Designation: F876 – 15a

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

This standard is issued under the fixed designation F876; 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 incorporates an optional polymeric inner, middle or outer layer and that is outside diameter controlled, made in nominal SDR9 tubing dimension ratios except where noted, and pressure rated for water at three temperatures (see Appendix X1). Included are requirements and test methods for material, workmanship, dimensions, burst pressure, hydrostatic sustained pressure, excessive temperature pressure, environmental stress cracking, stabilizer functionality, bent-tube hydrostatic pressure, oxidative stability in potable chlorinated water, and degree of crosslinking. Requirements for tubing markings 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 standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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]

D618 Practice for Conditioning Plastics for Testing

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D1505 Test Method for Density of Plastics by the Density-Gradient Technique

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 (Withdrawn 1998)[3]

D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

D2765 Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics

D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

F412 Terminology Relating to Plastic Piping Systems

F1281 Specification for Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe

F2023 Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Tubing and Systems to Hot Chlorinated Water

F2657 Test Method for Outdoor Weathering Exposure of Crosslinked Polyethylene (PEX) Tubing

2.2 *ANSI Standard:*

B36.10 Standards Dimensions of Steel Pipe (IPS)[4]

2.3 *Federal Standard:*

FED-STD-123 Marking for Shipment (Civil Agencies)[5]

2.4 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[5]

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

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

[5] DLA Document Services Building 4/D 700 Robbins Avenue Philadelphia, PA 19111-5094 http://quicksearch.dla.mil/

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

TABLE 1 Wall Thickness and Tolerances for Nominal 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.

2.5 *NSF Standard:*

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

2.6 *ISO Standards:*[4]

ISO 1167 Thermoplastics pipes, fittings and assemblies for the conveyance of fluids -- Determination of the resistance to internal pressure -- Part 1: General method

ISO 13760 Plastics pipes for the conveyance of fluids under pressure -- Miner's rule -- Calculation method for cumulative damage

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:*[7]

PPI TR-4 PPI Listing of Hydrostatic Design Basis (HDB), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600, 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*—a polyethylene material which has undergone a change in molecular structure using a chemical or a physical process whereby the polymer chains are chemically linked.

3.2.2 *hydrostatic design stress (HDS)*—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. The HDS is equal to the hydrostatic design basis (HDB) times the design factor (DF) for water. For this standard, the design factor is equal to 0.50.

$$HDS = HDB \times DF$$
$$= HDB \times 0.50 \ (for\ this\ standard)$$

3.2.3 *hydrostatic design basis (HDB)*—one of a series of established stress values (specified in Test Method D2837) for a plastic compound obtained by categorizing the long-term hydrostatic strength determined in accordance with Test Method D2837.

3.2.3.1 *Discussion*—A listing of HDB and HDS values are contained in PPI publication PPI TR–4.

3.2.4 *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.

3.2.5 *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

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

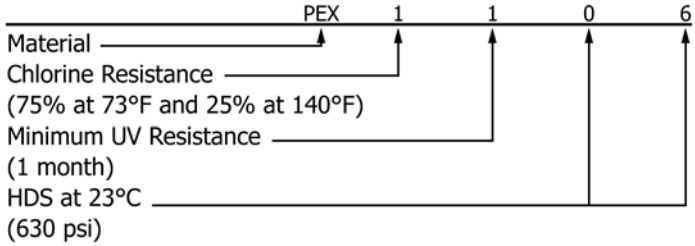
where:

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.

3.2.6 *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 5⁄16 in. and smaller, as specified in Table 1. The SDR values shall be rounded to the nearest 0.5.

3.2.7 *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 and as shown in Table 2. See Fig. 1.

[6] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, http://www.nsf.org.
[7] Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825 Irving TX, 75062. http://www.plasticpipe.org
[8] ISO R161-1690.



For example ASTM F876 PEX tubing marked with the material designation code PEX 1106 is a PEX tubing meeting the chlorine resistance requirement for 25% of the time at 140°F and 75% of the time at 73°F having a Minimum UV resistance of 1 month and having an HDS for water at 73°F of 630psi (HDB of 1250 psi).

FIG. 1 Standard Thermoplastic Tubing Materials Designation Code

TABLE 2 Material Designation Code Cells

Property	Standard	0	1	2	3	4	5	6	7	8	9
Chlorine Resistance	F2023	Not tested or rated	75 % at 73°F and 25 % at 140°F	Reserved	50 % at 73°F and 50 % at 140°F	Reserved	100 % at 140°F	...	...	...	...
Minimum UV Resistance	F2657	Not tested or rated	1 month	3 months	6 months	...	...	...	...	...	...
HDS for water at 73°F	...	...	...	...	...	...	...	630	...	800	...

3.2.7.1 *Discussion*—The first digit is for chlorine resistance tested in accordance with Test Method F2023.

(1) A digit "0" indicates that the PEX tubing either has not been tested for chlorine resistance or that the PEX tubing does not meet the minimum requirement for chlorine resistance.

(2) A digit "1" indicates the PEX tubing has been tested and meets the requirement of 6.10 for minimum chlorine resistance at the end use condition of 25% at 140°F (60°C) and 75% at 73°F (23°C).

(3) A digit "2" is reserved for future application.

(4) A digit "3" indicates that the PEX tubing has been tested and meets the requirement of 6.10 for minimum chlorine resistance at end use condition of 50% at 140°F and 50% at 73°F.

(5) A digit "4" is reserved for future application.

(6) A digit "5" indicates that the PEX tubing has been tested and meets the requirement of 6.10 for minimum chlorine resistance at end use conditions of 100% of the time at 140°F

3.2.7.2 *Discussion*—The second digit is for demonstrated UV resistance of PEX material when tested in accordance with Test Method F2657. For PEX tubing with the first digit of the material designation code equal to 1, 3, or 5 the second digit shall be one of the classification digits listed in Table 2 for the Nominal Exposure Time Period from Table 1 in Test Method F2657 where the decreased average failure time from 10.3 of Test Method F2657 is less than or equal to 21%. For PEX tubing with the first digit of the material designation code equal to 0, the second digit shall be one of the classification digits from Table 2 for the Nominal Exposure Time Period from Table 1 of Test Method F2657 where the UV-exposed samples meet the requirement of 7.10 Stabilizer Functionality, or alternatively using the criteria for potable water piping found in the preceding sentence of this clause.

3.2.7.3 *Discussion*—The 21% pass/fail criteria originates from the statistical analysis of an aggregate of data sets generated using Test Method F2023 and represents the mean Lower Predictive Limit (95% two sided) compared to the expected failure times based on three stress levels at each of three temperatures. Thus, this value represents the limit for statistical differentiation in failure times using Test Method F2023 at the 95% confidence level (2 sided). This research was conducted for the Plastics Pipe Institute in 2005.[9]

(1) The UV resistance shall be demonstrated on representative pipe samples for the original validation of pipe made from a particular PEX material, that material being the combination of PEX resin and its additive system.

(2) 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.

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) for nominal diameters ⅝ in. and larger, and with a specified wall thickness for smaller diameters. The pressure ratings are uniform for all nominal tubing sizes.

[9] PPI Technical literature, Final Report – Proposal for the Evaluation of the Chlorine Resistance of UV Exposed PEX Pipe.

TABLE 3 Hydrostatic Design Stresses and Pressure Ratings for PEX SDR 9 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)

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/ANSI 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 3, when determined in accordance with procedures no less restrictive than those of PPI TR-3.[10] Tubing incorporating an optional layer shall also meet the requirement of PPI TR-3[10]. 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 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 *Out-of Roundness*—The maximum out-of roundness requirements, shown in Table 4 for tubing, apply to the average, measured diameter. Tubing shall be measured prior to coiling.

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

6.3 *Dimensions and Tolerances:*

6.3.1 *Outside Diameters*—The outside diameters and tolerances of the tubing including the layers shall be as shown in Table 4, when measured in accordance with 7.4 and 7.4.1.

6.3.1.1 *Layer*—Tubing that incorporates an inner, middle or outer layer have to meet the minimum wall thickness and tolerances requirements as specified in Table 1. In addition, the layer shall not result in the reduction of the total PEX material below that specified in Table 1. In the case of tubing with a middle layer, the total base PEX material wall thickness shall be the sum of the inner and outer base PEX material wall thicknesses.

6.3.2 *Wall Thickness*—The wall thickness and tolerances shall be as shown in Table 1, when measured in accordance with 7.4 and 7.4.2.

NOTE 3—Tubing diameters less than ⅝ in. diameter have minimum wall thicknesses based on both hydrostatic and mechanical strength.

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

6.5 *Hydrostatic Sustained Pressure Strength*—The tubing shall not fail, balloon, burst, or weep as defined in Test Method D1598, at the test pressures shown in Table 5 when tested in accordance with 7.6.

6.6 *Hydrostatic Burst Pressure*—The minimum burst pressure for PEX plastic tubing shall be as shown in Table 6, when determined in accordance with 7.7.

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

6.8 *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.

6.8.1 *Layer*—For tubing with a layer, the degree of crosslinking of the PEX material excluding the layer shall be in accordance with 6.8.

NOTE 4—Techniques as found in Test Methods D2765.

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

6.10 *Oxidative Stability in Potable Chlorinated Water Applications*—PEX tubing intended for use in the transport of potable water shall have a minimum extrapolated time-to-time failure of 50 years when tested and evaluated in accordance with 7.11.

6.11 *Adhesion Test*—Tubing that incorporates an optional inner, middle or outer layer shall not show any delamination when tested in accordance with 9.3.1 of Specification F1281.

6.12 *Bent Tube Hydrostatic Sustained Pressure Strength:*

6.12.1 *General*—PEX tubing, up to and including 1 in. nominal diameter, can be installed bent by using either of two techniques described in X3.2.4 and X3.2.5, provided that 6.12.2 and 6.12.3 requirements are met.

TABLE 4 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 5 Minimum Hydrostatic Sustained Pressure Requirements for PEX Nominal SDR 9 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	515	(3.55)	305	(2.10)	260	(1.79)
⅜	10	425	(2.93)	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).

TABLE 6 Burst Pressure Requirements for Water at Different Temperatures for PEX SDR 9 Plastic Tubing

Nominal Tubing Size		Minimum Burst Pressures at Different Temperatures, psi[A] (MPa)					
in.	mm	73.4°F	(23°C)	180°F	(82.2°C)	200°F	(93.3°C)
⅛	3	870	(6.00)	390	(2.69)	330	(2.28)
¼	7	752	(5.19)	336	(2.32)	285	(1.96)
⅜	10	620	(4.27)	275	(1.90)	235	(1.62)
½	13	480	(3.31)	215	(1.48)	185	(1.28)
⅝ and larger	16 and larger	475	(3.27)	210	(1.45)	180	(1.24)

[A] The fiber stresses used to derive these test pressures are:
at 73.4°F (23.0°C) 1900 psi (13.10 MPa).
at 180°F (82.2°C) 850 psi (5.86 MPa).
at 200°F (93.3°C) 720 psi (4.96 MPa).

NOTE 5—PEX tubing, larger than 1 in. nominal diameter, is typically installed as main distribution lines and is installed in straight 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 6.12.2 and 6.12.3 are intended to evaluate PEX tubing installed in tight bend applications in accordance with the procedures in X3.2.4 and X3.2.5. This application applies to tubing up to and including 1 in nominal diameter only.

6.12.2 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 for 180°F as shown in Table 5 when tested in accordance with 7.6. The bend length and bend angle is kept throughout the testing period by rigid supports immediately outside the bend.

6.12.3 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 for 180°F as shown in Table 5 when tested in accordance with 7.6. The bend length and bend angle is kept throughout the testing period by rigid secures immediately outside the bend.

6.13 *Excessive Temperature—Pressure Capacity:*

6.13.1 *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.

6.13.2 *Excessive Temperature Hydrostatic Sustained Pressure*—Tubing shall not fail as defined in Test Method D1598 in less than 30 days (720 h) when tested in accordance with 7.12.

7. Test Methods

7.1 *Conditioning*—Condition the specimens at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5% relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D618, for those tests where conditioning is required. In cases of disagreement, the tolerances shall be ±1.8°F (±1°C) and ±2 % relative humidity.

7.2 *Test Conditions*—Conduct the test in the standard laboratory atmosphere of 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this specification. In cases of disagreement, the tolerances shall be ±1.8°F (±1°C) and ±2 % relative humidity.

7.3 *Sampling*—A sufficient quantity of tubing, 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.

7.3.1 *Test Specimens*—Not less than 50 % of the test specimens required for any pressure test shall have at least a part of the marking in their central sections. The central section is that portion of tubing that is at least one tubing diameter away from an end closure.

7.4 *Dimensions and Tolerances*—Use any length of tubing to determine the dimensions. Measure in accordance with Test Method D2122.

7.4.1 *Outside Diameter*—Measure the outside diameter of the tubing in accordance with Test Method D2122. The referee method of measurement is to be by circumferential wrap tape. The tolerance for out-of-roundness shall apply only to tubing prior to shipment. Averaging micrometer or vernier caliper measurements, four (4) maximum and minimum diameter measurements at any cross section, may be used for quality control checks if desired.

7.4.2 *Wall Thickness*—Make micrometer measurements of the wall thickness in accordance with Test Method D2122 to determine the maximum and minimum values. Measure the wall thickness at both ends of the tubing to the nearest 0.001 in. (0.025 mm).

7.4.2.1 *Layer*—Make measurements of the layer or layers using either a video microscope, a microscope with 0.001 in. graduation or optical comparator to determine the maximum and minimum values.

7.5 *Density*—Determine the density of the tubing compound in accordance with Test Method D1505, or Test Methods D792, using three specimens.

7.6 *Hydrostatic Sustained Pressure Test*—Select the test specimens at random. Test individually with water at the three controlled temperatures and under the pressures given in Table 5, 18 specimens of tubing, each specimen at least ten times the nominal diameter in length, but not less than 10 in. (25.4 cm) or more than 3 ft (91.4 cm) between end closures and containing the permanent marking on the tubing. Test six specimens at each temperature. Condition the specimens for at least 2 h to within ± 3.6°F (±2°C) of the specified test temperatures. Maintain the specimens at the pressures indicated for the appropriate temperatures for a period of 1000 h. Hold the pressure as closely as possible, but within ± 10 psi (±0.070 MPa). Maintain the test temperatures within ± 3.6°F (±2°C) of the specified temperature. Test in accordance with Test Method D1598 except maintain the pressure at the values given in Table 5 for 1000 h. Failure of two of the six specimens tested at either temperature constitutes failure in the test. Failure of one of six specimens tested at either temperature is cause for retest of six additional specimens at that temperature. Failure of one of six specimens tested at either temperature in retest constitutes failure in the test. Failure of the tubing shall be defined in accordance with Test Method D1598, namely:

7.6.1 *Failure*—Any continuous loss of pressure resulting from the transmission of the test liquid through the body of the specimen under test.

7.6.2 *Ballooning*—Any abnormal localized expansion of a tubing specimen while under internal hydraulic pressure.

7.6.3 *Bursting*—Failure by a break in the tubing with immediate loss of test liquid and continued loss at essentially no pressure.

7.6.4 *Seepage or Weeping*—Failure that occurs through essentially microscopic breaks in the tubing wall, frequently only at or near the test pressure.

NOTE 6—At lower pressures, the pipe may carry liquids without evidence of loss of liquids.

7.6.5 *Delamination*—Failure by separation of the layers visible to the unaided eye.

7.7 *Hydrostatic Burst Pressure*—Determine the minimum burst pressure with at least five specimens in accordance with Test Method D1599. The time of testing of each specimen shall be between 60 and 70 s. The pressure values are given in Table 6.

7.8 *Environmental Stress Cracking Test*— Use six randomly selected 10-in. (250-mm) long specimens for this test. Make a notch on the inside of the tubing wall in the axial direction. The notch depth shall be 10 % of measured minimum wall thickness and the notch length 1 in. (25 mm). Use a sharp blade mounted in a jig to make this imperfection. Use a depth micrometer or other means for setting the blade in the jig so that the notch depth is controlled as specified. The notch shall be placed, at its nearest point, at least 1.5 times the nominal diameter away from end closures. Fill the tubing with the test

medium which is 5 % "Igepal CO-630"[11] mixed with 95 % of untreated water. The test is then made in accordance with 7.6, under the pressures given in Table 5, except maintain the pressure for 100 h.

7.9 *Degree of Crosslinking*—Place a tubing sample in a lathe with automatic feeding. Shave a strip that consists of the full wall thickness. The strip thickness shall be approximately 0.004 in. (0.1 mm) which is obtained by setting the lathe feeding accordingly. Test the specimens in accordance with Test Methods D2765, Method B, with the only deviation: test specimen preparation. For the purpose of this specification, degree of crosslinking (*V*) is defined as 100 % minus extract percent equals *V*.

NOTE 7—This method provides a test method for measuring the average degree of crosslinking over the tube wall thickness. That, however, does not mean that the degree of crosslinking is allowed to vary outside the limits for the grade in question at any part of the tubing. In case of disagreement, strips of the same thickness, 0.004 in. (0.1 mm), can be taken in tangential, axial, or radial direction at any angle section or wall thickness depth, or both, etc. to measure the degree of crosslinking.

7.10 *Stabilizer Functionality*—The functionality of a stabilizer in a specific PEX compound shall be verified by hydrostatic testing of pipe made from the compound. Test six pipe samples continuously for 3000 h at a hoop stress of 0.70 MPa at 120° C, or for 8000 h at a hoop stress of 2.8 MPa at 110° C. This test is used to demonstrate the specific compound's ability to withstand long term temperature conditions set forth elsewhere in this standard.

7.10.1 *Procedure*—The test procedure shall be conducted in accordance with Test Method D1598 or ISO 1167. Test six (6) samples at one of the temperature conditions in 7.10. The internal medium is water the external medium is air. Failure of any one of the specimens constitutes failure of the test.

7.10.2 *Significance*—The test need only be performed for the original validation of pipe made from a particular compound.

7.11 *Oxidative Stability in Potable Chlorinated Water Applications*— The test shall be conducted, and the extrapolated time-to-failure shall be determined in accordance with Test Method F2023. The test fluid shall be prepared in accordance with 9.1.1 of Test Method F2023. The extrapolated time-to-failure shall be calculated in accordance with 13.3 of Test Method F2023 and as follows:

7.11.1 For a chlorine resistance cell of "1" using the coefficients from Test Method F2023, 13.1 and using Miners Rule, calculate the estimated time to-failure for a hoop stress corresponding to a sustained internal pressure of 80 psig (551.7 kPa) for the DR of the tested specimens at temperature exposure conditions of 25 % of the total time at 140°F (60°C) and 75% of the total time at 73°F (23°C) in accordance with ISO 13760.

7.11.2 For a chlorine resistance cell of "3" using the coefficients from Test Method F2023, 13.1, and using Miners Rule, calculate the estimated time to-failure for a hoop stress corresponding to a sustained internal pressure of 80 psig (551.7 kPa) for the DR of the tested specimens at temperature exposure conditions of 50 % of the total time at 140°F (60°C) and 50% of the total time at 73°F (23°C) in accordance with ISO 13760.

7.11.3 For a chlorine resistance cell of "5", using the coefficients from Test Method F2023, 13.1, calculate the estimated time-to-failure at a hoop stress corresponding to a sustained internal pressure of 80 psig (551.7 kPa) for the DR of the tested specimens at temperature of 100% of the time at 140°F (60°C)

7.11.4 *Significance*—The test need only be performed on representative pipe samples for the original validation of pipe made from a particular compound.

NOTE 8—The conditions described in Test Method F2023, 13.3 only apply to intermittent service such as might be found in normal residential use. This does not validate the use of PEX tubing in continuous recirculation applications.

7.12 *Excessive Temperature and Pressure Capability:*

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

7.12.1.1 Test at least six specimens from randomly selected specimens diameter ½ in. or greater. Specimens shall be at least 5 pipe diameters long.

7.12.1.2 Condition tubing in accordance with 7.1.

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

7.12.1.4 The external test environment shall be air.

7.12.1.5 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±21kPa).

7.12.1.6 Pressurize test specimens to the required pressure and maintain for 30 days (720 h). The pressure for PEX tubing shall be 150 psi (1034 kPa), for SDR9 diameters. The fiber stress used to derive this test pressure is 595 psi (4.1 MPa).

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 tubing 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 14/61.

10. Marking

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

[11] This method is based on the use of "Igepal Co-630," a trademark for a nonylphenoxypoly (ethyeneoxy) ethanol, which may be obtained from GAF Corp., Dyestuff and Chemical Div., 140 W. 51st St., New York, NY 10020.

without indentation in some permanent manner so as to remain legible under normal handling and installation practice.

10.2 Marking on the tubing shall include the following, spaced at intervals of not more than 5 ft:

10.2.1 Manufacturer's name (or trademark) and production code indicating the date of production.

10.2.2 Nominal tubing size (for example, 2 in.).

10.2.3 Type of plastic tubing material in accordance with the designation code given in 3.2.7.

10.2.4 A distinctive marking that identify the presence of an inner, middle or outer layer.

10.2.5 Standard dimension ratio, SDR 9.

10.2.6 Pressure rating(s) for water and temperature(s) for which the pressure(s) rating are valid.

10.2.7 This ASTM designation, F876.

10.2.8 Tubing intended for the transport of potable water shall also include the seal or mark of the laboratory making the evaluation for this purpose, spaced at intervals specified by the laboratory.

10.2.9 Standard designation(s) of the fitting system(s) for which the tubing is recommended for use by the tubing manufacturer.

11. Quality Assurance

11.1 When the product is marked with this designation, F876, 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.

12. Keywords

12.1 crosslinked polyethylene; hydrostatic stress; PEX; PPI; pipe; pressure; tubing

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 materials 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. SOURCE OF HYDROSTATIC DESIGN STRESSES

X1.1 The hydrostatic design stress recommended by the Plastics Pipe Institute is used to pressure rate PEX plastic tubing. These hydrostatic design stresses are: 630 psi (4.34 MPa) for water at 73.4°F (23°C), 400 psi (2.76 MPa) for water at 180°F (82.2°C), and 315 psi (2.17 MPa) for water at 200°F (93.3°C). These hydrostatic design stresses apply only to tubing meeting all the requirements of this specification.

X1.2 Refer also to 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. These hydrostatic design stresses may not be suitable for materials that show a wide departure from a straight-line plot of log stress versus log time to failure. All the data available to date on PEX-tubing

materials made in the United States exhibit a straight-line plot under these plotting conditions.

X1.3 The hydrostatic design stresses and pressure ratings in Table 3 apply to PEX SDR 9 tubing meeting the requirements of this specification.

X1.4 The hydrostatic design stresses recommended by the Plastics Pipe Institute are based on tests made on tubing ranging in size from ½ to 2 in.

X1.5 The stabilizer functionality test is not intended to determine the long term hydrostatic strength of the pipe but to serve as indicator of the individual PEX compound stabilization.

X1.6 Stabilizer Verification: The oxidation induction time (OIT) as described in Test Method D3895 may be used to monitor stabilizer content of a PEX material or freshly extruded pipe. Once the initial OIT value has been established for a specific compound, subsequent OIT values can be used to validate the stabilizer level in the pipe or compound without the need to run additional temperature tests. It should be mentioned that OIT tests are not an indicator of life expectancy, nor should differences in OIT values between compounds be construed to indicate differences in the stabilizer effectiveness of respective formulations.

NOTE X1.1—As of this writing no precision and bias statement is available for the OIT tests and will have to be determined for each compound as data is developed.

X2. UV LABELING GUIDELINES FOR PEX TUBING

X2.1 PEX tubing should be kept in original packaging until time of use, and it should not be used in direct sunlight. To inform customers and users about the need to prevent accidental overexposure of PEX tubing to sunlight (UV light), it is recommended that a UV CAUTION label be applied to all PEX tubing packaging by the manufacturer.

X2.2 The text and content of the recommended label is as shown X2.4. "X" is the maximum cumulative time period as recommended by the tubing manufacturer for direct sunlight exposure without harm to the long-term performance characteristics of the PEX tubing.

X2.3 The recommended text may be incorporated into existing labels with other information. The universal “no-sun” symbol may be shown in color, black-and-white or grayscale, and should be positioned close to the recommended text.

X2.4 *Caution Label*Do not store PEX tubing unprotected outdoors.

Keep PEX tubing in the original packaging or under protective cover until time of installation.

Ensure that exposure to sunlight during installation does not exceed the maximum recommended UV exposure time of "X".

X3. DESIGN, ASSEMBLY. AND INSTALLATION CONSIDERATIONS

X3.1 Design

X3.1.1 *Thermal Expansion*—The linear expansion rate for PEX is approximately 1.1 in./10°F temperature change for each 100 ft of tubing, or 28 mm/5.6°C temperature change for each 30 m of tubing. When installing long runs of tubing, allow ⅛ to 3⁄16 in. longitudinal clearance per ft (10 to 14 mm/m) of run to accommodate thermal expansion. Tubing should not be anchored rigidly to a support but allowed freedom of movement to expand and contract.

X3.1.2 *Water Heaters*—Components covered by this specification may not be suitable for use with the instantaneous-type (coil or immersion) water heaters. They are suitable for use with storage-type water heaters with connections made in an approved manner.

X3.1.3 *Sweating*—Even though the thermal conductivity of PEX is several orders of magnitude lower than that of metal. sweating or condensation, at a slow rate may occur under certain temperature and humidity conditions.

X3.1.4 *Water Hammer and Surge*—A PEX water system will withstand repeated pressure surges, well in excess of its rated pressure, but water hammer arrestors may be advisable when solenoid valves or other quick-closing devices are used in the system. In designing for such situations, it is advisable to consult the tubing manufacturer for recommended surge pressure limits. Water hammer and surge pressure calculations are reviewed in AWWA Manual M-l 1. Steel Pipe Design and Installation, Chapter 7[12].

X3.1.5 *Horizontal Support Spacing*—The maximum recommended spacing between horizontal supports is 32 in. (800 mm) for nominal tube sizes up to 1 in. Maximum spacing for nominal sizes 1¼ and larger is 48 in. (1200 mm) or as stated in the manufacturer’s instructions. Crosslinked polyethylene tubing should not be rigidly secured to a stud or joist but should be secured with smooth plastic strap hangers, which permit ease of movement during expansion/contraction cycles.

X3.1.6 When PEX tubing is to be used in sealed central heating systems, the fact that all plastics allow for a certain amount of oxygen diffusion should be taken into consideration.

X3.2 Installation

X3.2.1 *Storage and Handling*—PEX tubing should be stored under cover to avoid unnecessary dirt accumulation and long-term exposure to sunlight. Tubing can be stored in coils of

[12] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

number size and length recommended by the manufacturer. Care should be used in handling to ensure that unnecessary abuse, such as abrasion on concrete or crashing, is avoided.

X3.2.2 *Repairs*—If a leak is discovered, that portion of the system should be drained and the actual, part should be cut out. The tubing should be thoroughly dried and mechanical fitting(s) and if necessary, short length(s) of tubing should be installed.

X3.2.3 *Soldering in the Area*—Soldered metal fittings should not be made closer than 18 in. (460 mm) to an installed PEX-to-metal adapter in the same piece of tubing.

X3.2.4 *Hot Bending of Tubing*—For hot bending use a hot-air-gun with a so-called diffuser nozzle, not an open flame. The hot air temperature meeting the tubing surface must not exceed 338°F (170°C) and the heating up time must not exceed 5 min. The tubing shall be heated until the material, at the bending point becomes translucent, approximately 265°F (130°C), for non-colored pipes. Colored pipes will turn soft to allow the bending. Experience will show how much heat is enough. Bend and fix the tubing in the bent position, using conventional tube bending tools with side support. Cool the tubing in water or air before removal of bending tool. Fix the tubing by supports on both sides of the bend at installation. The minimum hot bending radius for PEX SDR 9 tubing is 2.5 times outside diameter. Outside diameter is equal to nominal diameter plus ⅛ in. (see 3.1).

X3.2.5 *Cold Bending of Tubing*—PEX SDR 9 tubing shall be bent at room temperature without the use of bending tools down to a minimum bending radius of 6 times outside diameter. Outside diameter is equal to nominal diameter plus ⅛ in. (see 3.1). Normal precaution is taken to avoid buckling or flattening. Fix the tubing by supports on both sides of the bend at installation

X4. OPTIONAL PERFORMANCE QUALIFICATION AND IN-PLANT QUALITY-CONTROL-PROGRAM FOR PEX HOT-WATER DISTRIBUTION SYSTEM COMPONENTS

X4.1 Scope

X4.1.1 The following program covers performance qualification and in-plant quality control for component design and manufacture respectively to provide reasonable assurance that PEX hot-water distribution system components supplied under this specification shall consistently meet its requirements.

X4.2 Performance Qualifications

X4.2.1 Performance qualification tests shall be run initially on each component design, size, and formulation in accordance with the requirements of this specification. The test results shall be independently certified and shall be made available to the purchaser on request.

X4.3 In-Plant Quality Control

X4.3.1 *Material*—The tubing material shall be PEX as defined in Section 4 of this specification. The manufacturer shall so certify.

X4.3.2 Tubing quality-control tests shall be run for each extrusion line in accordance with the requirements of this specification at a frequency agreed upon between the purchaser and the manufacturer. The program outlined in Table X4.1 is recommended. The test results shall be recorded and filed for inspection on request. Should a specimen fail to meet the specification in any test, production should be sampled back to the previous acceptable test result and tested to determine which specimens produced in the interim do not meet the requirement. Specimens that do not meet the requirements of this specification shall be rejected. See Table X4.2.

TABLE X4.1 Suggested Quality-Control Program

Component	Property	Frequency	Requirements
Tubing	Workmanship	continuously	6.1
	Dimensions	hourly	6.2
	Density	weekly	5.3
	Burst Pressure	daily	5.5
	Sustained pressure	3 months	5.4
	Environmental stress cracking	yearly	5.6
	Degree of crosslinking	3 days	5.7
	Bent tubing	yearly	6.6

TABLE X4.2 Type Test Program

Component	Property	Requirement
Tubing	Hydrostatic design basis for each temperature	ASTM D2837
	Potable Water	NSF/ANSI 14

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F876–15) that may impact the use of this standard. (Approved September 1, 2015.)

(1) X3.1.5 was revised.

Committee F17 has identified the location of selected changes to this standard since the last issue (F876–13a) that may impact the use of this standard. (Approved June 1, 2015.)

(1) 3.2.7.1 was revised.