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An American National Standard

Standard Guide for Construction Procedures for Buried Plastic Pipe[1]

This standard is issued under the fixed designation F1668; 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 guide describes installation techniques and considerations for open-cut construction of buried pipe. Although this guide was developed for plastic pipe, the concepts of providing the appropriate soil support, care in handling, correct joining techniques, proper soil compaction methods, and prevention of installation damage may apply to any pipe.

1.1.1 Plastic pipe refers to thermoplastic and fiberglass pipe.

1.1.2 Thermoplastic pipe refers to pipe fabricated from polyvinyl chloride (PVC), polyethylene (PE), acrylonitrile-butadiene styrene (ABS), cross-linked polyethylene (PEX), chlorinated polyvinyl chloride (CPVC), or polypropylene (PP). A list of specifications for these products is given in Appendix X2.

1.1.3 Fiberglass pipe refers to a glass-fiber-reinforced thermosetting-resin pipe. A list of ASTM specifications for these products is given in Appendix X2.

NOTE 1—Appendix X2 cannot be considered inclusive because there may be unlisted, recently adopted ASTM specifications for new products that may be installed using this guide.

NOTE 2—Only a few of the ASTM specifications listed in Appendix X2 include the associated fittings. While this guide applies to the installation of pipe, couplings, and fittings, no attempt was made to list all the possible fitting specifications that may be used in conjunction with the pipe specifications. Consult each specification or manufacturer for appropriate fitting standards.

1.1.4 For simplification, the term pipe will be used in this document to mean pipe sections, fittings, and couplings.

1.2 This guide contains general construction information applicable for plastic pipe and supplements the installation standards for the various types of pipe as described in Practices D2321, D2774, D3839, F690, and Guide F645.

NOTE 3—This guide is not applicable for gas pipe applications as additional requirements may apply.

1.3 Flexible pipe, such as thermoplastic and fiberglass, are typically designed to rely on the stiffness of the soil surrounding the pipe for support. The contract documents should describe the requirements of an appropriate soil support system. The construction practices described in this guide can be instrumental in attaining the required soil stiffness.

1.3.1 A discussion of the interaction between a buried pipe and the surrounding soil and the importance of attaining proper soil support is in Appendix X1.

1.3.2 Following these guidelines will be helpful in preventing local deformations in the pipe.

1.4 This guide does not cover underwater installation, pipe that needs to be supported on piling, perforated pipe used for drainage, or gas pipelines.

1.5 Pipelines through areas described as “expansive soils,” “collapsing soils,” landfills or water-logged land (such as swamps) should be constructed using site-specific installation procedures and are not discussed in this guide.

1.6 This guide is not intended to cover all situations. Specific pipe characteristics, fluid transported, local site conditions, environmental concerns, or manufacturer’s recommendations may require different guidelines.

1.7 The construction practices presented in this guide may be affected by the installation requirements of owners, specifying organizations, or regulatory agencies for pipelines crossing roads and highways, other pipelines or cables, or waterways such as streams, drainage channels, or floodways.

1.8 Culverts or pipe that are used as passages through water retaining embankments (for example, earth dams) may be constructed using the principles of this guide, if appropriate provisions are made to prevent water movement along the outside of the pipe (using impervious soils, cutoff collars, head walls, etc.).

1.9 The values stated in SI units are to be regarded as the standard. The inch-pound units in parentheses are given for information only.

NOTE 4—There is no similar or equivalent ISO standard covering the primary subject matter of this guide.

1.10 *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.*

1.11 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

[1] This guide is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.61 on Water.

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

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]

D8 Terminology Relating to Materials for Roads and Pavements

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D883 Terminology Relating to Plastics

D1600 Terminology for Abbreviated Terms Relating to Plastics

D4914/D4914M Test Methods for Density of Soil and Rock in Place by the Sand Replacement Method in a Test Pit

D5030/D5030M Test Methods for Density of In-Place Soil and Rock Materials by the Water Replacement Method in a Test Pit

F412 Terminology Relating to Plastic Piping Systems

Pipe Installation:

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

D2774 Practice for Underground Installation of Thermoplastic Pressure Piping

D3839 Guide for Underground Installation of "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe

F645 Guide for Selection, Design, and Installation of Thermoplastic Water- Pressure Piping Systems

F690 Practice for Underground Installation of Thermoplastic Pressure Piping Irrigation Systems (Withdrawn 2012)[3]

Soil Testing:

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))

D1556/D1556M Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

D2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

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

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedures)

D4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table

D4254 Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density

D4564 Test Method for Density and Unit Weight of Soil in Place by the Sleeve Method (Withdrawn 2013)[3]

D4653 Test Method for Total Chlorides in Leather

D4944 Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester

D4959 Test Method for Determination of Water Content of Soil By Direct Heating

D5080 Test Method for Rapid Determination of Percent Compaction

Joining Practices:

D2657 Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings

D2855 Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets

D6938 Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

F402 Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings

F477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

F913 Specification for Thermoplastic Elastomeric Seals (Gaskets) for Joining Plastic Pipe

F2164 Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure

F2620 Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

Other ASTM Standards:

C94/C94M Specification for Ready-Mixed Concrete

F1417 Practice for Installation Acceptance of Plastic Non-pressure Sewer Lines Using Low-Pressure Air

2.2 *American Water Works Association (AWWA) Standards:*[4]

C651 Disinfecting Water Mains

C904 Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping system Using Hydrostatic Pressure

2.3 *American Association of State Highway and Transportation Officials (AASHTO) Standard:*

Standard Specification for Highway Bridges[5]

2.4 *Uni-Bell PVC Pipe Association Standard:*

UNI-B-13 Recommended Performance Specification for Joint Restraint Devices for Use with Polyvinyl Chloride (PVC) Pipe[6]

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminologies D8, D653, D883, D1600, and F412 unless otherwise

[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

[5] 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.

[6] Available from the Uni-Bell PVC Pipe Assoc., 2655 Villa Creek Dr., Suite 155, Dallas, TX 75234.

indicated. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.1.1 The definitions and descriptions of soil are in accordance with the Unified Soil Classification System as presented in Classification D2487. Soils may be identified and described in the field using the procedures stated in Practice D2488.

NOTE 5—The terms describing an installation cross-section are illustrated in Fig. 1. Other terms related to parts of the pipe are illustrated in Fig. 2.

NOTE 6—These terms may be different from the ones used in Practices D2321, D2774, D3839, or F690. The terms in this guide are used to describe the construction sequence and are not meant to replace or conflict with other standards.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *backfill*—material placed over the embedment up to the ground surface.

3.2.2 *bedding*—material placed in the bottom of the trench on top of the foundation soil to provide uniform support for the pipe.

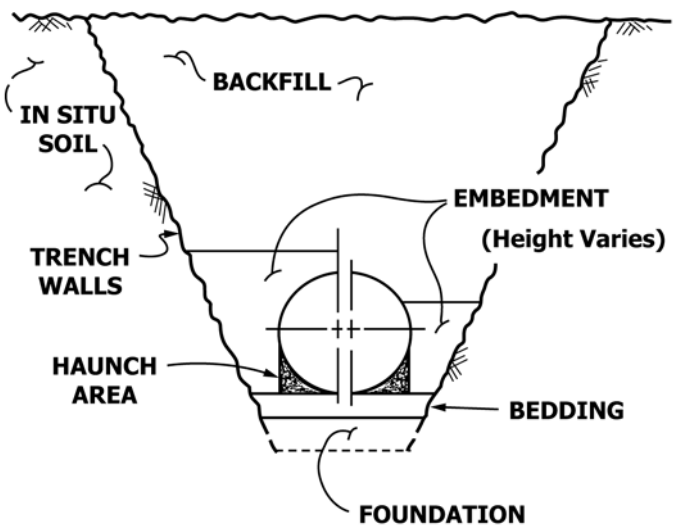
3.2.3 *embedment*—material placed around the pipe that provides side support.

3.2.4 *foundation soil*—material in the bottom of the trench that is (*1*) undisturbed and remains in place; (*2*) removed and replaced by another material, (*3*) displaced by another material; or (*4*) removed and then recompacted into place.

3.2.5 *haunch area*—the area of the embedment under the pipe from the bottom of the pipe up to the springline, as illustrated in Fig. 1.

3.2.6 *in situ material*—the in-place soil or rock that a trench is excavated through that is either (*1*) naturally formed or deposited; or (*2*) manmade.

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



NOTE 1—This drawing is illustrative only. Trench dimensions and slope vary with depth and soil conditions.

FIG. 1 Trench Cross Section Terminology

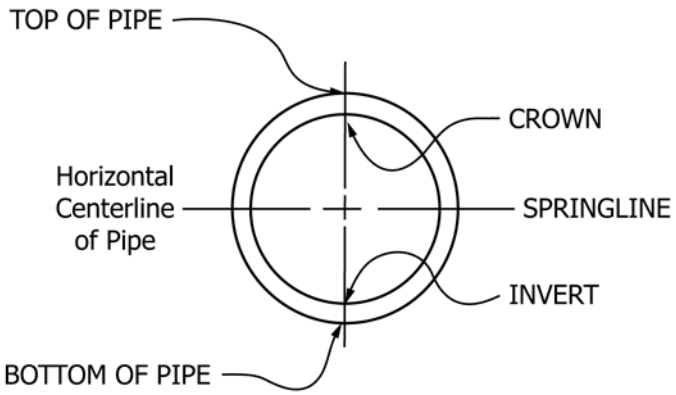


FIG. 2 Pipe Terminology

3.2.8 *springline*—a line along the length of the pipe at its maximum width along a horizontal plane. **(F412)**

4. Significance and Use

4.1 This guide may be used as a reference of acceptable open-cut construction practices for the proper installation of buried fiberglass and thermoplastic pipe. This guide may be used as follows:

4.1.1 Installation contractors have an awareness of the level of workmanship required and use this information for bidding purposes and during construction.

4.1.2 Construction inspectors have a reference of acceptable installation practices.

4.1.3 Specification writers may use this guide as a reference in contract documents.

4.1.4 Designers may review this information during planning and design for factors to consider in the preparation of plans and specifications.

4.1.5 The owner of the pipeline may use this guide as a reference for restoration of proper pipe support and embedment when original construction is disturbed due to repairs, modifications, or construction of adjacent or crossing pipelines or cables.

4.2 This guide should not be used to replace project specification requirements, manufacturer's recommendations, plumbing codes, building codes, or ASTM installation standards, but may be used to supplement that information.

5. Inspection, Handling, and Storage

5.1 *Load Inspection*—The pipe should be packaged or loaded as recommended by the supplier. The receiver of the pipe should be aware of (*1*) the loading and packaging requirements for each mode of transportation used; (*2*) the continuance of proper handling in any multiple loading and unloading before arrival; and (*3*) any transportation incident (wreck). Before unloading, the receiver should examine the load for transportation damage, particularly if the load has shifted, packaging is broken, or if there are signs of rough treatment. Damage may also have been caused from overtightening tie-down straps or from the tie-down straps not being located at the same point along the pipe barrel where the pipe supports are located. The pipe should be examined for abrasion due to (*1*) bells, couplings, or other joint surfaces being in

contact with each other or any hard object or surface; and (*2*) unpadded metal tie-down straps.

5.2 *Pipe Inspection*—Each load of pipe should be inspected and inventoried for conformance to product specifications and contract documents. Pipe markings vary according to ASTM specification, the type of pipe, and the manufacturer. In general, these markings include: ASTM specification, pipe class or pressure designation, cell classification, pipe diameter, date of manufacture, name or trademark of the manufacturer, and plant identification. In some circumstances, the plant inspector's approval mark may also be required. Pipe intended for the conveyance of potable water is evaluated, tested, and certified for use by an acceptable certifying organization when required by the regulatory authority having jurisdiction. The seal or mark of the laboratory making the evaluation should be on the pipe. Observe the unloading, uncrating, storage and distribution of the pipe, as applicable, and inspect each pipe section for damage, such as cuts, cracks, or gouges. Depths of cuts and gouges should be compared to allowable limits in the pipe specifications, contract documents, or manufacturer's recommendations.

5.2.1 Damaged pipe may or may not be repairable depending on the type of pipe.

5.2.1.1 Repairable pipe should be repaired in accordance with the manufacturer's recommendations.

5.2.1.2 Pipe that cannot be repaired should be clearly marked to prevent usage, in a manner acceptable to the supplier, and then removed from the job.

5.2.2 Gaskets should be checked for conformance to contract documents and inspected for transportation damage. If two or more types of gaskets are being used, the different gaskets should be clearly identified by appropriate markings. Specifications F477 and F913 cover the requirements for two types of gaskets.

5.2.3 All solvent cements, primers, cleaners, adhesives, and lubricants should be marked, or otherwise certified, for conformance to applicable standards and regulations.

5.3 *Nested Pipe*—The pipe interiors and exteriors should be inspected for transportation damage. Follow manufacturer's recommendations for unloading, or proceed as follows: The pipe should be removed starting with the inside pipe (smallest diameter). The pipe should be removed with a padded forklift boom and without touching other pipe.

5.4 *Handling*—Handling of the pipe to prevent damage should be in agreement with manufacturer's requirements. Typically, handling procedures will include the following precautions:

5.4.1 Avoid rough handling or dropping of the pipe and resting the pipe on hard objects that would create a point loading on the pipe. Pipe sections should not be rolled over rough or rocky ground. Prevent objects from being dropped on or impacting the pipe.

5.4.2 Move individual sections of pipe too heavy to be lifted manually with a fabric sling, a pair of slings, or with appropriate lifting equipment. Do not use chains, wire ropes, backhoe buckets, or hooks.

5.4.3 Move packaging units only with forks or slings that go under the packaging units. Packaging is not normally designed to be lifted by a chain or cable attached only to the top of the unit.

5.4.4 The flexibility and impact resistance of PVC, PE, ABS, and PB pipe are reduced as the temperature approaches freezing. Use extra care when handling these pipes during cold weather. (**Warning**—Unloading pipe may be hazardous and the unloading steps must always follow the supplier's instructions.)

5.5 *Storage*—Store the pipe in accordance with the manufacturer's recommendations. Depending on the material, typical precautions may be as follows:

5.5.1 Store pipe under appropriate protective cover for adverse weather conditions or if the unprotected storage time might exceed the manufacturer's recommendation.

5.5.2 Store pipe under conditions that will minimize dirt and foreign matter accumulating on the sealing surface and in the interior of the pipe to reduce future cleaning.

5.5.3 Store pipe in a manner that prevents bulges, flat areas, ovalization, or any other abrupt change in pipe curvature. If the pipe or packaging units are stacked, never exceed the stack height allowed by the manufacturer. If the pipes are not stored in their packaging units, use the original shipping supports. If this is not possible, store the pipe with supports that prevent the bells, spigots, couplings, or any other joint surface from contact. Space the supports at intervals along the pipe to prevent longitudinal sag. Use chocks, with or without fabric (or rope) tiedowns, to prevent the pipe from rolling.

5.5.4 Protect the pipe from excessive heat or harmful chemicals. Use cleaning solutions, detergents, solvents, etc., only in accordance with the manufacturer's recommendations.

5.5.5 Protect gaskets from harmful substances such as dust and grit, solvents, and petroleum-based greases and oils. Do not store gaskets close to electrical equipment that produces ozone. Some gaskets may need to be protected from sunlight.

5.6 *Stringing*—When distributing the pipe along the pipeline alignment, the same precautions mentioned in 5.4 should be followed. In addition, the pipe should be blocked to prevent any possibility of rolling, due to a slight slope, wind, wash-out, or accidental bumping. Pipe with bells and spigots should be supported along the barrel of the pipe to prevent deformation of the jointing ends. Supporting the pipe on two or more wooden blocks, sandbags, or earth mounds, will help prevent dirt accumulating on the sealing surfaces and inside the pipe and, where appropriate, provide a space to slip any pipe-lifting slings under the pipe.

6. Trench Excavation

6.1 *Excavation*—Excavate trenches so that sidewalls 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.

6.1.1 The amount of open trench and the length of time trenches remain open may be restricted for other reasons such as pedestrian safety, traffic disruptions, etc.

6.2 *Minimum Trench Width*—The trench width, normally specified in the contract documents, is based on design and construction factors such as pipe outside diameter, installation methods, and inspection requirements. Specific activities in the trench that might influence the width would be joining procedures, checking gaskets, compacting soil into the haunch area and beside the pipe, and soil density testing.

6.3 *Supported Trench Walls*—Sheeting, bracing, shoring, or trench shields should be used in the following conditions:

6.3.1 Where required by national or local safety regulations.

6.3.2 Where sloped trench walls are not adequate to protect personnel in the trench from slides, caving, sloughing, or other unstable soil conditions.

6.3.3 Where necessary to (*1*) prevent structural damage to adjoining buildings, roads, utilities, vegetation, or anything else that cannot be moved, or (*2*) prevent disruptions to businesses, provide traffic access, or similar concerns.

6.3.4 Where necessary to remain within the construction easement or right-of-way.

6.4 *Sheeting or Shoring*—When supports such as trench sheeting, shoring, bracing, or trench jacks are used, ensure that the pipe support and any compacted soil around the pipe is maintained throughout installation. Ensure that sheeting is sufficiently tight to prevent washing soil 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 Unless otherwise directed, sheeting should be left in place to preclude loss of support of foundation and embedment materials. When the top of sheeting is to be cut off, make a cut 0.5 m or more above the top of the pipe. Leave all vertical and horizontal braces in place. Top cross bracing may need to be installed after the sheeting is cut off. Sheeting that is to be left in the trench shall be constructed of materials that will not corrode or rot, resulting in a loss of support for the pipe.

6.4.2 Ensure that pipe and foundation and embedment materials are not disturbed by support removal. Avoid use of vibratory extraction equipment. Fill voids left upon removal of supports and compact all material to required densities.

6.5 *Trench Shields*—A trench shield or box is a rigid structure that can be moved along the trench to protect workers from potentially unstable trench walls.

6.5.1 *Application*—A shield can be used in two different ways, as follows:

6.5.1.1 *Trench Wall Support*—The trench is excavated from inside the shield. The trench box is lowered as the material is excavated.

6.5.1.2 *Protect Workers*—The trench shield is placed into an existing excavation.

6.5.2 *Soil Compaction*—Improper use of trench boxes while compacting the embedment soil can significantly affect the deflection of flexible pipe and compromise the structural integrity of the pipe. Do not compact embedment soil against the walls of a trench shield and then move the shield creating a void between the compacted embedment and the trench wall. The embedment soil must get completely compacted between the pipe and the trench walls. Typical methods used to attain full compaction between the pipe and the trench walls are as follows:

6.5.2.1 Provide bottom cutouts in the wall of the trench box so that embedment material can be compacted directly against the trench walls. A cutout area at the bottom of the shield on the trailing edge allows the shield to be moved forward laterally.

6.5.2.2 In some conditions, a “subtrench” may be excavated below the bottom of the trench shield. The depth of the subtrench is limited by safety regulations.

6.5.2.3 The shield is raised vertically in about 30 cm (12 in.) increments and the soil compacted below the bottom edge of the shield from the pipe to the trench wall. This operation is continued until the specified height of compacted soil is reached.

6.6 *Trench Walls*—The type of soil and the density of the trench walls may have a significant effect on the performance of the pipe and the soil-pipe system. If the conditions of the trench walls encountered are not as assumed in design, the pipeline designer shall be notified and alternative provisions made. The anticipated conditions should be stated in the contract documents.

6.7 *Contaminated Areas*—If the trench excavation encounters an area contaminated with significant concentrations of pollutants comprised of low-molecular weight petroleum products or organic solvents, there may be restrictions on the type of pipe and gaskets that are used. If a previously unknown contaminated area is encountered, all appropriate entities shall be notified and the contamination identified. (**Warning**—Working in excavated trenches may be hazardous. Follow all safety regulations.)

7. Groundwater Control During Construction

7.1 The pipe should not be installed in standing or running water. Control of both surface and subsurface water (groundwater) may be required.

7.2 *Groundwater*—When groundwater is present in the trench excavation, dewatering may be necessary to maintain stability of *in situ* and imported materials. As appropriate, use sump pumps, wells or well points, or drainage blankets to remove and control water in the trench. When excavating while controlling groundwater, ensure that the groundwater is below the bottom of the cut to prevent washout from behind sheeting or sloughing of exposed trench walls. The water should be controlled in the trench before, during, and after pipe installation and control maintained until the embedment is installed and sufficient backfill has been placed to prevent flotation of the pipe. To prevent loss of soil support, dewatering methods should be used that minimize removal of fines and the creation of voids in native materials.

7.2.1 *Drainage Blankets*—Free-drainage materials may be used for all or a portion of the foundation or bedding to drain water along the trench to sumps or other outlets for removal. Perforated drainage tubing may be used to supplement the flow capacity of the drainage blanket. Select a gradation for the drainage materials to minimize migration of fines from surrounding materials, or use a geotextile separator.

7.2.2 *Sump Pumps*—If direct pumping from sumps is used, the pumps should be submersible or self-priming, so that intermittent flows may be discharged. Diaphragm pumps are generally more suitable when muddy water is to be pumped, while centrifugal pumps are best for pumping large quantities of water. Regardless of the specific type of pump used, a standby pump should be readily available in case the operating pump stops or becomes clogged.

7.2.3 *Wells or Well Points*—Lowering of the water table with wells or a well-point system is an effective means of controlling groundwater in permeable soils and may eliminate the need for sheeting or shoring. However, when the water table is lowered, subsidence of the ground in the surrounding area may occur. Structures close to the dewatered area may also settle and develop structural damage or cracking.

7.3 *Surface Water*—Drainage should be controlled in the vicinity of the excavation by grading and ditching the ground surface to prevent runoff and surface water from running into the trench.

7.4 *Flotation*—If groundwater is encountered, potential flotation of the pipe following construction should be evaluated. If required, construct the pipeline to prevent flotation. Anti-flotation restraints, such as collars or anchors, may be required in some circumstances.

8. Foundation

8.1 *Requirements:*

8.1.1 The foundation is the material beneath the pipe that prevents excessive settlement or excessive differential settlement of the pipeline. If the native material is unsuitable, remove it (overexcavate) and replace with suitable material.

8.1.2 A description of what material is unsuitable for the foundation and what soil is suitable as a replacement material should be part of the contract documents.

8.1.3 Not all foundation problems may be anticipated in the design stages. If any unusual conditions are encountered during trench excavation, site-specific modifications may be required. Any changes during construction shall be approved by the specifying organization.

8.2 *Construction Considerations*—The following guidelines are recommended for the foundation:

8.2.1 A foundation is considered to be stable for laying pipe when a person can walk on the surface without sinking into the soil or can walk without feeling the soil move underfoot. If the trench bottom is unstable, gravel, cobbles, crushed rock, slag, crushed shell, or other durable inert material may be worked into the soil until the trench bottom is stable. In many cases, the unstable soil will have to be excavated and replaced with one of these materials until the foundation is stable.

8.2.1.1 Appropriate geotextiles may be used for stabilizing quick and unstable trench bottoms.

8.2.2 Some contract documents require that when the trench bottom is in rock, the minimum bedding thickness be increased.

8.2.3 If the trench bottom is inadvertently overexcavated below the intended grade, fill the overexcavation with compatible foundation material and compact to a density equivalent to the *in situ* material. (This may not be necessary for extensive lengths of overexcavation, where the pipeline grade is not critical.)

8.2.4 If trench sidewalls slough prior to installation of the pipe, remove all sloughed and loose material from the trench.

8.2.5 Selection of material for the foundation may be affected by the recommendations in Sections 7, 17, and 18.

9. Bedding

9.1 *Requirements:*

9.1.1 The bedding is material placed on the bottom of the trench to provide uniform support for the pipe. Since the pipe is laid directly on the bedding material, place the bedding so that the pipe will be at the proper elevation and slope. Where the trench is excavated in rock, the bedding also serves as a cushion for the pipe and is typically thicker than normal. When rock is excavated, the minimum bedding thickness is the distance between any point of rock and the pipe, pipe bell, coupling, or fitting.

9.1.2 The thickness, type of soil, and degree of compaction for the bedding should be specified in the contract documents. If not described, contact the specifying organization for specific instructions. Any change during construction shall be approved by the specifying organization.

9.1.3 The maximum particle size permitted in the bedding material is typically related to the type of pipe being installed. The allowable maximum particle size should be stated in the contract documents.

9.1.4 For some soil conditions, a bedding may not be specified and the pipe is laid directly on the trench bottom. However, a bedding should be constructed if the foundation contains alternating hard and soft areas, rock particles larger than permitted in the embedment material, or if rock is unexpectedly encountered. Continuous evaluation of the trench bottom during excavation may be required. Shaping the trench bottom to fit the curvature of the pipe is not recommended.

9.1.5 Selection of material for the bedding may be affected by the recommendations in Sections 7, 17, and 18.

9.2 *Construction Considerations*—Recommended steps in the placement of the bedding are as follows:

9.2.1 Remove any loose rocks, large dirt clods, and debris from the trench.

9.2.2 Do not use material for bedding that contains organic matter, stumps or limbs, frozen earth, debris, manmade waste, or other unsuitable materials.

9.2.3 If the soil in the bottom of the trench excavation is suitable for use as the bedding material, remove the soil and then place it back on the trench bottom. This is useful in obtaining an even thickness of bedding and avoids high and low areas or hard and soft spots beneath the pipe.

9.2.4 Place the bedding material so the pipe will be at the proper grade when laid on the bedding. Anticipate settlement of the pipe into uncompacted soil. Do not apply pressure to the pipe (such as with a backhoe bucket) to push the pipe down to grade.

9.2.5 Place the bedding material so each section of pipe will have a uniform bearing for the length of the pipe, except at

bell-and-spigot (or other protruding) joints. Do not use soil mounds or any blocking to bring the pipe to grade.

9.2.6 When the pipe has joints that form an offset on the outside of the pipe, such as bell-and-spigot joints, excavate bell holes in the bedding so that the bell does not rest on any part of the bedding or foundation.

9.2.7 When appropriate, excavate sling holes in the bedding to facilitate removal of the slings.

10. Laying

10.1 Lay the pipe in accordance with the manufacturer's recommendations. Typical laying practices may include the following:

10.1.1 Lower pipe too heavy to be handled manually carefully into place on the bedding using a pair of fabric slings. Do not use chains, wire ropes, or hooks. The pipe must never be thrown, rolled, or dropped into place.

10.1.1.1 Nylon slings with a colored wear-indicator are recommended for handling pipe. The slings should be discarded when the outer fabric layer has worn enough to expose the brightly colored inner layer. On these slings, the load capacity is usually indicated by numbers sewn into the fabric.

10.1.2 Avoid excessive bending of the pipe, if the pipe is assembled above ground and lowered into the trench. Bending should be within the limits recommended by the pipe manufacturer for the kind, type, grade, wall thickness, and diameter of a specific pipe.

10.1.3 Whenever pipe laying or joining is interrupted, protect the ends of the pipe so that people, animals, water, dust, dirt, mud, or foreign matter is kept out of the pipe.

10.1.4 Appropriate precautions should be taken on slopes to prevent separation of gasketed joints or pipe slippage, such as laying the pipe uphill or anchoring the pipe in place.

11. Joining

11.1 Plastic pipe may be joined to pipe of similar or dissimilar material using a number of different techniques. Use a technique suitable for the particular pipes being joined together. Manufacturers should be consulted for specific instructions not covered by contract documents.

11.2 Commonly used procedures, joining materials, and fittings are listed in Section 2.

11.3 Use the manufacturer's recommended techniques, tools, and equipment to join the pipe. Successfully joining pipe requires skill, knowledge, and experience. New personnel should be trained under the guidance of skilled installers. Detailed written procedures and visual aids for training personnel are usually available from manufacturers of pipe and joining equipment.

11.4 Unequal forces due to fluid pressure at changes in pipeline alignment or reduction in pipe size or at the end of a line may create a separation force at joining locations. These forces shall be accounted for as follows:

11.4.1 Bonded joints in pressure systems (such as heat fused, adhesive bonded, or solvent cemented), shall be designed and constructed to withstand the separation forces.

11.4.2 Joints and fittings in gasketed joint pressure systems should be restrained by mechanical restraint devices or thrust blocks to compensate for these pull-out forces. See Section 19.

11.5 *Gasket (Elastomeric Seal) Joints*—Pipe with gasketed joints are assembled section by section in the bottom of the trench. The bell end of the pipe should face the direction of laying. The sealing surfaces of the bell and spigot should be cleaned and inspected for damage. If lubricant is used, apply as recommended by manufacturer. Align the pipe sections, insert the spigot into the bell, and push until the insertion position marked on the pipe is reached or to the position recommended by the pipe manufacturer. Mark pipe insertion points if necessary. Protect the end of the pipe during assembly, and do not use excessive force that may result in damage to the pipe or dislodged gaskets. The following practices are recommended when joining the pipe:

11.5.1 When lubricant is required, use only the lubricant supplied or recommended for use by the manufacturer. Use lubricant liberally and apply to the bell, spigot, or gasket, or any combination thereof, as recommended by the manufacturer. The lubricated surfaces must be protected from dirt or grit until the joining is complete. Keep the containers of lubricant covered to prevent contamination with grit or debris.

11.5.2 Examine any splices in the gasket and discard if any separation exists. As recommended by the manufacturer, some pipe to be assembled with the gasket in the spigot groove should have the tension in the gasket equalized in an approved manner.

11.5.3 Use a bar and wooden block, padded come-alongs, or mechanical equipment with a padded push frame to push the spigot into the bell. Use caution when using power equipment that makes it difficult for the operator to judge when the pipe is overinserted. Be careful when using equipment that may apply uneven, non-aligned pressure such as the bucket of a backhoe. Equipment with pneumatic tires that may slip on loose or cohesionless bedding material shall be used with caution to prevent sudden, uncontrolled thrusts that may damage the pipe. Do not stab or swing one section of pipe into another pipe. Do not overinsert the pipe.

11.5.4 Following assembly of the joint, check the pipe for line and grade.

11.5.5 Small changes in direction for horizontal and vertical angle points, long radius curves, or alignment corrections may be made by a joint angle change (an unsymmetrical closure of the joint with a normal joint opening on one side of pipe and a wider space on the opposite side of pipe). Limit the amount of angle so that the seal between the gasket and the pipe remains intact. The permissible angular movement varies considerably among pipe manufacturers. The pipe manufacturer's literature should state the maximum permissible angle change and the recommended procedure. Typically, the pipe is joined as if the pipeline alignment were straight and then the last pipe section moved (pulled) to the desired angle.

11.5.6 With some types of gasketed joints, the gasket may be checked using a feeler gage to see if the gasket has been dislodged, twisted, or pinched during assembly. The pipe may leak where a gasket is not in the correct location. Check the gasket around the complete circumference of the pipe.