Designation: F 876 – 04

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:* [2]

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing

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

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

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

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

D 1600 Terminology for Abbreviated Terms Relating to Plastics

D 1898 Practice for Sampling of Plastics

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

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

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

D 3045 Practice for Heat Aging of Plastics Without Load

D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

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

F 412 Terminology Relating to Plastic Piping Systems

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

2.2 *ANSI Standard:*

B36.10 Standards Dimensions of Steel Pipe (IPS)[3]

2.3 *Federal Standard:*

FED-STD-123 Marking for Shipment (Civil Agencies)[4]

2.4 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[4]

2.5 *NSF Standard:*

NSF 14 for Plastic Piping Components and Related Materials[5]

2.6 *ISO Standard:*[3]

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

2.7 *PPI Standard:*[6]

PPI TR-4 PPI Listing of Hydrostatic Design Basis (HDB), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings

[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.

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

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

[5] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140.

[6] Available from the Plastic Pipe Institute, 1825 Connecticut Ave., NW Suite 680 Washington, DC 20009

for Thermoplastic Piping Materials or Pipe

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F 412, and abbreviations are in accordance with Terminology D 1600, 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 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,[7] 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 for the type of plastic (PEX) followed by four Arabic digits that describe short-term properties in accordance with applicable ASTM standards.

(1) The first digit is for chlorine resistance tested in accordance with Test Method F 2023. A digit "1" indicates the PEX tubing has been tested and meets the F 876 requirement for minimum chlorine resistance at the end use condition of 25% at 140°F (60°C) and 75% at 73°F (23°C). A digit "0" indicates it does not meet this requirement or it has not been tested.

*(2)*The second digit is a "0". This digit is reserved for another PEX tubing property.

(3) The last two digits are the hydrostatic design stress for water at 73°F (23°C) in units of 100 psi with any decimal figures dropped. Where the hydrostatic design stress code contains less than two figures, a zero is used before the number.

Thus, a complete material designation code for PEX tubing shall consist of the three letters "PEX" and four digits. For example, PEX 1006 is PEX tubing with a 630-psi design stress (1250-psi HDB) for water at 73°F (23°C) that meets the minimum chlorine resistance requirement. PEX material designation codes are listed in PPI TR-4.

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.[8] See Appendix X1 for additional information on PPI hydrostatic stress ratings.

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

[7] ISO R161-1690.

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

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)

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

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.

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 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.

TABLE 3 Wall Thickness and Tolerances for PEX SDR 9 Plastic Tubing[A]

Nominal Tubing		Minimum Wall Thickness		Tolerance	
in.	mm	in.	mm	in.	mm
⅛	3	0.047[B]	1.19[B]	+0.007	+0.18
¼	7	0.062[B]	1.57[B]	+0.010	+0.25
5/16	8	0.064	1.63	+0.010	+0.25
⅜	10	0.070[B]	1.78[B]	+0.010	+0.25
½	13	0.070[B]	1.78[B]	+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] The minimum is the lowest wall thickness of the pipe at any cross section. The maximum permitted wall thickness, at any cross section, is the minimum wall thickness plus the stated tolerance. All tolerances are on the plus side of the minimum requirement.

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

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 2765.

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

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.