



Standard Practice for Design and Installation of Underground Thermoplastic Irrigation Systems With Maximum Working Pressure of 125 psi¹

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1. Scope

1.1 This practice establishes procedures for the design and installation of thermoplastic flexible piping systems, for underground irrigation systems. Because there is considerable variability in end-use requirements, soil conditions, and thermoplastic piping characteristics, the intent of this practice is to outline general objectives and basics of systems design, proper installation procedures, and to provide pertinent references.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units which are for information only and are not considered standard.

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

- D1600 Terminology for Abbreviated Terms Relating to Plastics
- D2241 Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
- D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

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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.

- D2657 Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
- D2749 Symbols for Dimensions of Plastic Pipe Fittings
- F402 Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
- F412 Terminology Relating to Plastic Piping Systems
- F690 Practice for Underground Installation of Thermoplastic Pressure Piping Irrigation Systems
- F714 Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
- F771 Specification for Polyethylene (PE) Thermoplastic High-Pressure Irrigation Pipeline Systems
- F1290 Practice for Electrofusion Joining Polyolefin Pipe and Fittings

3. Terminology

3.1 The terminology used in this practice is in accordance with Terminology F412, Terminology D1600, and Symbols D2749, unless otherwise specified.

4. Summary of Practice

4.1 This practice gives standardized criteria and procedures for underground installation of thermoplastic pipe in pressure irrigation systems.

4.2 Thermoplastic pipe used in this practice is made of poly(vinyl chloride) (PVC) or polyethylene (PE) and shall be assembled to withstand the design working pressure for the pipeline without leakage, internal restriction, or obstruction that could reduce line capacity below design requirements.

4.3 Joining materials shall be of composition that will not damage the pipe and shall be recommended for use at the design pressure for the pipeline. Consult the manufacturer for design and installation recommendations.

4.4 When materials subject to corrosion are used in the line, they shall be adequately protected by wrapping or coating with high-quality corrosion preventatives. Wrappings or coatings applied to metallic surfaces should not be applied on plastic

pipe or fittings unless it is first established by consulting the piping manufacturer so that they have no detrimental effect on the plastic.

5. Requirements

5.1 Working Pressure—The pipe line shall have a pressure rating (see **Table 1** and **Annex A1**) greater than the static pressure or working pressure plus the surge pressure, at any point in the system. Surge and working pressures shall not exceed the pipe's pressure class.

5.2 Service Factor—Determine all pressure ratings in a water environment of $73.4 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$). As the temperature of the environment or fluid increases, the pipe becomes more ductile. Therefore, the pressure rating must be decreased for use at higher temperatures to allow for safe operation of the pipe. The service factors for PVC and PE are shown in **Table 2**. For PE pipe having improved strength retention with an increase in temperature and PE pipe used at temperatures exceeding 100°F (38°C), consult the manufacturer for recommended service factors.

5.3 System Capacity—The design capacity of the pipe line shall be sufficient to provide an adequate flow of water for all methods of irrigation planned.

5.4 Friction Losses—For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation using a flow coefficient (*C*) equal to 150.

5.5 Flow Velocity—The designed water velocity in a pipeline when operating at system capacity should not exceed 5 ft/s (1.5 m/s), unless special considerations are given to the control of surge or water hammer. Adequate protection from these pressures is provided (see **5.1** and **Table 3**). Use adequate pressure- or air-relief valves, or both, with all velocities.

5.6 Outlets—Outlets shall have adequate capacity at the pipeline working pressure to deliver the designed flow to the distribution system at the designed operating pressure of the respective system, that is, sprinklers, surface pipe, emitters, tricklers, and so forth.

5.7 Check Valves—Install a check valve between the pump discharge and the pipeline where detrimental back flow may occur. The check valve shall be designed to close without slamming shut at the point of zero velocity before damaging reversal flow can occur.

TABLE 2 Pressure Rating Service Factors for Temperatures from 73.4 to 140°F (23 to 60°C) for PVC and PE Pipes

Temperature,		PVC Factor	PE Factor
°F	°C		
73.4	23	1.00	1.00
80	26.7	0.88	0.92
90	32.2	0.75	0.81
100	37.8	0.62	0.70
110	43.3	0.50	...
120	48.9	0.40	...
130	54.4	0.30	...
140	60.0	0.22	...

5.7.1 The time that should be taken to close a valve in order that the pressure shall not exceed the normal pressure at no flow may be determined from the following equation:

$$\text{Time, s} = \frac{0.027 \times L \times V}{P - p}$$

where:

L = length of the pipe before the valve, ft,

V = velocity of flow, ft/s,

P = pressure in the pipe, lb/in.² (where there is no flow), and

p = pressure in the pipe at full flow.

5.8 Pressure-Relief Valves—Install these between the pump discharge and the pipeline when excessive pressures can develop by operating with all valves closed. Install pressure-relief valves or surge chambers on the discharge side of the check valve where back flow may occur, and at the end of the pipeline when needed to relieve the surge.

5.8.1 Low-Pressure Systems—Pressure-relief valves may be used as alternatives to serve pressure-relief functions of vents and stands open to the atmosphere. They do not function as air release valves and should not be substituted for such valves where release of entrapped air is required.

5.8.1.1 Pressure-relief valves shall be large enough to pass the full pump discharge with a pipeline pressure no greater than 50 % above the permissible working head of the pipe.

5.8.1.2 Mark pressure-relief valves with the pressure at which the valve starts to open. Install adjustable valves in such a manner to prevent changing of the adjustment marked on the valve.

5.8.2 High-Pressure Systems—The ratio of nominal size pressure-relief valves to pipeline diameter shall be no less than 0.25. Set the pressure-relief valves to open at a pressure no greater than 5 psi (34.5 kPa) above the pressure rating of the pipe, or the lowest pressure-ratio component in the system.

5.9 Air-Release and Vacuum-Relief Valves—Install air-release and vacuum-relief valves, at all summits, at the ends, and at the entrance of pipelines to provide for air escape and air entrance. Combination air- and vacuum-release valves, which provide both functions, may be used.

5.9.1 Air Flow Capacity—Valves having large orifices to exhaust large quantities of air from the pipelines when filling and to allow air to enter to prevent a vacuum when draining are required at the end and entrance of all pipelines. Valves

TABLE 1 Pressure Ratings for Poly(Vinyl Chloride) (PVC) and Polyethylene (PE)

SDR	PVC 12454	PE 2406 and PE 3406	PE 3408
50 ^{hd}	22		
93.5	43		
81	50		
64	63		
51	80		
41	100	40 (276)	31 (214)
32.5	125	51 (352)	40 (276)
26		64 (441)	50 (345)
21		80 (552)	63 (435)
17		78 (538)	78 (538)
15.5		86 (593)	86 (593)
13.5		100 (689)	100 (689)
11		125 (862)	125 (862)

intended to release only entrapped air may have smaller orifices and are required at all summits.

5.9.2 *Low-Pressure Systems (Not Open to the Atmosphere):*

5.9.2.1 Provide air-release and vacuum-relief, or combination air- and vacuum-release, valves at the downstream end of each lateral, at all summits of the line, at points where there are changes in grade of more than 10° (18 %) in a downward direction of flow, and immediately below any stand if the downward velocity in the stand exceeds 2 ft/s (0.6 m/s).

5.9.2.2 Air vacuum release valve outlets shall have a 2-in. minimum diameter. The valves shall be sized as shown in **Table 3**.

6. Trench Preparation

6.1 *Trench Depth*—In stable, granular soils that tend to be relatively smooth and free of rocks and debris larger than ½ in. (13 mm) in size, excavation may proceed directly to final grade. Where rocks or other protrusions are encountered which may cause point loading on the pipe, re-excavate the trench bottom to permit installation of proper bedding (see 6.5).

6.2 *Trench Width*—Establish the width of the trench at the top of the pipe with attention given to these considerations:

6.2.1 The wider the trench at the top of the pipe the greater the earth load on the pipe until the prism load has been achieved.

6.2.2 Trench width should allow sufficient assembly of joints. Generally, a trench width at the top of the pipe of a minimum of 18 in. wider than the pipe diameter is adequate. If a wider trench becomes necessary, restrict the enlargement as much as possible to only that section above the top of the pipe.

6.2.3 Trench width should allow adequate room for snaking when recommended by the manufacturer or as may be required to accommodate thermal expansion or contraction.

6.2.4 Narrow trench widths may be utilized by joining the pipe above ground and lowering it into the trench, provided enough room is available in the trench for proper haunching. Precautions outlined in 6.2.2 shall be followed.

6.3 *Trench Depth*—Establish the trench depth with consideration given to requirements imposed by foundation, beddings, pipe size, and cover.

6.4 *Foundation*—An adequate and stable foundation should be present, or provided, for proper support of the total load.

6.4.1 Foundation preparation is not necessary when smooth, stable trench bottoms are encountered.

6.4.2 Foundation preparation is necessary when unstable trench bottom conditions are encountered. The designer should specify the stabilizing method and materials which will satisfactorily stabilize the encountered condition and provide adequate and permanent support.

TABLE 3 Design Criteria for Vacuum Release Valve Outlets

Pipe Diameter, in. (mm)	Minimum Air-Relief Vacuum Release Valve Outlet Diameter, in. (mm)
6 (152)	2 (51)
7 to 10 (178 to 254)	3 (76)
12 or larger (305 or larger)	4 (102)

TABLE 4 Pipe stiffness of PVC

SDR	PS
64	7
51	14
41	28
32.5	57

6.5 *Bedding*—The bedding material should consist of gravel, sand, silty sand, silty gravel, or clayey sand in granular form and have a maximum particle size of ¾ in. (19 mm).

6.5.1 Provide bedding whenever rocks, hard pan, boulders, or other materials that might damage pipe are encountered in the trench bottom at the established grade.

6.5.2 When bedding is used, keep it as uniform in depth as possible to minimize differential settlement (see Fig. 1).

6.6 *Minimum Earth-Cover*—Protection from traffic loading or frost protection, or both, should be considered when establishing minimum earth cover requirements.

6.6.1 For installations exposed to normal farm vehicle traffic, the minimum total cover shall not be less than 30 in. (750 mm).

6.6.2 Install the pipe line at sufficient depths to provide protection from traffic crossing, farm operations, and soil cracking. Load-bearing capabilities of installed pipe vary with the type of pipe, type of backfill, soil conditions, and installation procedures. Consult the manufacturer for information on product response to expected maximum earth-load or live-load, or both.

6.6.3 The trench depth shall be sufficient to ensure placement of the top of the pipe at least 10 in. (250 mm) below the known frost line. When conditions and design requirements prevent satisfaction of this requirement, system design and installation must ensure proper drainage in the portions of the line without sufficient cover.

7. Other Requirements

7.1 *Preparation of Joints*—Joint assembly shall be done in accordance with specifications listed under 2.1.

7.2 If the pipe is to be assembled above ground, lower it into the trench, taking care not to drop it or damage it against the trench walls or to subject the pipe or its joints to treatment, such as dragging or excessive bending, which could be injurious to the piping. With elastomeric seal joints, take care to avoid joint displacement and pull-out. Allow heat-fused joints to cool or solvent-cement joints to cure for the minimum prescribed time before moving the pipe. Take care to avoid excessive stressing at the joints.

7.3 Changes in grade or line of direction of the pipe shall be limited and shall be gradual enough so that the bending of the pipe will develop neither excessive diametrical expansion, nor excessive bending stresses. At no time should the pipe be blocked or braced to hold a bend. Excess curvature can create stresses which could induce pipe failing under pressure. Consult the pipe manufacturer for the recommended minimum pipe-bending radius.

7.4 When installing pipe with elastomeric seal, flanged joints, or with any connector which protrudes beyond the pipe diameter bell, excavate holes in the bedding material or trench

TABLE 5 Pipe Stiffness Ranges for PE Materials and DR's psi

DR	41	32.5	26	21	17	11
Modulus, Cell Classification						
3	2-6	6-11	11-23	22-45	71-87	179-358
4	6-8	11-16	23-31	45-61	87-120	358-492
5	8-11	16-23	31-46	61-89	120-175	492-716

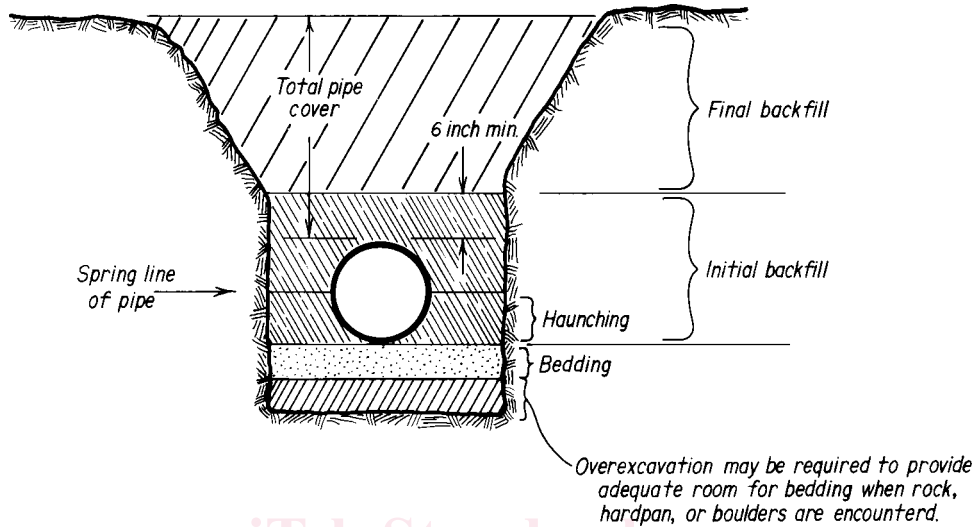


FIG. 1 Trench Cross Section

bottom to permit the pipe to be continuously supported. After pipe assembly and placement in the trench, fill each bell hole with bedding material and compact as necessary to attain the same general density as to the rest of the bedding.

7.5 It is advisable to permit newly installed pipe to cool to approximately ground temperature prior to backfilling. This will minimize the development of contraction stressed on the joints and in the case of solvent-cemented connections, it will prevent the possibility of joint separation due to contraction forces acting on the incompletely cured bond. Typically, pipe will cool adequately soon after being placed in a shaded trench bottom or covered with sufficient backfill material to shade it.

7.6 Where differential settlement could create concentrated loading on a pipe or joint, for example, at a point of connection of a buried pipe to a rigid structure, such as a manhole, follow the manufacturer's recommendations to prevent or to properly relieve damaging and shearing forces. One technique is to use extra care when compacting the foundation and bedding under a rigid structure. Other techniques might include construction of a supporting structure underneath the joint and pipe of about three diameters in cross section or another technique is the utilization of a flexible joint.

8. Thrust Blocking

8.1 When installing piping systems that include joints that are not self-restraining (for example, elastomeric seal joint), thrust blocking may be necessary at certain points in the system, such as changes in direction, in order to prevent possible disengagement of the fitting from the pipe.

8.2 Thrust blocking is required when line shift or joint separation at system operating pressure can be anticipated, that

is, pump discharge, directional changes, reducers, tees, and dead ends. Thrust blocking is essential to the proper performance of pressure irrigation piping when the systems include non-self restraining joints (reference Practice F690).

8.3 Thrust Block Construction:

8.3.1 The thrust block should be constructed of concrete having a compression strength of 2000 psi (14 MPa) or more. Wood blocking or stone blocking with wood edges are not acceptable.

8.3.2 The thrust block acts to distribute forces between pipe or fittings and the solid trench wall. The size of the thrust block should be adequate to prevent pipe movement at the point of thrust. Consult the system designer for size of thrust block.

8.3.3 The thrust block cavity should be hand dug in undisturbed soil and framed with soil or wood to hold freshly poured concrete. The earth-bearing surfaces should be undisturbed.

8.3.4 Before pressurizing the line, ensure that adequate time is allowed for the concrete blocks to set.

9. Line Charging and Testing

9.1 If possible, the pipeline should be thoroughly inspected and tested before backfilling. When so testing, it is advisable to anchor the pipe by placing haunching and initial backfill to about 6 in. (150 mm) over the pipe, taking care to leave all joints and fittings exposed for inspecting.

9.2 Line Charging:

9.2.1 Before filling and proceeding to test, allow sufficient time for solvent-cemented joints to cure or heat-fused joints to cool.