters must be able to restrict the movement of these particles into the pipe so that the hydraulic capacity of the pipe is maintained. In some instances, narrow perforations may be substituted for in-place filters.

NOTE 4—Narrow perforations are typically knife slits or fine needle punches into the pipe. Consult the specific pipe manufacturer for detailed perforation specifications.

4.4.1 *Granular Filters*—Design of a graded media filter should match the gradation of the specific soil following criteria developed by the Natural Resource Conservation Service, the U.S. Bureau of Reclamation, or the U.S. Army Corps of Engineers.

4.4.2 *Synthetic Filters*—Thin synthetic fabric material or geotextiles may be used where bedding, soil, and hydraulic conditions permit. The openings in synthetic filters must be

TABLE 2 Maximum Trench Depths for Pipe Buried with a Semi-Circular Groove, ft (m)[A]

NOTE 1—These depths are based on limited research and should be used with caution. Differences in commercial pipe from several manufacturers, including corrugation design and pipe stiffness and soil conditions, may change the assumptions; and, therefore, maximum depths may be more or less than stated above.

Nominal Pipe Inside Diameter in. (mm)	Typical Pipe Outside Diameter in. (mm)	Pipe Quality ASTM Standard	Trench Width at Springline of Pipe in. (mm)	Tolerance on Trench Width at Springline in. (mm)	Maximum Depth of Fill ft (m)
3 (76)	3.5 (90)	F667	3.5 (90)	+ 8 (+ 203)	9.8 (3.0)
4 (102)	4.5 (115)	F667	4.5 (115)	+ 8 (+ 203)	9.8 (3.0)
5 (127)	5.5 (140)	F667	5.5 (140)	+ 8 (+ 203)	9.8 (3.0)
6 (152)	6.5 (165)	F667	6.5 (165)	+ 8 (+ 203)	9.8 (3.0)
8 (203)	10 (254)	F667	10 (254)	+ 8 (+ 203)	9.8 (3.0)
10 (254)	12 (305)	F667	12 (305)	+ 10 (+ 254)	8 (2.4)
12 (305)	15 (381)	F667	15 (381)	+ 12 (+ 305)	6 (1.8)
15 (381)	18 (457)	F667	18 (457)	+ 12 (+ 305)	6 (1.8)
18 (457)	21 (533)	F667	21 (533)	+ 12 (+ 305)	6 (1.8)
21 (533)	24 (600)	F667	24 (610)	+ 12 (+ 305)	6 (1.8)
24 (610)	28 (711)	F667	28 (711)	+ 12 (+ 305)	6 (1.8)
Nominal Pipe Inside Diameter in. (mm)	Typical Pipe Outside Diameter in. (mm)	Pipe Quality ASTM Standard	Trench Width at Springline of Pipe in. (mm)[B]	Tolerance on Trench Width at Springline in. (mm)	Maximum Depth of Fill ft (m)
4 (102)	4.5 (115)	F2648	4.5 (115)	+ 8 (+ 203)	11 (3.4)
6 (152)	6.5 (165)	F2648	6.5 (165)	+ 8 (+ 203)	11 (3.4)
8 (203)	10 (254)	F2648	10 (250)	+ 8 (+ 203)	11 (3.4)
10 (254)	12 (305)	F2648	12 (305)	+ 10 (+ 254)	11 (3.4)
12 (305)	15 (381)	F2648	15 (381)	+ 12 (+ 305)	11 (3.4)
15 (381)	18 (457)	F2648	18 (457)	+ 12 (+ 305)	10 (3.0)
18 (457)	21 (533)	F2648	21 (533)	+ 12 (+ 305)	10 (3.0)
21 (533)	24 (610)	F2648	24 (610)	+ 12 (+ 305)	10 (3.0)
24 (610)	28 (711)	F2648	28 (711)	+ 12 (+ 305)	10 (3.0)
30 (762)	35 (889)	F2648	35 (889)	+ 16 (+ 406)	10 (3.0)
36 (914)	41 (1041)	F2648	41 (1041)	+ 18 (+ 457)	8 (2.4)
42 (1067)	48 (1219)	F2648	48 (1219)	+ 20 (+ 508)	8 (2.4)
48 (1219)	54 (1372)	F2648	54 (1372)	+ 20 (+ 508)	7 (2.1)
60 (1524)	67 (1702)	F2648	67 (1702)	+ 25 (+ 635)	6 (1.8)

[A] A small "V" notch or groove at the bottom of the shaped trench may be beneficial to accommodate any soil chunks or small clods that may fall into the plowed-in or excavated trench in order to prevent localized stress points on the invert crown of the pipe,

[B] The minimum trench width at the springline listed in the table are listed as the typical pipe OD in the industry. Pipe ODs vary and as such the minimum trench width should always be at least the pipe OD.

compatible with the soil that surrounds the drain to prevent excessive movement of soil that otherwise could plug the drain or filter (see 5.3).

NOTE 5—These filters must be specified to be compatible with the soil type that encompasses the pipe since protective filters can plug and decrease the inflow capability. Where fiberglass filter material is used, it shall be manufactured from borosilicate-type glass and the manufacturer shall certify that it is suitable for underground use. The fibers should be of variable size, with some larger fibers intertwined in the mat in a random manner.

NOTE 6—Vegetative filter material such as straw, hay, corn-cobs, woodchips, sawdust, and coconut fiber are not recommended for use with flexible pipes because such pipes depend on the development of lateral support and these soft materials may not provide the necessary lateral support.

4.5 *Grade*—Shall be as specified in the plan or guide. Deviations from specified grade should be avoided and shall be limited to vertical deviations of 0.2 ft (61 mm) in 100 ft (30.5 m) from specified grade. Negative grade that would fill the pipe more than 10 % with standing water shall not be allowed. Due to the speed of installation with the plow, automatic grade control is recommended. The pipe feeding system shall hold the pipe in place in the bottom of the trench until secured by the bedding, blinding, or envelope material.

4.6 *Material Requirements*—Pipe and fittings shall meet the requirements of the applicable ASTM standards referenced in 1.2, Table 1, and Table 2.

5. Significant Factors in Pipe/Soil Interactions

5.1 *Connections*—In start holes and adjacent open trenches, the pipe shall be aligned both vertically and horizontally, blinded and hand tamped along the sides of the pipe to prevent excessive deflection.

5.2 *Deflection*—The deflection of corrugated plastic pipe is affected by the installation practice, bedding, groove support angle, blinding, gradation and density of soil, depth of installation, trench width in relation to pipe size, live loads imposed, stretch, and pipe stiffness of the pipe. Maximum vertical pipe deflection should be specified and not exceed 10 % of its nominal diameter.

5.3 *Filters*—Synthetic materials should never be used when the soil has a silt content greater than 40 %.

5.4 *Trench Depth*—See 4.1.

6. Construction

6.1 *Alignment*—Should be as smooth as possible with a curve radius larger than five times the pipe diameter for single wall pipes (Specifcation F667). For double wall pipes, (Specification F2648), with bell and spigots, there should be no more than 3° of change in direction per joint without the use of a fitting.

6.2 *Backfilling*—Place the backfill material so displacement or deflection of the pipe will not occur. This is preferably on an

angle so the material flows down the front slope. Avoid large stones, frozen material, and dry clods that could cause concentrated direct loads on the pipe. The trench should be backfilled as soon as possible after blinding. When installing the pipe on a hot day back-filling should be delayed until pipe temperature cools to the soil temperature (see 8.1).

6.3 *Bedding*—Necessary for the support and protection of the pipe. If adequate support is not provided by the soil and trench bottom shape as shown in Fig. 2a, Fig. 2b, or Fig. 3, installation should proceed in accordance with Practice D2321. When bedding is used in place of a support groove, the bedding material should be a minimum of a Class III[3] material compacted to 90 % from the bottom of the pipe to the springline.

6.4 *Blinding*—Material used for this process should not contain any hard object larger than 1½ in. (38 mm) in diameter and should cover the pipe to a depth of 6 in. (150 mm).

6.5 *Bottom Shape*—The bottom should be one of the shapes shown in Fig. 2a or Fig. 2b. The 90° "V" bottom of Fig. 2 is suitable on nominal sizes 3 in. (76 mm) to 6 in. (152 mm) and the trapezoidal groove is suitable on sizes up to and including 8 in. (200 mm). The pipe is pressed into the void, which reduces horizontal deflection in the completed installations. For pipe larger than 8 in. (200 mm), the semi-circular groove should be used. The curve of the semi-circular groove shall closely fit the outside diameter of the pipe as specified in 4.1.3 or there will be insufficient support and deflection will be increased. The semi-circular groove is also suitable for pipes 8 in. and smaller as long as the semi-circular groove fits closely to the outside diameter of the pipe as specified in 4.1.3. For flat-bottom trench, installation in accordance with Practice D2321 should be used.

6.6 *Couplers, Fittings, and Curves*—Fittings should be installed in accordance with instructions furnished by the manufacturer. Couplers should be used to connect pipe together. Fittings should be used at all changes in direction where the centerline radius is less than five times the pipe diameter in single wall pipe or greater than 3° in double wall pipe, changes in diameter, and junctions with another line. All fittings shall be compatible with the pipe. Where bell and spigot joints are used with a slip fit, some form of fastener to secure the pipes together should be used to prevent the pipes from pulling apart as the pipe slides in the boot during installation.

6.7 *End Caps*—End caps or end plugs must be installed on the termination of each line.

NOTE 7—Bending of corrugated pipe creates tension in the pipe wall on the outside of the curve. Avoid pipe boots with less than five times the diameter radius. Avoid press wheels and slides that place the pipe on the bottom of the trench in a bent or stretched condition.

6.8 *Grade*—Equipment operating on uneven ground surfaces should use a grade control system capable of maintaining the specified depth and grade. Automatic grade control is recommended, using a ground speed that allows the control system to function properly.

6.9 *Over-Excavation*—Fill any area of over-excavation below the grade line with proper bedding material (see 6.3). Plane and shape the pipe bed to grade.

6.10 *Rock Excavation*—When the pipe is to be laid in a rock cut, the trench should be over-excavated to a depth of 6 in. (150 mm) below grade and the over-excavation filled to grade with suitable bedding to provide a firm foundation (see 6.3). The balance of the trench within the rock cut should be filled with designed bedding or envelope material.

6.10.1 *Stony Trench*—Remove stones larger than 1½ in. (38 mm) in the trench bottom. Any over-excavation should be treated as in 6.9. Inspection should also be made to locate

[3] See Practice D2487 for soil classification.

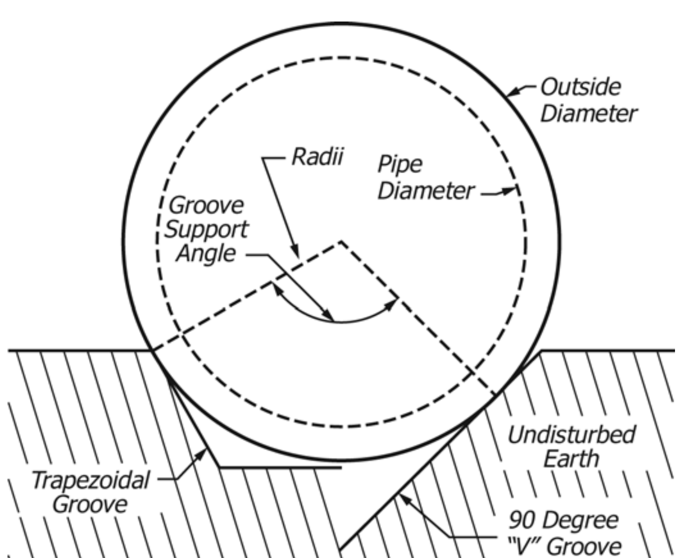

FIG. 2 a Support Grooves

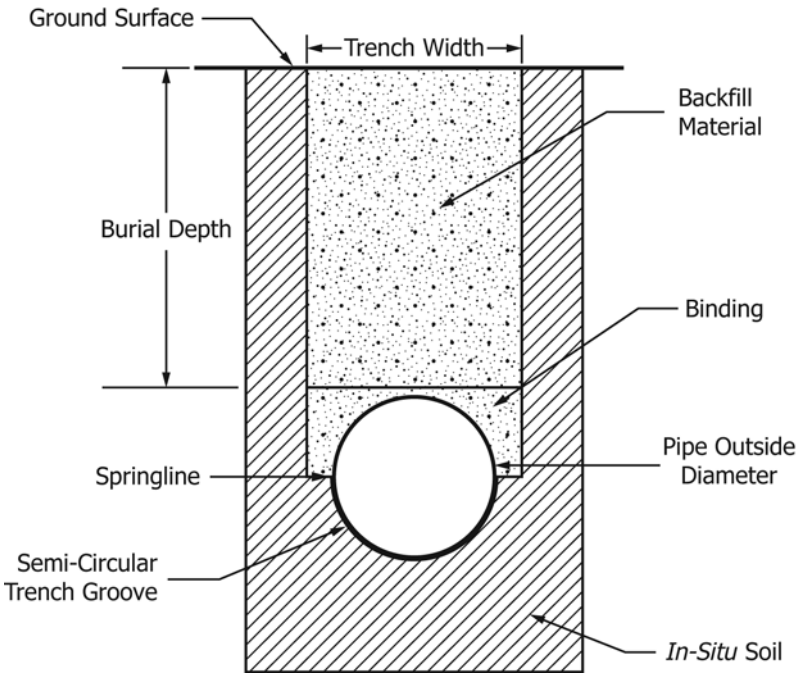

FIG. 2 b Semi-Circular Trench Groove *(continued)*

stones pushed aside by the plow that have fallen back against the pipe causing deflection.

6.11 *Safety*—Provision for safety of all operations shall be in compliance with applicable safety and health regulations.

6.12 *Special Problems:*

6.12.1 *Backfilling*—Most plow installations require a minimum of backfilling, yet care must be taken to ensure that the trench is filled and bridging does not occur. Open trenches should be overfilled to allow consolidation. Vehicular traffic over new pipe installations should be limited to crossing the trench in a perpendicular direction to the trench only. Large tractors and implements should not be allowed to drive on or cross the newly installed pipe trench until adequate soil consolidation occurs which can take 3-6 months.

6.12.2 *Granular Envelope Placement*—Take care to prevent separation or inclusion of nonspecified material.

6.12.3 *Start Hole*—Take special care to provide a support groove as specified in section 6.5 above or install according to Practice D2321 to prevent excessive deflection beyond what is listed in 5.2 for maximum deflection (see Fig. 3). Manufactured fittings should be used (see 6.7).

6.12.4 *Prerripping*—May be advisable in order to locate stones or other large unacceptable objects or problem areas and to lower the tractive effort in the installation pass.

6.12.5 *Unstable Soil*—Where unstable trench or noncohesive soil conditions are encountered, such as fine sandy soils or quicksand, extreme care must be taken to keep this material from entering the pipe and to ensure adequate support. Blinding must be done immediately as the pipe emerges from the boot or shield to prevent floating, movement, or deformation of the pipe resulting from soil caving. Steady but continuous speed should be used, as stopping will usually cause a grade deviation. Following 6.12.5.1 through 6.12.5.5 may be helpful when draining these soils.

6.12.5.1 *Foundation Cradle*—Where stabilizer materials do not provide adequate support, pipe should be placed in one of the recommended support structures as outlined in 6.5. The support structure must provide rigidity and furnish continuous support throughout the entire length of pipe.

6.12.5.2 *Dry Profile*—Install pipe when soil profile is in the driest condition possible. A temporary drain may be advisable in some conditions to lower the water table before installation.

6.12.5.3 *Foundation*—If a significant depth of unstable soil material is encountered at the foundation level, it should be removed and replaced with suitable bedding material. The depth of bedding will depend on the severity of the unstable soil. Install the bedding in a maximum of 6 in. (150 mm) compacted layers (see 6.9).

6.12.5.4 *Noncohesive Soil*—Pockets of noncohesive soil will need special construction to maintain grade and provide adequate support. Examples of special construction are nonperforated pipe, suitable envelope material or filter to prevent soil infiltration. Bedding or a cradle may also be needed to maintain grade.

6.12.5.5 *Organic Soil*—Organic soil is generally unstable and will not support the shoe of the trencher or the floating beam plow without special operating procedures.

7. Handling of Pipe

7.1 *High Temperature*—Ambient temperatures in excess of 90 °F results in a loss of pipe stiffness. Special care must be exercised during installation on a hot sunlit day, as black pipe can become much warmer than the air temperature. The resulting loss of pipe stiffness may allow extra stretch and even