Designation: F2929 – 13

Standard Specification for Crosslinked Polyethylene (PEX) Tubing of 0.070 in. Wall and Fittings for Radiant Heating Systems up to 75 psig[1]

This standard is issued under the fixed designation F2929; 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 0.070 in. wall thickness crosslinked polyethylene (PEX) tubing that is outside diameter controlled, and intended for non-potable radiant heating applications for pressures up to 75 psig in sizes ⅝ NTS (nominal tubing size) and ⅞ NTS. This specification also includes fittings that are specifically designed for this 0.070 in.-wall PEX tubing. Only 75-psig relief valves shall be used with this tubing. Included in this specification are requirements and test methods for material, workmanship, dimensions, burst pressure, hydrostatic sustained pressure, environmental stress cracking, stabilizer functionality, bent-tube hydrostatic pressure, excessive temperature and degree of crosslinking. Requirements for tubing markings are also given. This tubing does not have an oxygen diffusion barrier layer and shall not be used in systems that require a barrier layer. This tubing is not intended for field bending at temperatures above 120°F (49°C).

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:*

A269 Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

A276 Specification for Stainless Steel Bars and Shapes

A312/A312M Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

B16/B16M Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines

B61 Specification for Steam or Valve Bronze Castings

B62 Specification for Composition Bronze or Ounce Metal Castings

B140/B140M Specification for Copper-Zinc-Lead (Red Brass or Hardware Bronze) Rod, Bar, and Shapes

B283 Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed)

B371/B371M Specification for Copper-Zinc-Silicon Alloy Rod

B584 Specification for Copper Alloy Sand Castings for General Applications

B967/B967M Specification for Copper-Zinc-Tin-Bismuth Alloy Rod, Bar and Wire

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

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

E18 Test Methods for Rockwell Hardness of Metallic Materials

F412 Terminology Relating to Plastic Piping Systems

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

2.2 *ANSI Standard:*[2]

B36.10 Standards Dimensions of Steel Pipe (IPS)

2.3 *Federal Standard:*[3]

FED-STD-123 Marking for Shipment (Civil Agencies)

2.4 *Military Standard:*[3]

MIL-STD-129 Marking for Shipment and Storage

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

2.6 *PPI Standards:*[5]

PPI TR-3 Policies and Procedures for Developing Recommended Hydrostatic Design Basis (HDB), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe

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.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *crosslinked polyethylene, n*—molecular polyethylene chains chemically connected through irradiation with high-energy electron beams, or chemical agents such as organic peroxides or silanes.

3.2.2 *hydrostatic design stress (HDS), n*—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.

$$HDS = HDB \times DF$$
$$= HDB \times 0.05 \quad (\text{For this standard}) \tag{1}$$

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.

3.2.4.1 *Discussion*—If both ⅝ NTS and ⅞ NTS tubing are used in the same system, the pressure rating of the system is limited to the pressure rating of the ⅞ NTS tubing.

3.2.5 *relation between dimensions, hydrostatic design stress, and pressure rating*—the following expression, commonly known as the ISO equation, 6 is used in this specification to relate dimensions, hydrostatic design stress, and pressure rating:

$$2S/P = (D_O / t) - 1$$
or
$$2S/P = R - 1 \tag{2}$$

where:

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

3.2.6 *tubing material 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 1.

3.2.6.1 *Discussion*—The first digit is for chlorine resistance, which is not applicable for radiant tubing applications, but is mentioned here for information purposes.

3.2.6.2 *Discussion*—The second digit is for demonstrated UV resistance of PEX material when tested in accordance with Test Method F2657. For radiant heating, it shall be one of the classification digits from Table 1 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. The UV resistance shall be demonstrated on representative pipe samples for the original validation of pipe

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

[3] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

[4] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

[5] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

TABLE 1 PEX Tubing Material Designation Code Cells

Property	Standard	0	1	2	3	6	8
Chlorine Resistant		Not applicable	...	...	...	...	...
Minimum UV Resistance		Not tested or rated	1 month	3 months	6 months	...	...
HDS for water at 73°F, psi		...	...	...	...	630	800

made from a particular PEX material, that material being the combination of PEX resin and its additive system.

3.2.6.3 *Discussion*—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.

3.2.7 *0.070 in. wall radiant heating system*—PEX tubing with a 0.070 in. thickness, and corresponding fittings designed for 0.070 in. wall tubing, used for radiant heating applications.

4. Tubing Classification

4.1 *General*—This specification covers tubing for 0.070 in. wall radiant heating that is classified using the tubing material designation code for PEX tubing.

5. Materials

5.1 *Tubing*—Crosslinked polyethylene tubing, meeting the requirements of this specification, is 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.

5.1.1 *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 design basis (HDB) ratings equal to or better than 1250 psi at 73ºF (23ºC), 1000 psi at 120ºF (49ºC), and 800 psi at 180ºF (76ºC), when determined in accordance with procedures no less restrictive than those of PPI TR-3. The PEX material HDB values shall be listed in PPI TR-4. See Appendix X1 for additional information on PPI hydrostatic stress ratings.

NOTE 1—HDB values at 73ºF (23ºC) and 180ºF (76ºC) are published in PPI TR-4. The HDB at an intermediate temperature, such as 120ºF (49ºC), is determined by arithmetic interpolation.

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.

5.2 *Fittings*—The fittings shall be made from one of the following metals:

5.2.1 *Cast Copper Alloys*—Cast copper alloy fittings shall be made from material meeting the requirements of one of the following:

(1) Specification B61, copper alloy UNS C92200,

(2) Specification B62, copper alloy UNS No. C83600, or

(3) Specification B584, copper alloy UNS Nos. C84400, C83800, or C87850.

5.2.2 *Machined Brass*—Machined brass fittings shall be made from material meeting the requirements of one of the following:

(1) Specification B16/B16M, Copper Alloy UNS No. C36000,

(2) Specification B140/B140M copper alloy UNS No. C31400,

(3) Specification B371/B371M Copper Alloy UNS No. C69300, or

(4) Specification B967/B967M copper alloy UNS No. C49260 or C49340.

5.2.3 *Forged Brass*—Forged brass fittings shall be made from material meeting the requirements of Specification B283, Copper Alloy UNS Nos. C27450, C35330, C36500, C37700, C46400, C48600, C49260, C49340, or C69300.

5.2.4 *Stainless Steel*—Stainless steel fittings shall be made from material meeting requirements of one of the following:

(1) Specification A312/A312M, stainless steel alloy 304, 304L, 316 or 316L, (UNS Nos. S30400, S30403, S31600 or S31603),

(2) Specification A269, stainless steel alloy 304, 304L, 316, 316L (UNS Nos. S30400, S30403, S31600 or S31603), or

(3) Specification A276, Stainless steel alloy 304, 401L, 316, or 316L (UNS Nos. S30400, S30403, S31600 or S31603)

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 2 for tubing, apply to the average measured diameter. Tubing shall be measured prior to coiling.

6.3 *Dimensions and Tolerances:*

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

6.3.2 *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. This specification covers PEX tubing in two sizes, ⅝ NTS (nominal tubing size) and ⅞ NTS. The minimum wall thickness is 0.070 in. (1.78 mm), as shown in Table 3.

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

TABLE 2 Outside Diameters and Tolerances for 0.070 in.-Wall PEX Tubing

Nominal Tubing Size		Average Outside Diameter		Tolerances for Average Diameter		Out-of-Roundness[A]	
		in.	(mm)	in.	(mm)	in.	(mm)
⅝	DR 10.7	0.750	(19.05)	±0.004	(±0.10)	0.016	(0.40)
⅞	DR 14.3	1.000	(25.40)	±0.004	(±0.10)	0.016	(0.40)

[A]The Out-of-Roundness specification applies only to tubing prior to coiling.

TABLE 3 Wall Thickness and Tolerances for 0.070 in. -Wall PEX Tubing for Radiant Heating[A]

Nominal Tubing Size (NTS)		Minimum Wall Thickness		Tolerance	
		in.	mm	in.	mm
5/8	DR 10.7	0.070	(1.78)	+0.010	(+0.25)
7/8	DR 14.3	0.070	(1.78)	+0.010	(+0.25)

[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. The minimum wall thickness for tubing sizes below 7/8 in. (22.2 mm) is 0.070 in. (1.78 mm).

6.5 *Hydrostatic Sustained Pressure Strength*—The tubing and fittings (tested as assemblies) shall not fail, balloon, burst, or weep as defined in Test Method D1598, at the test pressures shown in Table 4 when tested in accordance with 7.6.

6.6 *Hydrostatic Burst Pressure*—The minimum burst pressure for PEX tubing and fittings (tested as assemblies) shall be as shown in Table 5, 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.

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

6.10 *Bent Tube Hydrostatic Sustained Pressure Strength:*

6.10.1 *General*—PEX tubing bent by using the technique described in X3.2.4 shall meet the requirements in 6.10.2.

6.10.2 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 120°F and a fiber stress of 1000 psi 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.

NOTE 3—5/8 NTS and 7/8 NTS PEX tubing with a 0.070 in. wall thickness may be more susceptible to mechanical damage, crushing, pinching, or kinking while bending than SDR 9 PEX tubing.

6.11 *Tubing Material Designation Code*—The tubing meeting the requirements of this specification shall be designated PEX followed by four digits per 3.2.6.

6.12 *Fittings:*

TABLE 4 Minimum Hydrostatic Sustained Pressure Requirements for 0.070 in.-Wall PEX Tubing and Fittings for Radiant Heating

Nominal Tubing Size		Pressure Required for Test, psi[A] (MPa)			
		73.4°F	(23°C)	180°F	(82.2°C)
5/8	DR 10.7	268	(1.85)	159	(1.10)
7/8	DR 14.3	197	(1.36)	117	(0.81)

[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).

TABLE 5 Burst Pressure Requirements for 0.070 in.-Wall PEX Tubing and Fittings for Radiant Heating

Nominal Tubing Size		Pressure Required for Test, psi[A] (MPa)			
		73.4°F	(23°C)	180°F	(82.2°C)
5/8	DR 10.7	391	(2.70)	175	(1.21)
7/8	DR 14.3	288	(1.98)	129	(0.89)

[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).

6.12.1 Fittings shall be compatible with tubing made to the requirements of this standard.

6.12.2 *Thermocycling*—Fittings, assembled using the manufacturer's instructions, shall not leak after completion of 1000 cycles between the temperatures of 60°F (16°C) and 180°F (82°C) when tested in accordance with 7.11.

6.13 *Excessive Temperature*—Pressure Capacity:

6.13.1 *Excessive Temperature Hydrostatic Sustained Pressure*—Tubing and fittings 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 ± 10% 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 ± 10 % 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). 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).

7.5 *Density*—Determine density in accordance with Test Method D1505 or Test Method D792 using three specimens taken from tubing after processing and crossliking.

7.6 *Hydrostatic Sustained Pressure Test*—Select the test specimens (assemblies) at random. Test individually with water at the controlled temperatures and under the pressures given in Table 4, specimens of tubing, each specimen at least ten times the 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 4 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 4—At lower pressures, the pipe may carry liquids without evidence of loss of liquids.

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 5.

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 diameter away from end closures. Fill the tubing with the test medium which is 5 % "Igepal CO-630"[6]mixed with 95 % of untreated water. The test is then made in accordance with 7.6, under the pressures given in Table 4, except maintain the pressure for 100 h.

NOTE 5—Studies have shown that there are environmental concerns regarding the disposal of Nonylphenoxy poly(ethyleneoxy) ethanol CAS 68412-54-4 for example, Igepal-630[6]. Users are advised to consult their supplier or local environmental office and follow the guidelines provided for the proper disposal of this chemical

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 6—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.

7.11 *Thermocycling:*

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

7.11.2 *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.

[6] This method is based on the use of "Igpal 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.

7.11.3 *Apparatus*—A nitrogen or air source capable of maintaining a nominal internal pressure of 50 ± 5 psi (0.35 ± 0.035 MPa) on the specimens is required. The immersion system shall consist of two water reservoirs controlled at 60 ± 4°F (16± 2°C) and 180 ± 4°F (82 ± 2°C). The specimen shall be cycled from one reservoir to the other or the hot and cold water shall be alternately cycled over the test specimens automatically and returned to the proper reservoirs.

NOTE 7—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.

7.12 *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. 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 75 psi (517 kPa), for all diameters.

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. Marking

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

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

9.2.1 Use only with 75 psig or lower relief valves.

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

9.2.3 Tubing size (example, ⅝ NTS).

9.2.4 Type of plastic tubing material in accordance with the designation code given in 3.2.7 (example PEX 0308).

9.2.5 Minimum wall thickness (0.070 in.).

9.2.6 Pressure rating for water and temperature for which the pressure rating is valid 75 psig at 120°F.

9.2.7 The words "0.070–Wall For Radiant Heating Only"

9.2.8 This ASTM designation, F2929.

9.3 All fittings shall be marked F2929 and "0.070" to indicate they are to be used only with 0.070 in. (1.78 mm) wall thickness PEX tubing made to this standard specification that is also marked F2929.

10. Quality Assurance

10.1 When the product is marked with this designation, F2929, 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.

11. Keywords

11.1 0.070 in. wall; crosslinked polyethylene; hydrostatic stress; PEX; pipe; PPI; radiant heating; tubing

SUPPLEMENTARY REQUIREMENTS

SUPPLEMENTARY REQUIREMENTSGOVERNMENT/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

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), 500 psi (3.45 MPa) for water at 120ºF (49ºC), and 400 psi (2.76 MPa) for water at 180°F (82.2°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 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.

X1.4 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 LabelX2.4

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.

X3.2 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 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 *Cold Bending of Tubing*—PEX 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 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-CONTROLPROGRAM 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 radiant heating 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.

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	D2837