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Standard Practice for Design and Installation of Thermoplastic Irrigation Systems With Maximum Working Pressure of 63 psi[1]

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1. Scope

1.1 This practice covers general and basic procedures related to the design and installation of thermoplastic flexible piping systems, with maximum pressures of 63 psi in nominal size diameters 14 in. (355.6 mm) through 42 in. (1066.8 mm), 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 for information only.

1.3 *This standard does not purport to address all of the safety problems, 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:*

D 1600 Terminology for Abbreviated Terms Relating to Plastics[2]

D 2241 Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)[3]

D 2487 Test Method for Classifications of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 2657 Practice for Heat-Joining Polyolefin Pipe and Fittings[3]

D 2749 Symbols for Dimensions of Plastic Pipe Fittings[3]

F 402 Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings[3]

F 412 Terminology Relating to Plastic Piping Systems[3]

F 690 Practice for Underground Installation of Thermoplastic Pressure Piping Irrigation Systems[3]

F 714 Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter[3]

F 771 Specification for Polyethylene (PE) Thermoplastic High-Pressure Irrigation Pipeline Systems[3]

3. Terminology

3.1 The terminology used in this practice is in accordance with Terminology F 412, Terminology D 1600, and Symbols D 2749, unless otherwise specified.

4. Summary of Practices

4.1 This practice gives standardized criteria and procedures for installation of large-diameter (14-in. (355.60-mm) and larger) thermoplastic pipe in pressure systems of 63 psi (434.37 kPa) or less.

4.2 Thermoplastic pipe used in this practice is made of poly(vinyl chloride) (PVC), polyethylene (PE), or acrylonitrile-butadiene styrene (ABS), and shall be assembled to withstand the design working pressure for the pipeline without leakage, internal restriction, or obstruction which 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 class rating (see Table 1 and Annex A1) greater than the static pressure or working pressure plus surge pressure at any point in the system. Surge pressures should not exceed 28 % of the pipe's pressure class rating. If surge is not known, the working pressure shall not exceed the maximum allowable working pressure as given in Table 2 for the particular pipe and SDR or DR used. Maximum or critical pressure as a function of pipe SDR or DR is shown in Table 3 for thermoplastic pipe having different moduli of elasticity.

[1] This practice is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.61on Water.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.04.

TABLE 1 Pressure Ratings (PR) for Non-Threaded Thermoplastic Pipe

SDR Materials		26, psi (kPa)	32.5, psi (kPa)	41.0, psi (kPa)	51.0, psi (kPa)	64.0, psi (kPa)	81.0, psi (kPa)	93.5, psi (kPa)	50 hd, psi (kPa)
PVC9	1120	. . .	. . .	. . .	. . .	63 (435)	50 (345)	43 (295)	22 (150)
	1220	. . .	. . .	. . .	. . .	63 (435)	50 (345)	43 (295)	22 (150)
	2120	. . .	. . .	. . .	. . .	63 (435)	50 (345)	43 (295)	22 (150)
	2116	. . .	. . .	. . .	. . .	50 (345)	40 (275)	. . .	. . .
	2112	. . .	. . .	. . .	. . .	40 (275)	30 (205)	. . .	. . .
	2110	. . .	. . .	. . .	. . .	30 (205)	25 (170)	. . .	. . .
PE	3408	64 (440)	50 (345)	40 (275)	. . .	. . .	. . .	. . .	. . .
	3406	50 (345)	40 (275)	31 (215)	. . .	. . .	. . .	. . .	. . .
	3306	50 (345)	40 (275)	31 (215)	. . .	. . .	. . .	. . .	. . .
	2306	50 (345)	40 (275)	31 (215)	. . .	. . .	. . .	. . .	. . .
ABS	1316	. . .	. . .	. . .	63 (440)	. . .	. . .	. . .	. . .
	2112	. . .	. . .	64 (440)	50 (345)	. . .	. . .	. . .	. . .
	1210	. . .	64 (440)	50 (345)	40 (275)	. . .	. . .	. . .	. . .

TABLE 2 Maximum Allowable Pressure for Non-Threaded Plastic Pipes When Surge Pressures Are Not Known

SDR Materials		26, psi (kPa)	32.5, psi (kPa)	41.0, psi (kPa)	51.0, psi (kPa)	64.0, psi (kPa)	81.0, psi (kPa)	93.5, psi (kPa)	50 hd, psi (kPa)
PVC	1120	. . .	. . .	. . .	. . .	45 (310)	36 (250)	31 (215)	21 (145)
	1220	. . .	. . .	. . .	. . .	45 (310)	36 (250)	31 (215)	21 (145)
	2120	. . .	. . .	. . .	. . .	45 (310)	36 (250)	31 (215)	21 (145)
	2116	. . .	. . .	. . .	. . .	36 (250)	29 (200)	. . .	. . .
	2112	. . .	. . .	. . .	. . .	29 (200)	22 (150)	. . .	. . .
	2110	. . .	. . .	. . .	. . .	22 (150)	18 (125)	. . .	. . .
PE	3408	45 (310)	36 (250)	29 (200)	. . .	. . .	. . .	. . .	. . .
	3406	36 (250)	29 (200)	22 (150)	. . .	. . .	. . .	. . .	. . .
	3306	36 (250)	29 (200)	22 (150)	. . .	. . .	. . .	. . .	. . .
	2306	36 (250)	29 (200)	22 (150)	. . .	. . .	. . .	. . .	. . .
ABS	1316	. . .	. . .	58 (400)	46 (315)	. . .	29 (200)	. . .	. . .
	2112	. . .	58 (400)	46 (315)	36 (250)	. . .	22 (150)	. . .	. . .
	1210	. . .	46 (315)	36 (250)	36 (250)	. . .	18 (125)	. . .	. . .

5.2 *Service Factor*—Determine all pressure ratings in a water environment of 73.4 ± 3.6°F (23 ± 2°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, ABS, and PE are shown in Table 4. 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 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, etc.

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 3 Maximum or Critical Surge Pressure for Thermoplastic Pipe[A]

SDR Outside Diameter Based	DR Inside Diameter Based	For Pipe Material of 400 000 psi (2800 MPa) Modulus (Includes Most PVC)		For Pipe Material of 300 000 psi (2100 MPa) Modulus (Includes Most ABS)		For Pipe Material of 100 000 psi (700 MPa) Modulus (Most PE)	
		psi	(kPa)	psi	(kPa)	psi	(kPa)
. . .	5.3	28.1	(195)	24.3	(170)	14.0	(95)
. . .	7.0	25.1	(175)	21.7	(150)	12.5	(85)
11.0	9.0	22.5	(155)	19.5	(135)	11.2	(75)
13.3	11.5	20.3	(140)	17.6	(120)	10.2	(70)
17.0	15.0	18.0	(125)	15.6	(110)	9.0	(60)
21.0	. . .	16.1	(110)	13.9	(95)	8.0	(55)
26.0	. . .	14.4	(100)	12.5	(85)	7.2	(50)
32.5	. . .	12.9	(90)	11.2	(75)	6.4	(45)
41.0	. . .	11.4	(80)	9.9	(70)	5.7	(40)
51.0	. . .	10.2	(70)	8.8	(60)	5.1	(35)
64.0	. . .	9.1	(65)	7.9	(55)	4.5	(30)
81.0	. . .	8.1	(55)	7.0	(50)	4.0	(30)
93.5	. . .	7.5	(50)	6.5	(45)	3.2	(20)

[A] Calculate pipe SDR (or DR) surge pressure per feet per second (0.3 m/s) of sudden change in flow velocity as follows:

$$P = V\left(\frac{3960Et}{Et + 300\,000D}\right)^{1/2}$$

where:

P = surge pressure, psi,
V = sudden change in velocity, ft/s,
E = modulus of elasticity of material,
t = pipe wall thickness, in., and
D = pipe inside diameter (ID), in.

TABLE 4 Pressure Rating Service Factors for Temperatures from 73.4 to 140°F (23 to 60°C) for PVC, ABS, and PE Pipes

Temperature,		PVC Factor	ABS Factor	PE Factor
°F	°C			
73.4	23	1.00	1.00	1.00
80	26.7	0.88	0.94	0.92
90	32.2	0.75	0.84	0.81
100	37.8	0.62	0.68	0.70
110	43.3	0.50	0.56	. . .
120	48.9	0.40	0.49	. . .
130	54.4	0.30	0.44	. . .
140	60.0	0.22	0.84	. . .

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 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 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 intended to release entrapped air only 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 vacuum relief 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 5.

6. Trench Preparation

6.1 *Trench Depth*—In stable granular soils which 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.

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.

TABLE 5 Design Criteria for Vacuum Release Valve Outlets

Pipe Diameter, in. (mm)	Minimum Air 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)