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An American National Standard

Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems[1]

This standard is issued under the fixed designation F877; 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 specification covers requirements, test methods, and methods of marking for crosslinked polyethylene plastic hot- and cold-water distribution systems components made in one standard dimension ratio and intended for 100 psi (0.69 MPa) water service up to and including a maximum working temperature of 180°F (82°C). Components are comprised of tubing and fittings. Requirements and test methods are included for materials, workmanship, dimensions and tolerances, burst pressure, sustained pressure, excessive temperature and pressure, temperature cycling tests, and bend strength. Also included are tests related to system malfunctions. The components covered by this specification are intended for use in residential and commercial, hot and cold, potable water distribution systems as well as sealed central heating, including under-floor heating systems.

1.2 The text of this specification references notes, footnotes, and appendixes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the specification.

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

NOTE 1—Suggested hydrostatic design stresses and hydrostatic pressure ratings for tubing and fittings are listed in Appendix X1. Design, assembly, and installation considerations are discussed in Appendix X2. An optional performance qualification and an in-plant quality control program are recommended in Appendix X3.

1.4 The following safety hazards caveat pertains only to the test method portion, Section 7, of this specification: *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]

D618 Practice for Conditioning Plastics for Testing
D1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
D1599 Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings
D1600 Terminology for Abbreviated Terms Relating to Plastics
D1898 Practice for Sampling of Plastics [3]
D2749 Symbols for Dimensions of Plastic Pipe Fittings
D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
D3140 Practice for Flaring Polyolefin Pipe and Tubing[3]
F412 Terminology Relating to Plastic Piping Systems
F876 Specification for Crosslinked Polyethylene (PEX) Tubing
F1960 Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) Tubing
F1961 Specification for Metal Mechanical Cold Flare Compression Fittings with Disc Spring for Crosslinked Polyethylene (PEX) Tubing
F1807 Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Cross-linked Polyethylene (PEX) Tubing
F1865 Specification for Mechanical Cold Expansion Insert Fitting With Compression Sleeve for Cross-linked Polyethylene (PEX) Tubing
F2080 Specification for Cold-Expansion Fittings With Metal Compression-Sleeves for Cross-Linked Polyethylene (PEX) Pipe

[1] This specification 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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[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.

F2159 Specification for Plastic Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Cross-linked Polyethylene (PEX) Tubing

F2434 Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Cross-linked Polyethylene/Aluminum/Cross-linked Polyethylene (PEX-AL-PEX) Tubing

2.2 *ANSI Standards:*

B 36.10 Welded and Seamless Wrought Steel Pipe[4]

Z 17.1 Preferred Numbers[4]

2.3 *AWWA Standard:*

Manual M-11, Steel Pipe Design and Installation[5]

2.4 *Federal Standard:*

Fed Std. No. 123 Marking for Shipment (Civil Agencies)[6]

2.5 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[6]

2.6 *NSF Standard:*

Standard No. 14 for Plastic Piping Components and Related Materials[7]

3. Terminology

3.1 The terminology used in this specification is in accordance with Terminology F412, Terminology D1600, and Symbols D2749, unless otherwise specified. The abbreviation for crosslinked polyethylene is PEX. Plastic tubing denotes a particular diameter schedule of plastic pipe in which outside diameter of the tubing is equal to the nominal size plus ⅛ in. Plastic pipe outside diameter schedule conforms to ANSI B 36.10.

3.2 *crosslinked polyethylene plastics*—plastics prepared by crosslinking (curing) polyethylene compounds.

3.3 *relation between standard dimension ratio, stress, and internal pressure*—the following expressions, commonly known as the ISO equation, is used to relate standard dimension ratio, stress, and internal pressure for tubing:

$$2S/P = R - 1$$

or

$$2S/P = (D_o/t) - 1$$

where:

S = stress in circumferential or hoop direction, psi (MPa),
P = internal pressure, psi (MPa),
t = minimum wall thickness, in.,
R = standard dimension ratio, SDR, and
D_o = average outside diameter, in.

3.4 *standard dimension ratio (SDR)*—a selected series of numbers in which the average outside diameter to minimum wall thickness dimension ratios are constant for all sizes of tubing in each standard dimension ratio, and which are the ANSI Z 17.1 Preferred Number Series R 10 modified by +1. If the wall thickness calculated by SDR for PEX tubing is less than 0.070 in. (1.78 mm), it shall be arbitrarily increased to 0.070 in. except for sizes ¼ in. and smaller.

3.5 *standard material designation code*—the crosslinked polyethylene tubing material designation code shall consist of the abbreviation PEX.

3.6 *manifold*—an appurtenance that has at least one inlet and multiple outlets.

4. Materials

4.1 *General*— PEX tubing materials shall meet the requirements as described in Specification F876. Fitting and manifold materials shall meet the applicable requirements as described in Specifications F1807, F1865, F1960, F1961, F2080, F2159, or F2434.

4.2 *Basic Materials Description*—Crosslinked polyethylene tubing meeting the requirements of this specification are primarily defined by two criteria namely, basic short-term properties and long-term hydrostatic strength, 4.2.1 and 4.2.2 respectively.

4.2.1 *Basic Short-Term Properties*—This specification covers tubing materials meeting the requirements of Specification F876.

4.2.2 *Long-Term Hydrostatic Pressure Strength*—This specification covers PEX tubing which is further defined on the basis of long-term hydrostatic strength tests (Appendix X1).

4.3 *Certification*—PEX tubing and fittings, used for the distribution of potable water, shall be products approved for that service by the regulatory bodies having such jurisdiction. These products shall be tested for that service by a nationally recognized and accredited testing laboratory and shall bear the certification mark of the testing agency.

5. Classification

5.1 *Tubing*—This specification classifies PEX tubing by a single standard dimension ratio that shall be SDR 9, and by a maximum continuous use temperature that shall be 180°F (82°C), and by nominal tubing diameters from ⅛ in. through 6 in.

5.2 *Fittings*—This specification classifies fittings including manifolds, intended for use in systems with PEX tubing, by a maximum continuous use temperature that shall be 180°F (82°C) and by nominal sizes from ⅛ in. through 6 in. on the basis of resistance to burst pressure, hydrostatic sustained pressure, excessive temperature and pressure, and by thermocycling.

6. Requirements

6.1 *Workmanship*—The tubing shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, or other defects. The pipe shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

6.2 *Dimensions and Tolerances*:

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[5] Available from the American Water Works Association, 6666 W. Quincey Ave., Denver, CO 80235.

[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[7] Available from the National Sanitation Foundation, P.O. Box 1468, Ann Arbor, MI 48106.

6.2.1 Compliance with this specification requires that fittings contained in Specifications F1807, F1865, F1960,and F1961 must meet the Performance and Test Method requirements of F877.

6.2.1.1 *Tubing*—The PEX tubing shall meet the requirements of Specification F876. The tolerances for outside diameters are also given in Table 1.

6.2.1.2 *Out-of-Roundness*—The maximum out-of-roundness requirements, shown in Table 1 for tubing, apply to the average measured diameter after rounding with a rounding tool recommended by the manufacturer.

6.2.2 *Wall Thickness*—Table 2 provides for wall thickness tolerances. Calculated SDR 9 tubing wall thickness that fall below 0.070 in. (1.78 mm) shall be arbitrarily increased to that value except for sizes ¼ in. and smaller.

6.2.3 *Fittings (Basic Dimensions)*—Fittings shall be compatible with tubing made to the requirements of Table 1 and Table 2. Fittings shall be made from materials that are generally regarded as corrosion resistant.

6.3 *Hydrostatic Burst*:

6.3.1 Tubing and fittings (tested as assemblies) shall meet the minimum hydrostatic burst requirements shown in Table 3 when tested in accordance with 7.6.

6.3.2 Fittings assembled using the manufacturer's instructions shall meet the minimum hydrostatic burst requirement shown in Table 3 when tested in accordance with 7.6.

6.3.2.1 If present, valves shall be tested in the open or unrestricted position.

6.3.2.2 If the manifold has more than one connection size, the test pressure selected from Table 3 shall be based upon the largest nominal PEX connection.

6.4 *Hydrostatic Sustained Pressure Strength*

6.4.1 Tubing and fittings (tested as assemblies) shall meet the minimum hydrostatic sustained pressure strength requirements shown in Table 4 when tested in accordance with 7.4.

6.4.1.1 If present, valves shall be tested in the open or unrestricted position.

6.5 *Thermocycling*:

6.5.1 Fittings, assembled using the manufacturer's instructions, shall not leak after completion of 1000 cycles between the temperatures of 60°F (16°C) and 180°F (82°C) when tested in accordance with 7.5.

6.5.1.1 If present, valves shall be tested in the open or unrestricted position.

6.6 *Bent Tube Hydrostatic Sustained Pressure Strength*:

TABLE 2 Wall Thickness and Tolerances for PEX SDR 9 Plastic Tubing

Nominal Tubing		Minimum Wall Thickness		Tolerance	
in.	mm	in.	mm	in.	mm
⅛	3	0.047[A]	1.19[A]	+0.007	+0.18
¼	7	0.062[A]	1.57[A]	+0.010	+0.25
5⁄16	8	0.064	1.63	+0.010	+0.25
⅜	10	0.070[A]	1.78[A]	+0.010	+0.25
½	13	0.070[A]	1.78[A]	+0.010	+0.25
⅝	16	0.083	2.12	+0.010	+0.25
¾	19	0.097	2.47	+0.010	+0.25
1	25	0.125	3.18	+0.013	+0.33
1¼	32	0.153	3.88	+0.015	+0.38
1½	38	0.181	4.59	+0.019	+0.48
2	51	0.236	6.00	+0.024	+0.61
2½	64	0.292	7.41	+0.030	+0.76
3	76	0.347	8.82	+0.033	+0.84
3½	89	0.403	10.23	+0.035	+0.89
4	102	0.458	11.64	+0.040	+1.02
4½	114	0.514	13.05	+0.045	+1.14
5	127	0.569	14.46	+0.050	+1.27
6	152	0.681	17.29	+0.060	+1.52

[A] For tubing sizes of ½ in. and below, wall thickness minimums are not functions of SDR.

TABLE 3 Minimum Hydrostatic Burst Strength Requirements for PEX Tubing and Fittings

Nominal Tubing Size		Minimum Burst Pressures at Different Temperatures			
in.	mm	psi[A] at 73.4°F	(MPa) at (23°C)	psi[A] at 180°F	(MPa) at (82.2°C)
⅛	3	870	(6.00)	390	(2.69)
¼	7	752	(5.19)	336	(2.32)
⅜	10	620	(4.27)	275	(1.90)
½	13	480	(3.31)	215	(1.48)
⅝ and larger	16 and larger	475	(3.27)	210	(1.45)

[A] The fiber stress used to derive this test pressure is:
at 73.4°F (23.0°C) 1900 psi (13.10 MPa).
at 180°F (82.2°C) 850 psi (5.86 MPa).

TABLE 1 Outside Diameters and Tolerances for PEX Tubing

Nominal Tubing Size		Average Outside Diameter		Tolerances for Average Diameter		Out of Roundness[A]	
in.	mm	in.	mm	in.	mm	in.	mm
⅛	3	0.250	6.35	±0.003	±0.08	0.008	0.20
¼	7	0.375	9.52	±0.003	±0.08	0.008	0.20
5⁄16	8	0.430	10.92	±0.003	±0.08	0.008	0.20
⅜	10	0.500	12.70	±0.003	±0.08	0.012	0.32
½	13	0.625	15.88	±0.004	±0.10	0.016	0.40
⅝	16	0.750	19.05	±0.004	±0.10	0.016	0.40
¾	19	0.875	22.22	±0.004	±0.10	0.016	0.40
1	25	1.125	28.58	±0.005	±0.12	0.020	0.48
1¼	32	1.375	34.92	±0.005	±0.12	0.020	0.48
1½	38	1.625	41.28	±0.006	±0.16	0.024	0.60
2	51	2.125	53.98	±0.006	±0.16	0.030	0.76
2½	64	2.625	66.68	±0.007	±0.18	0.038	0.95
3	76	3.125	79.38	±0.008	±0.20	0.045	1.14
3½	89	3.625	92.08	±0.008	±0.20	0.046	1.16
4	102	4.125	104.78	±0.009	±0.23	0.052	1.32
4½	114	4.625	117.48	±0.009	±0.23	0.059	1.49
5	127	5.125	130.18	±0.010	±0.25	0.065	1.65
6	152	6.125	155.58	±0.011	±0.28	0.072	1.83

[A] The out-of-roundness specification applies only to tubing prior to coiling.

TABLE 4 Minimum Hydrostatic Sustained Pressure Requirements for PEX SDR 9 Tubing and Fitting Assemblies[A,B]

Nominal Tubing Size		Pressure Required for Test, psi (MPa)[A]	
in.	mm	180°F	(82.2°C)
⅛	3	355	(2.45)
¼	7	305	(2.10)
⅜	10	250	(1.72)
½	13	195	(1.34)
⅝ and larger	16 and larger	190	(1.31)

[A] The fiber stress used to derive this test pressure is: 770 psi (5.31 MPa) at 180°F (82.2°C).
[B] Test duration is 1000 h.

6.6.1 *General*—PEX tubing, up to and including 1in. nominal diameter, can be installed bent by using either of two techniques described in X2.3.5 and X2.3.6 provided that 6.6.2 and 6.6.3 requirements are met.

NOTE 2—PEX tubing, larger than 1 in. nominal diameter, is typically installed as main distribution lines and is installed in staight runs. Fittings are used when a change in direction of 90° or greater and a bend radius of 6 times the outside diameter is needed. The test procedures in 6.6.2 and 6.6.3 are intended to evaluate PEX tubing installed in tight bend applications in accordance with the procedures in X2.3.5 and X2.3.6. This application applies to tubing up to and including 1 in. nominal diameter only.

6.6.2 Hot-bent tubing, with a radius of 2.5 times the outside diameter and consisting of a continuous bend length inducing not less than 90° angle, shall meet the minimum hydrostatic sustained pressure strength requirements shown in Table 4 when tested in accordance with 7.4. The bend length and bend angle is kept throughout the testing period by rigid supports immediately outside the bend.

6.6.3 Cold-bent tubing, with a radius of 6 times the outside diameter and consisting of a continuous bend length inducing not less than 90° angle, shall meet the minimum hydrostatic sustained pressure strength requirements shown in Table 4 when tested in accordance with 7.4. The bend length and bend angle is kept throughout the testing period by rigid secures immediately outside the bend.

6.7 *Excessive Temperature—Pressure Capability*:

6.7.1 *General*—In the event of a water heating system malfunction, PEX tubing shall have adequate strength to accommodate short-term conditions, 48 h of 210°F (99°C), 150 psi (1034 kPa) until repairs can be made.

6.7.2 *Excessive Temperature Hydrostatic Sustained Pressure*—Tubing and fittings, when tested as assemblies, shall not fail as defined in Test Method D1598 in less than 30 days (720 h) when tested in accordance with 7.7.

6.7.2.1 If present, valves shall be tested in the open or unrestricted position.

NOTE 3—Test applicable to assemblies and bends (6.3, 6.4, 6.5, 6.6, and 6.7) are intended to be performance qualification tests and not tests required of each fitting.

7. Test Methods

7.1 *Conditioning*—The test specimens should be conditioned at 70 to 77°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Practice D618, for those tests where conditioning is required.

7.2 *Test Conditions*—Conduct the tests in the standard laboratory atmosphere of 70 to 77°F (23 ± 2°C) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this specification.

7.3 *Sampling*—A sufficient quantity of tubing or fittings, as agreed upon by the purchaser and the seller, shall be selected and tested to determine conformance with this specification (see Practice D1898). In the case of no prior agreement, random samples selected by the testing laboratory shall be deemed adequate.

7.4 *Hydrostatic Sustained Pressure*— Determine in accordance with Test Method D1598, except for the following:

7.4.1 Test at least six joints, from randomly selected specimens assembled per the manufacturer's instructions with at least 5-pipe diameters between joints.

7.4.2 Test temperature shall be 180 ± 4°F (82 ± 2°C).

7.4.3 The external test environment shall be air or water.

7.4.4 Fill the specimens with water at a temperature of at least 120°F (50°C).

7.5 *Thermocycling*:

7.5.1 *Summary of Test Method*—This test method describes a pass-fail test for thermally cycling PEX tubing and fittings assemblies over a critical temperature range for a selected number of cycles while subjected to a nominal internal pressure. This test method provides a measure of resistance to failure due to the combined effects of differential thermal expansion and creep for PEX tubing and fittings intended for continuous use up to and including 180°F (82°C).

7.5.2 *Apparatus*—A nitrogen or air source capable of maintaining a nominal internal pressure of 100 ± 10 psi (0.69 ± 0.069 MPa) on the specimens is required. The immersion system shall consist of two water reservoirs controlled at 60 ± 4°F (16± 2°C) and 180 ± 4°F (82 ± 2°C). The specimen shall be cycled from one reservoir to the other or the hot and cold water shall be alternately cycled over the test specimens automatically and returned to the proper reservoirs.

NOTE 4—Automatic cycling may be accomplished by pumping from each reservoir, through a delivery system having timer-actuated valves, to a specimen water trough having synchronized, timer-actuated return drains. Any automatic apparatus shall provide for complete immersion of the test specimen in the trough.

7.5.3 *Sampling and Specimen Preparation*— Select at least six joints from randomly selected specimens assembled per the manufacturer's instructions. Close the specimen assembly with any suitable end closures that allow "free-end" mounting and will not leak under the thermocycling conditions, and connect the specimen assembly to the pressure source.

7.5.4 *Procedure*—Pressurize the specimen assembly with nitrogen or air to 100 ± 10 psi (0.69 ± 0.069 MPa) . Immerse in 60 ± 4°F (16 ± 2°C) water to determine if there are any initial leaks. All leaks shall be eliminated before the thermocycling test is started. Thermally cycle the specimen assembly either manually or automatically and under an internal pressure of 100 ± 10 psi (0.69± 0.069 MPa), alternately between 60 ± 4°F (16 ± 2°C) and 180 ± 4°F (82 ± 2°C) by means of immersion in water using the following test cycle:

Water immersion at 180°F (82°C)	2 min (min)
Air immersion at ambient	2 min (max)