Designation: D 2321 – 05

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 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 *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 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))

D 2487 Test Method for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D 3839 Practice for Underground Installation of Fiberglass (Glass-Fiber Reinforced Thermosetting Resin) Pipe

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

F 412 Terminology Relating to Plastic Piping Systems

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

[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.

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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.

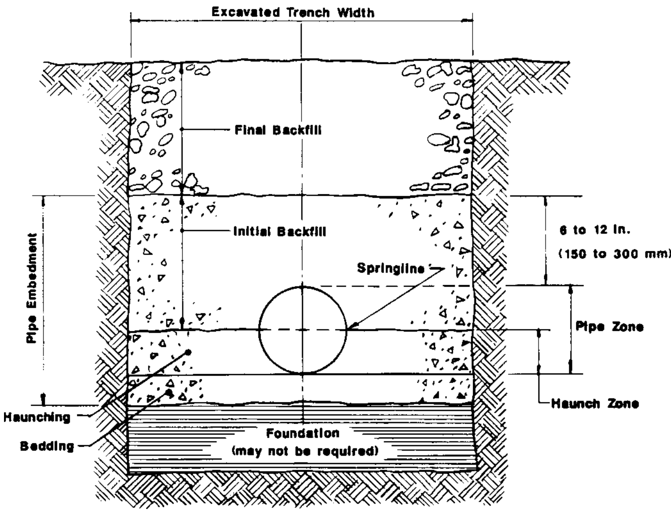

FIG. 1 Trench Cross Section Showing Terminology

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).

3.2.9 *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 Table 1. They include natural, manufactured, and processed aggregates and the soil types classified according to Test Method D 2487.

NOTE 4—See Practice D 2488 for a visual-manual procedure for field identification of soils.

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

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.

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 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 Classes of Embedment and Backfill Materials

Class	Type	Soil Group Symbol D 2487	Description	Percentage Passing Sieve Sizes			Atterberg Limits		Coefficients	
				1½ in. (40 mm)	No. 4 (4.75 mm)	No. 200 (0.075 mm)	LL	PI	Uniformity C_U	Curvature C_C
IA	Manufactured Aggregates: open-graded, clean.	None	Angular, crushed stone or rock, crushed gravel, broken coral, crushed slag, cinders or shells; large void content, contain little or no fines.	100 %	≤10 %	<5 %	Non Plastic			
IB	Manufactured, Processed Aggregates; dense-graded, clean.	None	Angular, crushed stone (or other Class 1A materials) and stone/sand mixtures with gradations selected to minimize migration of adjacent soils; contain little or no fines (see X1.8).	100 %	≤50 %	<5 %	Non Plastic			
II	Coarse-Grained Soils, clean	GW	Well-graded gravels and gravel-sand mixtures; little or no fines.	100 %	<50 % of "Coarse Fraction"	<5 %	Non Plastic		>4	1 to 3
		GP	Poorly-graded gravels and gravel-sand mixtures; little or no fines.						<4	<1 or >3
		SW	Well-graded sands and gravelly sands; little or no fines.		>50 % of "Coarse Fraction"				>6	1 to 3
		SP	Poorly-graded sands and gravelly sands; little or no fines.						<6	<1 or >3
	Coarse-Grained Soils, borderline clean to w/fines	e.g. GW-GC, SP-SM.	Sands and gravels which are borderline between clean and with fines.	100 %	Varies	5 % to 12 %	Non Plastic		Same as for GW, GP, SW and SP	
III	Coarse-Grained Soils With Fines	GM	Silty gravels, gravel-sand-silt mixtures.	100 %	<50 % of "Coarse Fraction"	12 % to 50 %		<4 or <"A" Line		
		GC	Clayey gravels, gravel-sand-clay mixtures.					<7 and >"A" Line		
		SM	Silty sands, sand-silt mixtures.		>50 % of "Coarse Fraction"			>4 or <"A" Line		
		SC	Clayey sands, sand-clay mixtures.					>7 and >"A" Line		
IVA[A]	Fine-Grained Soils (inorganic)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, silts with slight plasticity.	100 %	100 %	>50 %	<50	<4 or <"A" Line		
		CL	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays.					>7 and >"A" Line		
IVB	Fine-Grained Soils (inorganic)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	100 %	100 %	>50 %	>50	<"A" Line		
		CH	Inorganic clays of high plasticity, fat clays.					>"A" Line		
V	Organic Soils	OL	Organic silts and organic silty clays of low plasticity.	100 %	100 %	>50 %	<50	<4 or <"A" Line		
		OH	Organic clays of medium to high plasticity, organic silts.				>50	<"A" Line		
	Highly Organic	PT	Peat and other high organic soils.							

[A]Includes Test Method D 2487 borderline classifications and dual symbols depending on plasticity index and liquid limits.

Note—"Coarse Fraction" as used in this table is defined as material retained on a No. 200 sieve.

TABLE 2 Recommendations for Installation and Use of Soils and Aggregates for Foundation, Embedment and Backfill

	Soil Class (see Table 1)[A]				
	Class IA	Class IB	Class II	Class III	Class IV-A
General Recommendations and Restrictions	Do not use where conditions may cause migration of fines from adjacent soil and loss of pipe support. Suitable for use as a drainage blanket and underdrain in rock cuts where adjacent material is suitably graded (see X1.8).	Process materials as required to obtain gradation which will minimize migration of adjacent materials (see X1.8). Suitable for use as drainage blanket and underdrain.	Where hydraulic gradient exists check gradation to minimize migration."Clean" groups suitable for use as drainage blanket and underdrain.	Do not use where water conditions in trench may cause instability.	Obtain geotechnical evaluation of proposed material. May not be suitable under high earth fills, surface applied wheel loads, and under heavy vibratory compactors and tampers. Do not use where water conditions in trench may cause instability.
Foundation	Suitable as foundation and for 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.	Suitable as a foundation and for 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 trench bottom as restricted above. Do not use in thicknesses greater than 12 in. total. Install and compact in 6-in. maximum layers.	Suitable only in undisturbed condition and where trench is dry. Remove all loose material and provide firm, uniform trench bottom before bedding is placed.
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).	Suitable as restricted above. Install and compact in 6-in. maximum layers. Level final grade by hand. Minimum depth 4 in. (6 in. in rock cuts).	Suitable only in dry trench conditions. Install and compact in 6-in. maximum layers. Level final grade by hand. Minimum depth 4 in. (6 in. in rock cuts).	Suitable only in dry trench conditions and when optimum placement and compaction control is maintained. 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.	Suitable as restricted above. Install and compact in 6-in. maximum layers. Work in around pipe by hand to provide uniform support.	Suitable as restricted above. Install and compact in 6-in. maximum layers. Work in around pipe by hand to provide uniform support.	Suitable only in dry trench conditions and when optimum placement and compaction control is maintained. 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 crown.	Install and compact to a minimum of 6 in. above pipe crown.	Suitable as restricted above. Install and compact to a minimum of 6 in. above pipe crown.	Suitable as restricted above. Install and compact to a minimum of 6 in. above pipe crown.	Suitable as restricted above. Install and compact to a minimum of 6 in. above pipe crown.
Embedment Compaction[B]	Place and work by hand to insure all excavated voids and haunch areas are filled. For high densities use vibratory compactors.	Minimum density 85 % Std. Proctor.[C] Use hand tampers or vi bratory compactors.	Minimum density 85 % Std. Proctor.[C] Use hand tampers or vibratory compactors.	Minimum density 90 % Std. Proctor.[C] Use hand tampers or vibratory compactors. Maintain moisture content near optimum to minimize compactive effort.	Minimum density 95 % Std. Proctor.[C] Use hand tampers or impact tampers. Maintain moisture content near optimum to minimize compactive effort.
Final Backfill	Compact as required by the engineer.	Compact as required by the engineer.	Compact as required by the engineer.	Compact as required by the engineer.	Suitable as restricted above. Compact as required by the engineer.

[A]Class IV-B (MH-CH) and Class V (OL, OH, PT) Materials are unsuitable as embedment. They may be used as final backfill as permitted by the engineer.
[B]When using mechanical compactors avoid contact with pipe. When compacting over pipe crown maintain a minimum of 6 in. cover when using small mechanical compactors. When using larger compactors maintain minimum clearances as required by the engineer (See X1.7).
[C]The minimum densities given in the table are intended as the compaction requirements for obtaining satisfactory embedment stiffness in most installation conditions (see 7.5.1).

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 D 698). 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 *Maximum Particle Size*—Maximum particle size for embedment is limited to material passing a 1½-in. (37.5-mm) sieve (see Table 1). To enhance placement around small diameter pipe and to prevent damage to the pipe wall, a smaller maximum size may be required (see X1.9). When final backfill contains rocks, cobbles, etc., the engineer may require greater initial backfill cover levels (see Fig. 1).

6. Trench Excavation

6.1 *General*—Procedures for trench excavation that are especially important in flexible thermoplastic pipe installations are given herein.

6.1.1 *Excavation*—Excavate trenches to ensure that sides will be stable under all working conditions. Slope trench walls or provide supports in conformance with all local and national standards for safety. Open only as much trench as can be safely maintained by available equipment. Backfill all trenches as soon as practicable, but not later than the end of each working day.

6.2 *Water Control*—Do not lay or embed pipe in standing or running water. At all times prevent runoff and surface water from entering the trench.

6.2.1 *Ground Water*—When groundwater is present in the work area, dewater to maintain stability of in-situ and imported materials. Maintain water level below pipe bedding and foundation to provide a stable trench bottom. Use, as appropriate, sump pumps, well points, deep wells, geofabrics, perforated underdrains, or stone blankets of sufficient thickness to remove and control water in the trench. When excavating while depressing ground water, ensure the ground water is below the bottom of cut at all times to prevent washout from behind sheeting or sloughing of exposed trench walls. Maintain control of water in the trench before, during, and after pipe installation, and until embedment is installed and sufficient backfill has been placed to prevent flotation of the pipe. To preclude loss of soil support, employ dewatering methods that minimize removal of fines and the creation of voids in in-situ materials.

6.2.2 *Running Water*—Control running water emanating from drainage of surface or ground water to preclude undermining of the trench bottom or walls, the foundation, or other zones of embedment. Provide dams, cutoffs or other barriers periodically along the installation to preclude transport of water along the trench bottom. Backfill all trenches after the pipe is installed to prevent disturbance of pipe and embedment.

6.2.3 *Materials for Water Control*—Use suitably graded materials in foundation or bedding layers or as drainage blankets for transport of running water to sump pits or other drains. Use well graded materials, along with perforated underdrains, to enhance transport of running water, as required. Select the gradation of the drainage materials to minimize migration of fines from surrounding materials (see X1.8).

6.3 *Minimum Trench Width*—Where trench walls are stable or supported, provide a width sufficient, but no greater than necessary, to ensure working room to properly and safely place and compact haunching and other embedment materials. The space between the pipe and trench wall must be wider than the compaction equipment used in the pipe zone. Minimum width shall be not less than the greater of either the pipe outside diameter plus 16 in. (400 mm) or the pipe outside diameter times 1.25, plus 12 in. (300 mm). In addition to safety considerations, trench width in unsupported, unstable soils will depend on the size and stiffness of the pipe, stiffness of the embedment and in-situ soil, and depth of cover (see X1.10). Specially designed equipment may enable the satisfactory installation and embedment of pipe in trenches narrower than specified above. If it is determined that the use of such equipment provides an installation consistent with the requirements of this standard, minimum trench widths may be reduced, as approved by the engineer.

6.4 *Support of Trench Walls*—When supports such as trench sheeting, trench jacks, trench shields or boxes are used, ensure that support of the pipe and its embedment is maintained throughout installation. Ensure that sheeting is sufficiently tight to prevent washing out of the trench wall from behind the sheeting. Provide tight support of trench walls below viaducts, existing utilities, or other obstructions that restrict driving of sheeting.

6.4.1 *Supports Left in Place*—Unless otherwise directed by the engineer, sheeting driven into or below the pipe zone should be left in place to preclude loss of support of foundation and embedment materials. When top of sheeting is to be cut off, make cut 1.5 ft (0.5 m) or more above the crown of the pipe. Leave rangers, whalers, and braces in place as required to support cutoff sheeting and the trench wall in the vicinity of the pipe zone. Timber sheeting to be left in place is considered a permanent structural member and should be treated against biological degradation (for example, attack by insects or other biological forms) as necessary, and against decay if above ground water.

NOTE 6—Certain preservative and protective compounds may react adversely with some types of thermoplastics, and their use should be avoided in proximity of the pipe material.

6.4.2 *Movable Trench Wall Supports*—Do not disturb the installed pipe and its embedment when using movable trench boxes and shields. Movable supports should not be used below the top of the pipe zone unless approved methods are used for maintaining the integrity of embedment material. Before moving supports, place and compact embedment to sufficient depths to ensure protection of the pipe. As supports are moved, finish placing and compacting embedment.

6.4.3 *Removal of Trench Wall Support*—If the engineer permits the use of sheeting or other trench wall supports below the pipe zone, ensure that pipe and foundation and embedment materials are not disturbed by support removal. Fill voids left on removal of supports and compact all material to required densities.

6.5 *Rock or Unyielding Materials in Trench Bottom*—If ledge rock, hard pan, shale, or other unyielding material, cobbles, rubble or debris, boulders, or stones larger than 1.5 in. (40 mm) are encountered in the trench bottom, excavate a minimum depth of 6 in. (150 mm) below the pipe bottom and replace with proper embedment material (see 7.2.1).

7. Installation

7.1 *General*—Recommendations for use of the various types of materials classified in Section 5 and Table 1 for foundation, bedding, haunching and backfills, are given in Table 2.

NOTE 7—Installation of pipe in areas where significant settlement may be anticipated, such as in backfill adjacent to building foundations, and in sanitary landfills, or in other highly unstable soils, require special engineering and are outside the scope of this practice.

7.2 *Trench Bottom*—Install foundation and bedding as required by the engineer according to conditions in the trench bottom. Provide a firm, stable, and uniform bedding for the pipe barrel and any protruding features of its joint. Provide a minimum of 4 in. (100 mm) of bedding unless otherwise specified.

7.2.1 *Rock and Unyielding Materials*—When rock or unyielding material is present in the trench bottom, install a cushion of bedding, of 6 in. (150 mm) minimum thickness, below the bottom of the pipe.

7.2.2 *Unstable Trench Bottom*—Where the trench bottom is unstable or shows a "quick'' tendency, excavate to a depth as required by the engineer and replace with a foundation of Class IA, Class IB, or Class II material. Use a suitably graded material where conditions may cause migration of fines and loss of pipe support (see X1.8). Place and compact foundation material in accordance with Table 2. For severe conditions, the engineer may require a special foundation such as piles or sheeting capped with a concrete mat. Control of quick and unstable trench bottom conditions may be accomplished with the use of appropriate geofabrics.

7.2.3 *Localized Loadings*—Minimize localized loadings and differential settlement wherever the pipe crosses other utilities or subsurface structures, or whenever there are special foundations such as concrete capped piles or sheeting. Provide a cushion of bedding between the pipe and any such point of localized loading.

7.2.4 *Over-Excavation*—If the trench bottom is over-excavated below intended grade, fill the over-excavation with compatible foundation or bedding material and compact to a density not less than the minimum densities given in Table 2.

7.2.5 *Sloughing*—If trench sidewalls slough off during any part of excavating or installing the pipe, remove all sloughed and loose material from the trench.

7.3 *Location and Alignment*—Place pipe and fittings in the trench with the invert conforming to the required elevations, slopes, and alignment. Provide bell holes in pipe bedding, no larger than necessary, in order to ensure uniform pipe support. Fill all voids under the bell by working in bedding material. In special cases where the pipe is to be installed to a curved alignment, maintain angular "joint deflection'' (axial alignment) or pipe bending radius, or both, within acceptable design limits.

7.4 *Jointing*—Comply with manufacturer's recommendations for assembly of joint components, lubrication, and making of joints. When pipe laying is interrupted, secure piping against movement and seal open ends to prevent the entrance of water, mud, or foreign material.

7.4.1 *Elastomeric Seal Joints*—Mark, or verify that pipe ends are marked, to indicate insertion stop position, and ensure that pipe is inserted into pipe or fitting bells to this mark. Push spigot into bell using methods recommended by the manufacturer, keeping pipe true to line and grade. Protect the end of the pipe during homing and do not use excessive force that may result in over-assembled joints or dislodged gaskets. If full entry is not achieved, disassemble and clean the joint and reassemble. Use only lubricant supplied or recommended for use by the pipe manufacturer. Do not exceed manufacturer's recommendations for angular "joint deflection'' (axial alignment).

7.4.2 *Solvent Cement Joints*—When making solvent cement joints, follow recommendations of both the pipe and solvent cement manufacturer. If full entry is not achieved, disassemble or remove and replace the joint. Allow freshly made joints to set for the recommended time before moving, burying, or otherwise disturbing the pipe.

7.4.3 *Heat Fusion Joints*—Make heat fusion joints in conformance with the recommendations of the pipe manufacturer. Pipe may be joined at ground surface and then lowered into position, provided it is supported and handled in a manner that precludes damage.

7.5 *Placing and Compacting Pipe Embedment*—Place embedment materials by methods that will not disturb or damage the pipe. Work in and tamp the haunching material in the area between the bedding and the underside of the pipe before placing and compacting the remainder of the embedment in the pipe zone. Follow recommendations for compaction given in Table 2. Do not permit compaction equipment to contact and damage the pipe. Use compaction equipment and techniques