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An American National Standard

Standard Guide for Selection, Design, and Installation of Thermoplastic Water-Pressure Piping Systems[1]

This standard is issued under the fixed designation F645; 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 is intended for use in the selection, design, and installation of thermoplastic water systems for use outside buildings. For specific projects, a thorough review of this guide is recommended for the purpose of selecting specific materials, methods of joining, system design factor, and any special procedures deemed necessary to assure a satisfactory system.

1.2 It is recommended that governing codes and project specifications be consulted prior to the use of this guide. Nothing in this guide should be construed as recommending practices or systems at variance with governing codes and project specifications.

1.3 *Units*- The values stated in either SI units or inch-pound units are to be regarded separately as standard. Values in parentheses are for informational purposes only. The values in each system may not be exact equivalents, therefore, each system shall be used independently of the other, Combining values for the two systems may result in non-conformance with the standard. The pipe, fittings, and joining materials shall meet the requirements of one or more of the following component product standards listed in 1.3.11.3.1 through 1.3.3 1.3.3to the extent applicable. Those pipe standards followed by (*a*) are outside diameter-controlled pipes. Those followed by (*b*) are inside diameter-controlled pipes.

1.3.1 *For poly(vinyl chloride) (PVC) plastic piping components*:

Title of Specification	ASTM Designation
Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120 (*a*)	D1785
Poly(Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR) (*a*)	D2241
Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80	D2464
Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40	D2466
Socket-Type Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80	D2467
Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings	D2564
Bell-End Poly(Vinyl Chloride) (PVC) Pipe (*a*)	D2672
Poly(Vinyl Chloride) (PVC) Plastic Tubing (*a*)	D2740
Socket-Type Poly(Vinyl Chloride) (PVC) Plastic Line Couplings	D3036
Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals	D3139
Elastomeric Seals (Gaskets) for Joining Plastic Pipe	F 477
PVC and ABS Injected Solvent Cemented Plastic Pipe Joints	F 545

1.3.2 *For polyethylene (PE) plastic piping components*:

Title of Specification	ASTM Designation
Polyethylene (PE) Plastic Pipe, Schedule 40 (*b*)	D2104
Polyethylene (PE) Plastic Pipe, (SDR-PR) (*b*)	D2239
Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter (*a*)	D2447
Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe	D2609
Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe (*a*)	D2683
Polyethylene (PE) Plastic Tubing (*a*)	D2737
Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter (*a*)	D3035
Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing	D3261

1.3.3 *For poly(vinyl chloride) (PVC) and polyethylene (PE) Plastic Piping Components Issued By the American Water Works Association*:

C900 Poly(Vinyl Chloride) (PVC) Pressure Pipe, 4-inch through 12-inch, for Water (a)
C901 Polyethylene (PE) Pressure Pipe, Tubing and Fittings, ½-inch through 3-inch, for Water

1.3.4 Pipes with wall thicknesses less than 1.50 mm (0.06 in.) are not recommended.

1.4 *Other Joining Devices*—Joining devices other than those covered by the listed standards may be selected by the user on the basis of his own engineering evaluation and service experience.

[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 Systems.

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1.5 *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:*[2]

D1600 Terminology for Abbreviated Terms Relating to Plastics

D1785 Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

D2104 Specification for Polyethylene (PE) Plastic Pipe, Schedule 40[3]

D2239 Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter

D2241 Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)

D2447 Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter[3]

D2564 Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems

D2737 Specification for Polyethylene (PE) Plastic Tubing

D2740 Specification for Poly(Vinyl Chloride) (PVC) Plastic Tubing[3]

D2774 Practice for Underground Installation of Thermoplastic Pressure Piping

D2855 Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings

D3035 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

D3139 Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

F412 Terminology Relating to Plastic Piping Systems

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

F545 Specification for PVC and ABS Injected Solvent Cemented Plastic Pipe Joints[3]

F1498 Specification for Taper Pipe Threads 60° for Thermoplastic Pipe and Fittings

2.2 *American Water Works Association Standards*[4]*:*

C651 Disinfecting Water Mains

C900 Poly(Vinyl Chloride) (PVC) Pressure Pipe, 4-Inch Through 12-Inch, for Water

C901 Polyethylene (PE) Pressure Pipe, Tubing and Fittings, ½-Inch Through 3-Inch, for Water

2.3 *Plastics Pipe Institute Report:*

PPI-TR 4 HDB/SDB/PDB/MRS Listed Materials[5]

2.4 *NSF Standards:*

ANSI/NSF 14 for Plastic Piping Components and Related Materials[6]

ANSI/NSF61 for Drinking Water Systems Components—Health Effects[6]

3. Terminology

3.1 Definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600 and Symbols unless otherwise specified.

3.2 *relation between standard dimension ratio, hydrostatic design stress, and pressure rating*—the following expression is used in this guide to relate standard dimension ratio, hydrostatic design stress, and pressure rating:

$$2S/P = R - 1 \text{ or } 2\,S/P = (D/t) - 1 \quad (1)$$

where:

S = hydrostatic design stress, MPa (or psi),
P = pressure rating, MPa (or psi),
D = average outside diameter, mm (or in.),
t = minimum wall thickness, mm (or in.), and
R = standard thermoplastic pipe dimension ratio also known as SDR or SIDR, whichever is applicable.
d = average inside diameter, mm (or in.)—substitute d for D in equations and change minus sign to plus.

4. Significance and Use

4.1 The requirements of this specification are intended to provide information to select, design and install thermoplastic, water-pressure piping systems for use outside buildings. Materials covered in this specification are Poly(Vinyl Chloride) (PVC) and Polyethylene (PE) plastic pipe fittings.

5. System Pressure Design

5.1 The maximum pressure ratings in Tables 1-9 make allowance for normal operating conditions, reasonable installation procedures, good handling, good jointing workmanship, operating temperatures below 27°C (80°F), and surges likely to be encountered at water flow velocities up to 5 ft/s (1.5 m/s). Tubing Sizes with pressure ratings less than 160 psi are listed in the tables. (Note 1).

NOTE 1—See Marking section and appendix of applicable pipe specification for marking pipe with pressure ratings lower than the maximum values given in Tables 1-9.

5.2 The maximum safe water velocity in a thermoplastic piping system depends on the specific details of the system and the operating conditions. In general, 5 ft/s (1.5 m/s) is considered to be safe. Higher velocities may be used in cases where the operating conditions can be controlled or a higher design factor than 2.0 is used, or both. The total pressure in the system at any time (operating plus surge or water hammer) due to surges or water hammers shall not exceed 150 % of the pressure rating of the system.

5.3 The maximum pressure ratings in Tables 1-9 make some allowance for surge and water hammer. However, when

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

[4] Available from American Water Works Association (AWWA), 1401 New York Ave., NW, Suite 640, Washington, DC 20005.

[5] Available from Plastics Pipe Institute, 355 Lexington Ave., New York, NY 10017.

[6] Available from NSF International, P.O. Box 130140, Ann Arbor, MI 48113-0140.

TABLE 1 Maximum Water Pressure Ratings at 23°C (73°F) for Schedule 40 PVC Plastic Pipe (Specification D1785)

Nominal Pipe Size, in.	PVC 1120 PVC 1220 PVC 2120	Pressure Rating, psi[A]		
		PVC 2116	PVC 2110	PVC 2112
½	600	480	300	370
¾	480	390	240	300
1	450	360	220	280
1¼	370	290	180	230
1½	330	260	170	210
2	280	220	140	170
2½	300	240	150	190
3	260	210	130	160
3½	240	190	120	150
4	220	180	110	140
5	190	160	100	120
6	180	140	90	110
8	160	120	80	100
10	140	110	NPR[B]	90
12	130	110	NPR	80

[A] These maximum pressure ratings apply only to unthreaded pipe. The industry recommends against the use of threaded PVC plastic pipe in Schedule 40 wall thickness in nominal pipe sizes 6 in. and smaller. See applicable ASTM standard for code designation, for example, PVC 1120. Pipe with pressure ratings less than 0.34 MPa (50 psi) is not recommended for use in pressure systems.

[B] NPR = not pressure rated.

excessive surges and water hammer are likely to be encountered, extra allowance should be made or protective devices installed. The surge or water hammer resulting from rapid flow stoppage may be calculated by means of the following equation:

$$p = V\sqrt{\frac{4{,}033}{\left(1+\frac{300\,000d}{Et}\right)}} \qquad (2)$$

where:

p = peak water surge pressure, psi,
E = modulus of elasticity of the pipe material, psi,
d = inside diameter of the pipe, inclusive, in.,
t = wall thickness, in., and
V = water velocity, ft/s.

5.4 The pressure rating of properly solvent-cemented joints is the same as the pipe joined after reasonable time for cure of the joint. The pressure rating of well-made heat-fused joints is the same as the pipe joined, after the material in the joint has cooled to the pipe temperature.

5.5 PVC threaded pipe shall be pressure rated at 50 % of that of nonthreaded pipe (see Specification F1498). Pipe with wall thicknesses less than those of Schedule 80 pipe shall not be threaded. PE pipe shall not be threaded.

5.6 Joints and the allied fittings made by means other than those covered above shall be pressure-rated by engineering evaluations and service experience by either the design engineer or user, or both. The recommendations of the manufacturers should also be considered (see Specification D3139).

5.7 Allowance shall be made for operating conditions in which the water will be above 27°C (80°F) under normal service conditions. Hydrostatic design stresses for thermoplastic pipe materials are given in PPI-TR4, Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Pipe and Fittings Compounds, a report issued at intervals by the Plastics Pipe Institute.

5.8 In piping system design the selection of a design or safety factor depends on the operating conditions that will be encountered. It may be necessary to use pressure ratings lower than the pressure ratings listed in Tables 1-9 when the following are likely to be encountered: (*1*) surges or water hammer, (*2*) cyclic pressure oscillations, (*3*) air pockets, (*4*) quick-closing valves, (*5*) pumps with more capacity than the lines can deliver, (*6*) flow velocities more than 5 ft/s, and (*7*) similar factors or combinations of (1) through (6). This will result in using pipe and fittings with heavier walls. Consult manufacturers for specific recommendations. Operating temperatures above 23°C (73°F) will make the pipe more flexible and will lower both the short-term and long-term hydrostatic strengths; for a temperature of 38°C (100°F) a pressure rating of 80 % of the 23°C (73°F) values has been found to be adequate for most thermoplastic piping materials covered in current ASTM standards. The designer of the piping system shall use any additional design (safety) factors that are deemed necessary to cover any unusual or special conditions that may be encountered on a specific job. When long-term factors are translated to short-term pressure loadings, the corresponding short-term factors are 2 to 4 times greater, depending on the kind and type of plastic; for example, a 2.0 long-term factor for PVC 1120 gives a 4.0 short-term factor; a 2.0 long-term factor for PE 3306 gives a 5.0 short-term factor.

5.9 Pressure surges may adversely affect the long-term performance of system components and shall be kept to the absolute minimum practical. Where surges are anticipated due to the action of pressure regulating valves, pumps, and other operating equipment, the manufacturer shall be consulted for recommendations.

6. Joints and Connections

6.1 Plastic pipe, tubing, and fittings may be joined by the solvent-cement method, heat-fusion method, threading, elastomeric seals, or by means of other mechanical devices. Consult applicable ASTM practices. The method used shall be compatible with the materials being joined. The recommendations of the manufacturer shall be taken into consideration when determining which method and the details of the procedure to be used.

6.2 *Joint Requirements*:

6.2.1 Solvent-cement joints and heat-fusion joints shall be made in accordance with qualified procedures that have been established and proven by test to produce water-tight joints at least as strong as the pipe or tubing being joined.

6.2.2 Solvent-cement or heat-fusion joints shall not be made between different kinds of plastics.

6.2.3 Heat-fusion or mechanical joints shall be used when joining polyethylene pipe, tubing, or fittings.

6.2.4 Solvent-cement joints may be made between PVC pipe and PVC fittings.

6.2.5 Flanges or special joints may be used, provided that they are properly qualified and utilized by the design engineer or user, or both.

6.3 *Solvent-Cement Joints*:

6.3.1 Square-cut ends free of burrs are required for a proper socket joint.

TABLE 2 Maximum Water Pressure Ratings at 23°C (73°F) for Schedule 80 PVC Plastic Pipe (Specification D1785)

Nominal Pipe Size in.	Pressure Rating, psi[A]							
	PVC 1120 ,PVC 1220 and PVC 2120		PVC 2116		PVC 2110		PVC 2112	
	Unthreaded	Threaded	Unthreaded	Threaded	Unthreaded	Threaded	Unthreaded	Threaded
¼	850	420	680	340	420	210	530	260
¾	690	340	550	280	340	170	430	210
1	630	320	500	250	320	160	390	200
1¼	520	260	420	210	260	130	320	160
1½	470	240	380	190	240	120	290	150
2	400	200	320	160	200	100	250	130
2½	420	210	340	170	210	110	260	130
3	370	190	300	150	190	90	230	120
3½	350	170	280	140	170	90	220	110
4	320	160	260	130	160	80	200	100
5	290	140	230	120	140	NPR[B]	180	90
6	280	140	220	110	140	NPR	170	90
8	250	120	200	100	120	NPR	150	80
10	230	120	190	90	120	NPR	150	NPR
12	230	110	180	90	110	NPR	140	NPR

[A] See applicable ASTM standard for code designation, for example, PVC 1120. Pressure ratings are lower at elevated temperatures. Pipe with pressure ratings less than 0.34 MPa (50 psi) is not recommended for use in pressure systems.
[B] NPR, not pressure rated.

TABLE 3 Maximum Water Pressure Ratings at 23°C (73°F) for Schedule 120 PVC Plastic Pipe (Specification D1785)

Nominal Pipe Size,	Pressure Rating, psi[A]							
	PVC 1120, PVC 1220 PVC 2120		PVC 2116		PVC 2110		PVC 2112	
	Unthreaded	Threaded	Unthreaded	Threaded	Unthreaded	Threaded	Unthreaded	Threaded
½	1010	510	810	410	510	250	630	320
¾	770	390	620	310	390	190	480	240
1	720	360	570	290	360	180	450	220
1¼	600	300	480	240	300	150	370	190
1½	540	270	430	210	270	130	340	170
2	470	240	380	190	240	120	290	150
2½	470	230	370	190	230	120	290	150
3	440	220	360	180	220	110	280	140
3½	380	190	310	150	190	100	240	120
4	430	220	340	170	220	110	270	130
5	400	200	320	160	200	100	250	120
6	370	190	300	150	190	90	230	120
8	380	180	290	140	180	90	230	110
10	370	180	290	140	180	90	230	110
12	340	170	270	140	170	80	210	110

[A] See applicable ASTM standard for code designation, for example, PVC 1120. Pressure ratings are lower at elevated temperatures.

6.3.2 Proper fit between the pipe or tubing and mating socket or sleeve is essential to a good joint.

6.3.3 The mating surfaces shall be clean, dry, and free of materials that might be detrimental to the joint.

6.3.4 Solvent cements shall conform to Specification D2564 or F545 for making PVC joints.

6.3.5 A uniform coating of the solvent cement is required on both mating surfaces unless otherwise recommended by the manufacturer. Use a primer on PVC pipe. After the joint is made, excess cement shall be wiped from the outside of the joint. This paragraph is not applicable to joints made in accordance with Specification F545.

6.3.6 The joint shall not be disturbed until it has properly set.

6.3.7 A solvent-cement joint shall not be heated to accelerate the setting of the cement.

6.3.8 For more detail on making PVC solvent-cement joints see Practice D2855. For more detail on making joints by injecting solvent cement see Specification F545.

6.4 *Heat Fusion Joints*:

6.4.1 Sound butt heat-fusion joints require the use of a jointing device that holds the heater element square to the machined ends of the piping, compresses the heated ends together, and holds the piping in proper alignment while the plastic hardens.