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An American National Standard

Standard Specification for Crosslinked Polyethylene (PEX) 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 marking requirements for system components when tested with nominal SDR9 crosslinked polyethylene (PEX) tubing as a system. Systems are intended for 100 psi (0.69 MPa) water service up to and including a maximum working temperature of 180 °F (82 °C). Requirements and test methods are included for materials, workmanship, dimensions and tolerances, burst pressure, hydrostatic sustained pressure, excessive temperature and pressure, corrosion resistance, and thermocycling tests. The components covered by this specification are intended for use in, but not limited to, residential and commercial hot and cold potable water distribution systems or other applications such as reclaimed water, fire protection, municipal water service lines, radiant heating and cooling systems, hydronic distribution systems, snow and ice melting systems, geothermal ground loops, district heating, turf conditioning, compressed air distribution, and building services pipe.

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. For additional information on the use of PEX tubing for high-temperature non-potable applications and for chlorinated potable water, see PPI Technical Notes 52 and 53, respectively.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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

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
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
F412 Terminology Relating to Plastic Piping Systems
F876 Specification for Crosslinked Polyethylene (PEX) Tubing

[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.

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

F1807 Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps, for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing
F1960 Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) and Polyethylene of Raised Temperature (PE-RT) Tubing
F2080 Specification for Cold-Expansion Fittings with Metal Compression-Sleeves for Crosslinked Polyethylene (PEX) Pipe and SDR9 Polyethylene of Raised Temperature (PE-RT) Pipe
F2098 Specification for Stainless Steel Clamps for Securing SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) to Metal Insert and Plastic Insert Fittings
F2159 Specification for Plastic Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) 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
F2735 Specification for Plastic Insert Fittings For SDR9 Cross-linked Polyethylene (PEX) and Polyethylene of Raised Temperature (PE-RT) Tubing
F2854 Specification for Push-Fit Crosslinked Polyethylene (PEX) Mechanical Fittings for Crosslinked Polyethylene (PEX) Tubing
F3347 Specification for Metal Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Cross-linked Polyethylene (PEX) Tubing
F3348 Specification for Plastic Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Cross-linked Polyethylene (PEX) Tubing

2.2 *ANSI Standards:*
B 36.10 Welded and Seamless Wrought Steel Pipe[3]

2.3 *AWWA Standard:*
Manual M-11, Steel Pipe Design and Installation[4]

2.4 *Federal Standard:*
Fed Std. No. 123 Marking for Shipment (Civil Agencies)[5]

2.5 *Military Standard:*
MIL-STD-129 Marking for Shipment and Storage[5]

2.6 *NSF Standard:*
NSF/ANSI Standard No. 14 for Plastic Piping Components and Related Materials[6]
NSF/ANSI Standard No. 61 for Drinking Water System Components-Health Effects[6]

2.7 *Plastic Pipe Institute Technical Notes:*[7]
Technical Note-52 Guide to High-Temperature Applications of Non-Potable PEX Pipe and Tubing Systems
Technical Note-53 Guide to Chlorine Resistance Ratings of PEX Pipes and Tubing for Potable Water Applications

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 *Definitions of Terms Specific to This Standard:*

3.2.1 *crosslinked polyethylene plastics*—a polyethylene material that has undergone a change in molecular structure through processing whereby a majority of the polymer chains are chemically linked.

3.2.2 *fitting*—a piping component used to join or terminate sections of PEX tubing or to provide changes of direction or branching in a piping system. This includes appurtenances such as couplings, elbows, tees, or plugs used to connect tubing or as an accessory to tubing.

3.2.3 *standard dimension ratio (SDR)*—the ratio of outside diameter to wall thickness. For PEX tubing, it is calculated by dividing the average outside diameter of the tubing in inches or in millimeters by the minimum wall thickness in inches or millimeters. If the wall thickness calculated by this formula is less than 0.070 in. (1.78 mm) it shall be arbitrarily increased to 0.070 in. except for nominal tubing sizes 5⁄16 and smaller, as specified in Table 3. The SDR values shall be rounded to the nearest 0.5.

3.2.4 *manifold*—an appurtenance that has at least one inlet and multiple outlets with integral fittings, valves, or both.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.
[5] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.
[6] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, http://www.nsf.org.
[7] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

3.2.5 *system components*—fittings, valves with integral fittings, and manifolds which connect directly to PEX tubing made in accordance with Specification F876.

3.2.6 *system component assembly*—system component connected directly to PEX tubing made in accordance with Specification F876.

4. Materials

4.1 *General*—PEX systems shall use crosslinked polyethylene tubing as described in Specification F876.

4.2 Fitting and manifold materials shall meet the applicable requirements as described in Specifications F1807, F1960, F2080, F2098, F2159, F2434, F2735, F2854, F3347 or F3348.

4.3 *Certification*—PEX tubing and system components, 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 testing laboratory that is accredited for this specification and shall bear the certification mark of the testing agency.

5. Classification

5.1 *Fittings*—This specification classifies fittings, including system components, intended for use in systems with PEX tubing, by a maximum continuous use temperature that shall be 180 °F (82 °C) and by nominal tubing sizes (NTS) from ⅛ through 6 on the basis of resistance to burst pressure, hydrostatic sustained pressure, excessive temperature pressure capability, and by thermocycling. Fittings shall be compatible with tubing made to the requirements of Specification F876.

6. Requirements

6.1 *General*—Compliance with this specification requires that fittings contained in Specifications F1807, F1960, F2080, F2098, F2159, F2434, F2735, F2854, F3347 and F3348 and system components must meet all requirements of this section.

6.2 *Workmanship*—Fittings shall be homogeneous throughout, uniform in appearance and free of cracks, holes, blisters, voids, foreign inclusions, or other defects that are visible to the naked eye and may affect fitting integrity. All sealing surfaces shall be smooth and free of foreign material.

6.3 *Dimensions and Tolerances:*

6.3.1 The dimensions and tolerances of fittings shall meet the specific requirements contained in Specifications F1807, F1960, F2080, F2098, F2159, F2434, F2735, F3347 and F3348 or other recognized specification.

6.4 *Corrosion Resistance*—Fittings intended for potable water applications shall comply with dezincification resistance and stress corrosion cracking resistance requirements of NSF/ANSI Standard 14.

6.5 *Hydrostatic Burst:*

6.5.1 System component assemblies assembled using the manufacturer's instructions shall meet the minimum hydrostatic burst requirements shown in Table 1 when tested in accordance with 7.7.

6.5.2 System components with integral shut-offs (valves) shall be tested with all ports in the full-open or unrestricted position.

6.5.2.1 If the system component assembly has more than one connection size, the test pressure selected from Table 1 shall be based upon the largest nominal PEX connection.

6.6 *Hydrostatic Sustained Pressure Strength*

6.6.1 System component assemblies shall meet the minimum hydrostatic sustained pressure strength requirements shown in Table 2 when tested in accordance with 7.5. Test duration shall be 1000 h.

6.6.1.1 System components with integral shut-off (valves) shall be tested with all ports in the full-open or unrestricted position.

TABLE 1 Burst Pressure Requirements for SDR9 PEX System Component Assemblies

Nominal Tubing Size	Minimum Burst Pressures at Different Temperatures			
	psi[A] at 73 °F	(MPa) at (23 °C)	psi[A] at 180 °F	(MPa) at (82 °C)
⅛	870	(6.00)	390	(2.69)
¼	752	(5.19)	336	(2.32)
⅜	620	(4.27)	275	(1.90)
½	480	(3.31)	215	(1.48)
⅝ and larger	475	(3.27)	210	(1.45)

[A] The fiber stress for SDR9 PEX tubing used to derive this test pressure is:
at 73 °F (23 °C) 1900 psi (13.10 MPa).
at 180 °F (82 °C) 850 psi (5.86 MPa).

TABLE 2 Minimum Hydrostatic Sustained Pressure Requirements for SDR9 PEX System Component Assemblies[A]

Nominal Tubing Size	Pressure Required for Test, psi (MPa)[A]	
	180 °F	(82 °C)
⅛	355	(2.45)
¼	305	(2.10)
⅜	250	(1.72)
½	195	(1.34)
⅝ and larger	190	(1.31)

[A] The fiber stress for SDR9 PEX tubing used to derive this test pressure is: 770 psi (5.31 MPa) at 180 °F (82 °C).

6.7 *Thermocycling:*

6.7.1 System components, 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 7.6.

6.7.1.1 System components with integral shut-offs (valves) shall be tested with all ports in the full open or unrestricted position.

6.8 *Excessive Temperature/Pressure Capability*—System component assemblies shall not fail as defined in Test Method D1598 in less than 30 days (720 h) when tested in accordance with 7.8.

NOTE 2—The rationale for test requirement 6.8 is so that in the event of a domestic hot-water system malfunction, PEX tubing and system components 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.

6.8.1 System components with integral shut-offs (valves) shall be tested with all ports in the full open or unrestricted position.

NOTE 3—Tests applicable to assemblies and bends (6.5, 6.6, 6.7, and 6.8) are intended to be performance qualification tests and not tests required of each fitting.

7. Test Methods

7.1 *General*—Sections 7.4, 7.5, 7.6, 7.7, and 7.8 shall use separate sets of assemblies for each test.

7.2 *Conditioning*—The test specimens should be conditioned at 73 ± 4 °F (23 ± 2 °C) and 50 ± 10 % relative humidity for not less than 40 h prior to test in accordance with Practice D618, for those tests where conditioning is required.

7.3 *Test Conditions*—Conduct the tests in the standard laboratory atmosphere of 73 ± 4 °F (23 ± 2 °C) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this specification.

7.4 *Sampling*—A sufficient quantity of tubing and system components, as agreed upon by the purchaser and the seller, shall be selected and tested to determine conformance with this specification. In the case of no prior agreement, random samples selected by the testing laboratory shall be deemed adequate.

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

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

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

7.5.3 The external test environment shall be air or water.

7.5.4 Condition the specimens in accordance with Test Method D1598.

7.6 *Thermocycling:*

7.6.1 *Summary of Test Method*—This test method describes a pass-fail test for thermally cycling system component 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 system components intended for continuous use up to and including 180 °F (82 °C).

7.6.2 *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 °F (82 °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.

7.6.3 *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.

7.6.4 *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)
Water immersion at 60 °F (16 °C)	2 min (min)
Air immersion at ambient	2 min (max)

Upon the completion of 1000 thermal cycles, immerse the specimen assembly again in 60 ± 4 °F (16 ± 2 °C) water and check for any sign of gas leakage. Any evidence of leakage at the joint or separation of the fitting from the tubing constitutes a failure.

7.6.5 *Interpretation of Results*—Failure of any one of the system component assemblies, including six joints tested, shall constitute failure of this test.

7.7 *Hydrostatic Burst Strength*—Determine the minimum hydrostatic strength for tubing and system component assemblies at both 73 °F (23 °C) and 180 °F (82 °C) in accordance with Test Method D1599, except as herein specified.

7.7.1 *Procedure*—Select at least six joints from randomly selected specimens assembled per the manufacturer's instructions with at least 5-pipe diameters between joints. After assembly, attach end closures, fill the specimen assembly with water, and condition in water at the test temperature for 2 h min (or in air for 4 h min). In the case of testing at 180 °F (82 °C), the sample should be filled with water of at least 120 °F (50 °C) temperature prior to conditioning.

7.7.1.1 Increase the internal pressure at a constant rate so as to reach the maximum burst requirement in 60 to 70 s. Leakage or separation at any of the joints tested, at less than the minimum hydrostatic burst requirements for either temperature specified in Table 1, shall constitute failure in this test.

7.8 *Excessive Temperature / Pressure Capability of System Components:*

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

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

7.8.1.2 Condition the specimens in accordance with 7.2.

7.8.1.3 Test temperature shall be 210 ± 4 °F (99 ± 2 °C).

7.8.1.4 The external test environment shall be air.

7.8.1.5 Fill the specimens with water and condition for 2 h at a temperature of 210 ± 4 °F (99 ± 2 °C) and a pressure of 30 ± 3 psi (207 ± 21 kPa).

7.8.1.6 Pressurize test specimens to 150 psi (1034 kPa) and maintain for 30 days (720 h).

8. Retest and Rejection

8.1 If the results of any test(s) do not meet the requirements of this specification, the tests(s) shall be conducted again only by agreement between the purchaser and seller. Under such agreement, minimum requirements shall not be lowered, changed, or modified, nor shall specification limits be changed. If upon retest, failure occurs, the quantity of product represented by the test(s) does not meet the requirements of this specification.

9. Certification

9.1 PEX system components intended for use in the transport of potable water shall be evaluated and certified as safe for this purpose by a testing agency acceptable to the local health authority. The evaluation shall be in accordance with the requirements for chemical extraction, taste, and odor, that are no less restrictive than those included in NSF/ANSI Standard No. 14 and NSF/ANSI Standard No. 61. The seal or mark of the laboratory making the evaluation shall be included on the system components.

10. Marking

10.1 *Quality of Marking*—The marking shall be applied to system components in such a manner that it remains legible (easily read) after installation and inspection.

10.1.1 Markings or symbols may be rolled, molded, hot-stamped, etched or applied by printing methods.

10.1.2 Where recessed marking is used, the marking shall not cause cracks or reduce the wall thickness below the minimum requirement in the specific standard specification for the system component.

10.2 *Content of Marking:*

10.2.1 Manufacturer's name or trademark.

10.2.2 Certification mark or seal of the laboratory making the evaluation for this purpose.

10.2.3 This designation, F877 or the specified standard specification for the system component.

11. Quality Assurance

11.1 When the product is marked with this designation, F877 or the with the specific standard specification for the system component, the manufacturer affirms that the product was manufactured, inspected sampled and tested in accordance with this specification and has been found to meet the requirements of this specification.

SUPPLEMENTARY REQUIREMENTS

GOVERNMENT/MILITARY PROCUREMENT

These requirements apply *only* to federal/military procurement, not domestic sales or transfers.

S1. *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless the purchaser disapproves. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

NOTE S1.1—In U. S. Federal contracts, the contractor is responsible for inspection.

S2. *Packaging and Marking for U.S. Government Procurement:*

S2.1 *Packaging*—Unless otherwise specified in the contract, the system components shall be packaged in accordance with the supplier's standard practice in a manner ensuring arrival at destination in satisfactory condition and which will be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification rules or National Motor Freight Classification rules.

S2.2 *Marking*—Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

NOTE S2.1—The inclusion of U.S. Government procurement requirements should not be construed as an indication that the U.S. Government uses or endorses the products described in this specification.

APPENDIXES

(Nonmandatory Information)

X1. HYDROSTATIC DESIGN STRESS

X1.1 Hydrostatic design stresses recommended by the Plastic Pipe Institute are used to pressure rate PEX plastic tubing. These design stresses are based on the 100 000-h hydrostatic strength of the tubing obtained in accordance with Test Method D2837. Additional information regarding the method of test and other criteria used in developing these hydrostatic design stresses may be obtained from the Plastics Pipe Institute at www.plasticpipe.org. See Table X1.1.

TABLE X1.1 Hydrostatic Design Stresses and Pressure Ratings for SDR9 PEX Distribution Systems

Rated Temperature		Hydrostatic Design Stress		Pressure Rating for Water	
°F	(°C)	psi	(MPa)	psi	(MPa)
73	(23)	630	(4.34)	160	(1.10)
180	(82)	400	(2.76)	100	(0.69)