



Standard Specification for Crosslinked Polyethylene (PEX) Tubing of 0.070 in. Wall and Fittings for Radiant Heating Systems up to 75 psig¹

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 cross-linked polyethylene (PEX) tubing that is outside diameter controlled, and intended for non-potable radiant heating applications for pressures up to 75 psig in sizes $\frac{5}{8}$ NTS (nominal tubing size) and $\frac{7}{8}$ 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. Current edition approved May 1, 2013. Published June 2013. DOI: 10.1520/F2929-13

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

hydrostatic design basis (HDB) times the design factor (DF) for water. For this standard, the design factor is equal to 0.50.

$$HDS = HDB \times DF$$

$$= HDB \times 0.05 \text{ (For this standard)}$$

(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 5/8 NTS and 7/8 NTS tubing are used in the same system, the pressure rating of the system is limited to the pressure rating of the 7/8 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

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

(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

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

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 73°F (23°C), 1000 psi at 120°F (49°C), and 800 psi at 180°F (76°C), 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 73°F (23°C) and 180°F (76°C) are published in PPI TR-4. The HDB at an intermediate temperature, such as 120°F (49°C), 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, 5/8 NTS (nominal tubing size) and 7/8 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/cm³.

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) |
| 5/8 DR 10.7 | 0.750 | (19.05) | ±0.004 | (±0.10) | 0.016 (0.40) |
| 7/8 DR 14.3 | 1.000 | (25.40) | ±0.004 | (±0.10) | 0.016 (0.40) |

^aThe 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) |

^AThe 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) | |

^AThe 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) | | |

^AThe 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.