INTERNATIONAL

~~Designation:D 2321–05~~ Designation: D 2321 – 08

An American National Standard

Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications[1]

This standard is issued under the fixed designation D 2321; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This practice provides recommendations for the installation of buried thermoplastic pipe used in sewers and other gravity-flow applications. These recommendations are intended to ensure a stable underground environment for thermoplastic pipe under a wide range of service conditions. However, because of the numerous flexible plastic pipe products available and the inherent variability of natural ground conditions, achieving satisfactory performance of any one product may require modification to provisions contained herein to meet specific project requirements.

1.2 The scope of this practice necessarily excludes product performance criteria such as minimum pipe stiffness, maximum service deflection, or long term strength. Thus, it is incumbent upon the product manufacturer, specifier, or project engineer to verify and assure that the pipe specified for an intended application, when installed according to procedures outlined in this practice, will provide a long term, satisfactory performance according to criteria established for that application. A commentary on factors important in achieving a satisfactory installation is included in Appendix X1.

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

NOTE~~2—The following ASTM standards may be found useful in connection with this practice: Practice D420, Test Method D1556, Method D2216, Specification D2235, Test Method D2412, Specification D2564, Practice D2657, Practice D2855, Test Methods D2922, Test Method D3017, Practice F402, Specification F477, Specification F545, and Specification F913.~~ 2—The following ASTM standards may be found useful in connection with this practice: Practice D 420, Test Method D 1556, Method D 2216, Specification D 2235, Test Method D 2412, Specification D 2564, Practice D 2657, Practice D 2855, Test Methods D 2922, Test Method D 3017, Practice F 402, Specification F 477, Specification F 545, and Specification F 913.

NOTE 3—Most Plumbing Codes and some Building Codes have provisions for the installation of underground "building drains and building sewers." See them for plumbing piping applications.

1.3 *Units*—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 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D 8 Terminology Relating to Materials for Roads and Pavements
D 420 Guide to Site Characterization for Engineering Design and Construction Purposes
D 653 Terminology Relating to Soil, Rock, and Contained Fluids
D 698 ~~Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft (600 kN-m/m))~~ Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3(600 kN-m/m^3))
D 1556 Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D 2235 Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
D 2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
D 2487 ~~Test Method~~Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.62 on Sewer ~~Pipe.~~.
Current edition approved ~~August~~Dec. 1, ~~2005.~~2008. Published ~~September 2005.~~January 2009. Originally approved in 1989. Last previous edition approved in ~~2004~~2005 as ~~D2321–04^{ε1}.~~ D 2321 – 05.

[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.**

D 2564 Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
D 2657 Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
D 2855 Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
D 2922 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
D 3017 Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
D 3839 ~~Practice for Underground Installation of Fiberglass (Glass-Fiber Reinforced Thermosetting Resin) Pipe~~
~~D4318Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils~~ Guide for Underground Installation of Fiberglass (Glass-FiberReinforced Thermosetting-Resin) Pipe
D 4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
F 402 Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
F 412 ~~Terminology Relating to Plastic Piping Systems~~ Terminology Relating to Plastic Piping Systems
F 477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
F 545 Specification for PVC and ABS Injected Solvent Cemented Plastic Pipe Joints
F 913 Specification for Thermoplastic Elastomeric Seals (Gaskets) for Joining Plastic Pipe
2.2 *AASHTO Standard:*[3]
AASHTO M145 Classification of Soils and Soil Aggregate Mixtures

3. Terminology

3.1 *General—Definitions used in this practice are in accordance with Terminologies F 412 and D 8 and Terminology D 653 unless otherwise indicated.*

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *foundation, bedding, haunching, initial backfill, final backfill, pipe zone, excavated trench width*—See Fig. 1 for meaning and limits, and trench terminology.

3.2.2 *aggregate*—a granular material of mineral composition such as sand, gravel, shell, slag or crushed stone (see Terminology D 8).

3.2.3 *deflection*—any change in the inside diameter of the pipe resulting from installation and imposed loads. Deflection may be either vertical or horizontal and is usually reported as a percentage of the base (undeflected) inside pipe diameter.

3.2.4 *dense-graded aggregate*—an aggregate that has a particle size distribution such that, when it is compacted, the resulting voids between the aggregate particles, expressed as a percentage of the total space occupied by the material, are relatively small.

3.2.5 *engineer*—the engineer in responsible charge of the work or his duly recognized or authorized representative.

3.2.6 *manufactured aggregates*—aggregates such as slag that are products or byproducts of a manufacturing process, or natural aggregates that are reduced to their final form by a manufacturing process such as crushing.

3.2.7 *open-graded aggregate*—an aggregate that has a particle size distribution such that, when it is compacted, the voids between the aggregate particles, expressed as a percentage of the total space occupied by the material, are relatively large.

3.2.8 *optimum moisture content*—The moisture content of soil at which its maximum density is obtained (see Test Methods D 698).

[3] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

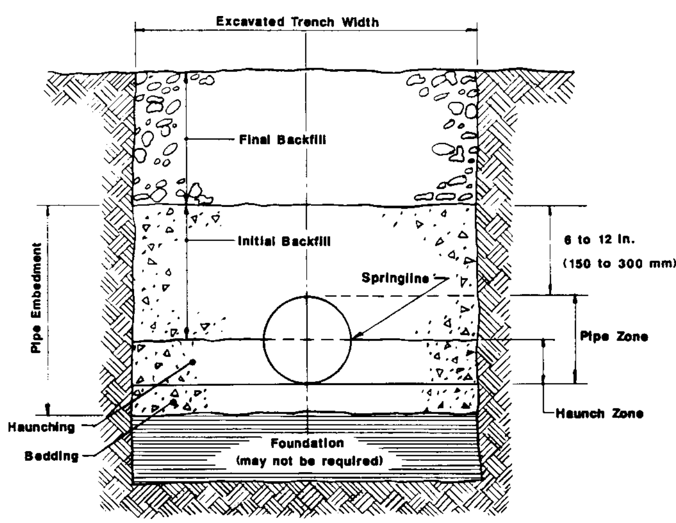

FIG. 1 Trench Cross Section Showing Terminology

3.2.9 *processed aggregates*—aggregates that are screened, washed, mixed, or blended to produce a specific particle size distribution.

3.2.10 *standard proctor density*—the maximum dry unit weight of soil compacted at optimum moisture content, as obtained by laboratory test in accordance with Test Methods D 698.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, installation contractors, regulatory agencies, owners, and inspection organizations who are involved in the construction of sewers and other gravity-flow applications that utilize flexible thermoplastic pipe. As with any standard practice, modifications may be required for specific job conditions or for special local or regional conditions. Recommendations for inclusion of this practice in contract documents for a specific project are given in Appendix X2.

5. Materials

5.1 *Classification*~~—Materials for use as foundation, embedment, and backfill are classified in~~ —Soil types used or encountered in burying pipes include those classified in Table 1 ~~. They include natural, manufactured, and processed aggregates and the soil types classified according to Test Method D2487.~~ and natural, manufactured, and processed aggregates. The soil classifications are grouped into soil classifications in Table 2 based on the typical soil stiffness when compacted. Class I indicates a soil that generally provides the highest soil stiffness at any given percentage of maximum Proctor density, and provides a given soil stiffness with the least compactive effort. Each higher-number soil class provides successively less soil stiffness at a given percentage of maximum Proctor density and requires greater compactive effort to provide a given level of soil stiffness

NOTE~~4—See Practice D2488 for a visual-manual procedure for field identification of soils.~~
4—See Practices D 2487 and D 2488 for laboratory and field visual-manual procedures for identification of soils.

NOTE 5—Processed materials produced for highway construction, including coarse aggregate, base, subbase, and surface ~~course~~coarse materials, when used for foundation, embedment, and backfill, should be ~~classified~~categorized in accordance with this section and Table 1 ~~according to particle size, shape and gradation.~~ in accordance with particle size and gradation.

5.2 *Installation and Use*~~—Table 2 provides recommendations on installation and use based on class of soil or aggregates and location in the trench.~~ —Table 3 provides recommendations on installation and use based on soil classification and location in the trench. Soil Classes I to IV should be used as recommended in Table 3. Soil Class V, including clays and silts with liquid limits greater than 50, organic soils, and frozen soils, shall be excluded from the pipe-zone embedment.

5.2.1 ~~*Use of Class I to Class IVA Soils and Aggregates* —These materials may be used as recommended in Table 2, unless otherwise specified.~~ Class I— Class I materials provide maximum stability and pipe support for a given percent compaction due to the low content of sand and fines. With minimum effort these materials can be installed at relatively high-soil stiffnesses over a wide range of moisture contents. In addition, the high permeability of Class I materials may aid in the control of water, and these materials are often desirable for embedment in rock cuts where water is frequently encountered. However, when ground-water flow is anticipated, consideration should be given to the potential for migration of fines from adjacent materials into the open-graded Class I materials. (See X1.8.)

5.2.2 ~~*Use of Class IV-B and Class V Soils and Frozen Materials*—These materials are not recommended for embedment, and should be excluded from the final backfill except where allowed by project specifications.~~

~~5.3*Description of Embedment Material*— Sections 5.3.1 through 5.3.5 describe characteristics of materials recommended for embedment.~~

~~5.3.1*Class IA Materials*—Class IA materials provide maximum stability and pipe support for a given density due to angular interlock of particles. With minimum effort these materials can be installed at relatively high densities over a wide range of moisture contents. In addition, the high permeability of Class IA materials may aid in the control of water, and these materials are often desirable for embedment in rock cuts where water is frequently encountered. However, when ground water flow is anticipated, consideration should be given to the potential for migration of fines from adjacent materials into the open-graded Class IA materials (see~~ Class II—Class II materials, when compacted, provide a relatively high level of pipe support; however, open-graded groups may allow migration and the sizes should be checked for compatibility with adjacent material. (See X1.8)~~).~~

~~5.3.2*Class IB Materials*—Class IB materials are processed by mixing Class IA and natural or processed sands to produce a particle size distribution that minimizes migration from adjacent materials that contain fines (see X1.8). They are more densely graded than Class IA materials and thus require more compactive effort to achieve the minimum density specified. When properly compacted, Class IB materials offer high stiffness and strength and, depending on the amount of fines, may be relatively free draining.~~

~~5.3.3*Class II Materials*—Class II materials, when compacted, provide a relatively high level of pipe support. In most respects, they have all the desirable characteristics of Class IB materials when densely graded. However, open graded groups may allow migration and the sizes should be checked for compatibility with adjacent material (see X1.8). Typically, Class II materials consist of rounded particles and are less stable than angular materials unless they are confined and compacted.~~

TABLE 1 Soil Classes oif Embedmenticationd B Chackrt (see Classifill Mcaterialson D 2487)

		ClassType		
		Criteria for AssType		
1½ in. (40 mm)	No. 4 (4.75 mm)	No. 200 (0.075 mm)	LL	PI
IA	Manufactured Aggregates: open graded, clean.	None	Angul ar, crushed stone or rock, crushed gravel, brokencoral, crushed slag, cinders or shells; large void content, contain little or no fines.	100 %
Coarse-Grained Soils	gravels	clean gravels	C ≥ 4 and 1 ≤ Cc ≤ 3[C]	
IB Manufactured, Pr ocessed Aggregates; dense-graded, clean.	None Angular, crushed stone (or other Class 1A materials) and stone/sand mixtures with gradations selected t o minimize migration of adjacent soils; contain little or no fines (see X1.8).	100 %	≤50 %	<5 %
More than 50% retained on No. 200 sieve	more than 50% of coarse fraction retained on No. 4 sieve	less than	≤50 % 5% of fines[E]	<5 %
II	Coarse-Grained Soils, clean	GW	Well-graded gravels and gravel-sand mixtures; little or no fines.	100 %
II	Coarse-Grained Soils, clean	Cu < 4 and/or 1> Cc> 3[C]		100 %
–	–		GP Poorly-graded gravels and gravel-sand mixtures; little or no fines.	
			gravels with fines	GP more than 12 % fines
-	–	SW		Well graded sands a elly sands; little or
		Fines classify as CL or CH		-
–	–	SP	Poorly gr aded sands and gravelly sands; little or no fines.	–
	sands	clean sands	Cu ≥ 6 and 1 ≤ Cc ≤ 3[C]	
–	C oarse-Grained S oils, borderline cleanto w/fines	e.g. GW-GC, SP-SM.	S ands and gravels which are borderline betweenclean and with fines.	100 %
	50% or more of coarse fraction passes on No. 4 sieve	less than 5% fines[I]	Cu < 6 and/or 1 > Cc > 3[C]	
III	Coarse-Grained Soils With Fines	sand with fines	G M	Silty gravels, gravel mixtures.
		sand with fines	Fines cLassify as ML or MH	
–	–	GC	Clayey gravels, gravel-sand-clay mixtures.	–
		more than 12 % fines[I]	Fines classify as CL or CH	–
–	– silts and clays	inorganic	SM	Silty sands, san mixtures.
Fine-Grained Soils	silts and clays		inorganic	PI > 7 and plots on or a

TABLE 2 Rec Sommendations for Instal Clation and Use of Soils and Aggregates for Foundation, Embedment and Backfill

Soil Class (see Table 1)[A] / Soil Group[A]	Class IA / Soil Class	Class IB
–	Class IA	Class IB
–	Soil Class	Class IB
Foundation	Suitable asfoundation andfor replacing over-excavated and unstable trench bottom as restricted above. Install and compact in 6-in. maximum layers.	Suitable as foundation and for replacing over-excavated and unstable trench bottom. Install and compact in 6-in. maximum layers.
Foundation	Suitable as Officials.	Suitable as foundation and for replacing over-excavated and unstable trench bottom. Install and compact in 6-in. maximum layers.
Bedding	Suitable as restricted above. Install in 6-in. maximum layers. Level final grade by hand. Minimum depth 4 in. (6 in. in rock cuts).	Install and compact in 6-in. maximum layers. Level final grade by hand. Minimum depth 4 in. (6 in. in rock cuts).
Bedding	Suitable as restricted above. Install in 6-in. maximum layers. Level final grade by hand. Minimum depth 4 in. (6 in. in rock cuts).	Install and compact in 6-in. maximum layers. Level final grade by hand. Minimum depth 4 in. (6 in. in rock cuts).
Haunching	Suitable as restricted above. Install in 6-in. maximum layers. Work in around pipe by hand to provide uniform support.	Install and compact in 6-in. maximum layers. Work in around pipe by hand to provide uniform support.
Initial Backfill	Suitable as restricted above. Install to a minimum of 6 in. above pipe	Install and compact to a minimum of 6 in. above pipe crown.

TABLE 3 Recommendations for Installation and Use of Soils and Aggregates for Foundation and Pipe-Zone Embedment

Soil Class[A]	Class I[B]	Class II	Class III	Class IV
General Recommendations and Restrictions	Acceptable and common where no migration is probable or when combined with a geotextile filter media. Suitable for use as a drainage blanket and under drain where adjacent material is suitably graded or when used with a geotextile filter fabric (see X1.8).	Where hydraulic gradient exists check gradation to minimize migration. Clean groups are suitable for use as a drainage blanket and underdrain (see Table 2). Uniform fine sands (SP) with more than 50 % passing a #100 sieve (0.006 in., 0.15 mm) behave like silts and should be treated as Class III soils.	Do not use where water conditions in trench prevent proper placement and compaction. Not recommended for use with pipes with stiffness of 9 psi or less	Difficult to achieve high-soil stiffness. Do not use where water conditions in trench prevent proper placement and compaction. Not recommended for use with pipes with stiffness of 9 psi or less
Foundation	Suitable as foundation and for replacing over-excavated and unstable trench bottom as restricted above.	Suitable as foundation and for replacing over-excavated and unstable trench bottom as restricted above. Install and compact in 12 in. (300 mm) maximum layers	Suitable for replacing over-excavated trench bottom as restricted above. Install and compact in 6 in. (150 mm) maximum layers	Not suitable.
Pipe Zone Embedment	Suitable as restricted above. Work material under pipe to provide uniform haunch support.	Suitable as restricted above. Work material under pipe to provide uniform haunch support.	Suitable as restricted above. Difficult to place and compact in the haunch zone.	Suitable as restricted above. Difficult to place and compact in the haunch zone.
Embedment Compaction: Min Recommended Density, SPD[C]	[D]	85 %	90 %	95 %
Relative Compactive Effort Required to Achieve Minimum Density	low	moderate	high	very high
Compaction Methods	vibration or impact	vibration or impact	impact	impact
Required Moisture Control	none	none	Maintain near optimum to minimize compactive effort	Maintain near optimum to minimize compactive effort

[A] Class V materials are unsuitable as embedment. They may be used as final backfill as permitted by the engineer.
[B] Class I materials have higher stiffness than Class II materials, but data on specific soil stiffness of placed, uncompacted Class I materials can be taken equivalent to Class II materials compacted to 95% of maximum standard Proctor density (SPD95), and the soil stiffness of compacted Class I materials can be taken equivalent to Class II materials compacted to 100% of maximum standard Proctor density (SPD100). Even if placed uncompacted (that is, dumped), Class I materials should always be worked into the haunch zone to assure complete placement.
[C] SPD is standard Proctor density as determined by Test Method D 698.
[D] Minimum density typically achieved by dumped placement (that is, uncompacted but worked into haunch zone to ensure complete placement).

~~5.3.4 *Class III Materials*—Class III materials provide less support for a given density than Class I or Class II materials. High levels of compactive effort may be required unless moisture content is controlled. These materials provide reasonable levels of pipe support once proper density is achieved.~~

~~5.3.5 *Class IV-A Materials*—Class IV-A materials require a geotechnical evaluation prior to use. Moisture content must be near optimum to minimize compactive effort and achieve the required density. Properly placed and compacted, Class IV-A materials can provide reasonable levels of pipe support; however, these materials may not be suitable under high fills, surface applied wheel loads, or under heavy vibratory compactors and tampers. Do not use where water conditions in the trench may cause instability and result in uncontrolled water content.~~

~~5.4 *Moisture Content of Embedment Material*—The moisture content of embedment materials must be within suitable limits to permit placement and compaction to required levels with reasonable effort. For non-free draining soils (that is, Class III, Class IVA, and some borderline Class II soils), moisture content is normally required to be held to ±3% of optimum (see Test Methods D698). The practicality of obtaining and maintaining the required limits on moisture content is an important criterion for selecting materials, since failure to achieve required density, especially in the pipe zone, may result in excessive deflection. Where a chance for water in the trench exists, embedment materials should be selected for their ability to be readily densified while saturated (that is, free-draining, cohesionless granular materials).~~

~~5.5.~~)

5.2.3 *Class III*— Class III materials provide less support for a given density than Class I or Class II materials. Higher levels of compactive effort are required and moisture content must be near optimum to minimize compactive effort and achieve the required density. These materials provide reasonable levels of pipe support once proper density is achieved.