Designation: F 876 – 02

An American National Standard

Standard Specification for Crosslinked Polyethylene (PEX) Tubing[1]

This standard is issued under the fixed designation F 876; 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 crosslinked polyethylene (PEX) tubing that is outside diameter controlled, made in standard thermoplastic tubing dimension ratios, and pressure rated for water at three temperatures (see Appendix X1). Included are requirements and test methods for material, workmanship, dimensions, sustained pressure, burst pressure, environmental stress cracking, stabilizer migration resistance, and degree of crosslinking. Methods of marking are also given.

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 given in parentheses are for information only.

1.4 The following safety hazards caveat pertains only to the test methods 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:*

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[2]

D 1505 Test Method for Density of Plastics by the Density-Gradient Technique[2]

D 1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure[3]

D 1599 Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings[3]

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

D 1898 Practice for Sampling of Plastics[2]

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings[3]

D 2765 Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics[4]

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials[3]

D 3045 Practice for Heat Aging of Plastics Without Load[4]

D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials[4]

D 3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry[4]

F 412 Terminology Relating to Plastic Piping Systems[3]

F 2023 Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Tubing and Systems to Hot Chlorinated Water[3]

2.2 *ANSI Standard:*

B36.10 Standards Dimensions of Steel Pipe (IPS)[5]

2.3 *Federal Standard:*

FED-STD-123 Marking for Shipment (Civil Agencies)[6]

2.4 *Military Standard:*

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

2.5 *NSF Standard:*

NSF 14 for Plastic Piping Components and Related Materials[7]

2.6 *ISO Standard:*[5]

ISO R 161-1690 Pipes of Plastic Materials for the Transport of Fluids (Outside Diameters and Nominal Pressures) Part 1, Metric Series

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F 412F 412, and abbreviations are in accordance with Terminology D 1600D 1600, unless otherwise specified. The

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.26 on Olefin Based Pipe.

Current edition approved November 10, 2002. Published March 2003. Originally approved in 1984. Last previous edition approved in 2001 as F 876 – 01$^{\epsilon 1}$.

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

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

[4] *Annual Book of ASTM Standards*, Vol 08.02.

[5] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

[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.

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 B36.10.

3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.2 *hydrostatic design stress*—the estimated maximum tensile stress the material is capable of withstanding continuously with a high degree of certainty that failure of the tube will not occur. This stress is circumferential when internal hydrostatic water pressure is applied.

3.2.3 *pressure rating (PR)*—the estimated maximum water pressure the tube is capable of withstanding continuously with a high degree of certainty that failure of the tube will not occur.

3.2.4 *relation between dimensions, hydrostatic design stress, and pressure rating*—the following expression, commonly known as the ISO equation,[8] is used in this specification to relate dimensions, hydrostatic design stress, and pressure rating:

$$2S/P = (D_O/t) - 1 \quad (1)$$

or

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

where:

S = hydrostatic design stress, psi (or MPa),
P = pressure rating, psi (or MPa),
D_O = average outside diameter, in. (or mm),
t = minimum wall thickness, in. (or mm), and
R = standard dimension ratio, SDR.

3.2.5 *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 millimetres by the minimum wall thickness in inches or millimetres. 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 sizes ⅛ in. and smaller. The SDR values shall be rounded to the nearest 0.5.

3.2.6 *standard thermoplastic tubing materials designation code*—the tubing material designation code shall consist of the abbreviation PEX for the type of plastic.

4. Tubing Classification

4.1 *General*—This specification covers one PEX tubing material in one standard dimension ratio and having pressure ratings for water of three temperatures. The pressure ratings decrease as the temperature is increased.

4.2 *Standard Thermoplastic Pipe Dimension Ratio (SDR)*—This specification covers PEX tubing in one standard dimension ratio (SDR 9). The pressure ratings are uniform for all nominal tubing sizes.

5. Materials

5.1 *General*—Crosslinked polyethylene tubing, meeting the requirements of this specification, are primarily defined by means of three criteria, namely, (*1*) nominal density, (*2*) degree of crosslinking, and (*3*) long-term strength tests. There is a strong correlation between nominal density and results of short-term strength tests.

NOTE 1—PEX tubing intended for use in the transport of potable water should be evaluated and certified as safe for this purpose by a testing agency acceptable to the local health authority. The evaluation should be in accordance with requirements for chemical extraction, taste, and odor that are no less restrictive than those included in NSF 14. The seal or mark of the laboratory making the evaluation should be included on the tubing.

5.2 *Basic Materials*—PEX tubing shall be made from polyethylene compounds which have been crosslinked by peroxides, Azo compounds, or silane compounds in extrusion, or by electron beam after extrusion, or by other means such that the tubing meets the performance requirements of Section 6. For the use temperatures that the tubing will be marked for, the materials, procedure for mixing, and the process for crosslinking shall result in a product with long term hydrostatic stress ratings equal to or better than those shown in Table 1, when determined in accordance with procedures no less restrictive than those of PPI TR-3/92.[9] See Appendix X1 for additional information on PPI hydrostatic stress ratings.

TABLE 1 Hydrostatic Design Stresses and Pressure Ratings for PEX SDR 9 Plastic Tubing for Water at Different Temperatures

Rated Temperature		Hydrostatic Design Stress		Pressure Rating for Water	
°F	°C	psi	(MPa)	psi	(MPa)
73.4	23	630	(4.34)	160	(1.10)
180	82.2	400	(2.76)	100	(0.69)
200	93.3	315	(2.17)	80	(0.55)

NOTE 2—Tubing produced by crosslinking by peroxides, Azo compounds, or silane compounds in extrusion, or by electron beam after extrusion have met the requirements of Section 6. There are several other processes for producing crosslinked polyethylene tubing. However, each process must be established as meeting the requirements of this specification.

5.3 *Tubing Material Designation*—The tubing meeting the requirements of this specification shall be designated PEX.

6. *Requirements* 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*:

6.2.1 *Outside Diameters*—The outside diameters and tolerances shall be as shown in Table 2, when measured in accordance with 7.4 and 7.4.1.

6.2.2 *Wall Thickness*—The wall thickness and tolerances shall be as shown in Table 3, when measured in accordance with 7.4 and 7.4.2.

[8] ISO R161-1690.

[9] *PPI Technical Report TR-3/92*, Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials.

TABLE 2 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 3 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.

6.2.3 *Wall Thickness Range*—The wall thickness range shall be within 12 %, when measured in accordance with 7.4 and 7.4.2.

6.3 *Density*—When determined in accordance with 7.5, the crosslinked polyethylene tubing material shall have a minimum density of 0.926 Mg/m^3.

6.4 *Sustained Pressure*—The tubing shall not fail, balloon, burst, or weep as defined in Test Method D 1598D 1598, at the test pressures given in Table 4 when tested in accordance with 7.6.

6.5 *Burst Pressure*—The minimum burst pressure for PEX plastic tubing shall be as given in Table 5, when determined in accordance with 7.7.

6.6 *Environmental Stress Cracking*— There shall be no loss of pressure in the tubing, when tested in accordance with 7.8.

6.7 *Degree of Crosslinking*—When tested in accordance with 7.9, the degree of crosslinking for PEX tubing material shall be within the range from 65 to 89 % inclusive. Depending on the process used, the following minimum percentage crosslinking values shall be achieved: 70 % by peroxides, 65 % by Azo compounds, 65 % by electron beam, or 65 % by silane compounds.

NOTE 3—Techniques as found in Test Methods D 2765D 2765.

6.8 *Stabilizer Functionality*— Stabilizer Functionality shall be tested in accordance with 7.10.

6.9 *Oxidative Stability in Potable Chlorinated Water Applications*—PEX tubing intended for use in the transport of

TABLE 4 Sustained Water Pressure Test Condition for PEX SDR 9 Plastic Tubing

Nominal Tubing Size		Pressure Required for Test, psi[A] (MPa)					
in.	mm	73.4°F	(23°C)	180°F	(82.2°C)	200°F	(93.3°C)
⅛	3	595	(4.10)	355	(2.45)	300	(2.07)
¼	7	595	(4.10)	355	(2.45)	300	(2.07)
⅜	10	525	(3.62)	250	(1.72)	210	(1.45)
½	13	330	(2.28)	195	(1.34)	165	(1.14)
⅝ and larger	16 and larger	325	(2.24)	190	(1.31)	165	(1.14)

[A] The fiber stresses used to derive these test pressures are:
at 73.4°F (23.0°C) 1300 psi (8.96 MPa).
at 180°F (82.2°C) 770 psi (5.31 MPa).
at 200°F (93.3°C) 650 psi (4.48 MPa).