Designation: F3253 – 23

An American National Standard

Standard Specification for Crosslinked Polyethylene (PEX) Tubing with Oxygen Barrier for Hot- and Cold-Water Hydronic Distribution Systems[1]

This standard is issued under the fixed designation F3253; 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 requirements, test methods, and marking requirements for crosslinked polyethylene (PEX) tubing with a polymeric oxygen barrier layer, made in one standard dimension ratio (SDR 9), and distribution system components intended for hydronic heating and cooling applications up to and including a maximum working temperature of 200 °F (93 °C).

1.1.1 Components are comprised of tubing, fittings, valves, and manifolds. Tubing made to this specification incorporates a single outer or middle wall oxygen barrier layer intended for inhibiting the transmission or permeation of oxygen through the tubing wall. Requirements and test methods are included for materials, workmanship, tubing dimensions and tolerances, burst pressure, sustained pressure, excessive temperature and pressure, thermo-cycling, bent tube, oxidative resistance, layer adhesion, UV resistance, oxygen permeation, and fitting pull-out strength tests. The components covered by this specification are intended for use in residential and commercial hydronic heating and cooling systems. Requirements for potable water applications are outside the scope of this specification.

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 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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
D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
D2749 Symbols for Dimensions of Plastic Pipe 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
F412 Terminology Relating to Plastic Piping Systems
F876 Specification for Crosslinked Polyethylene (PEX) Tubing
F877 Specification for Crosslinked Polyethylene (PEX) Hot- and Cold-Water Distribution Systems
F1281 Specification for Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe
F1588 Test Method for Constant Tensile Load Joint Test (CTLJT)
F1960 Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene

[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 Feb. 1, 2023. Published April 2023. Originally approved in 2017. Last previous edition approved in 2019 as F3253–19. DOI: 10.1520/F3253–23

[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.

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

(PEX) and Polyethylene of Raised Temperature (PE-RT) Tubing

F1807 Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps, for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing

F1865 Specification for Mechanical Cold Expansion Insert Fitting With Compression Sleeve for Cross-linked Polyethylene (PEX) Tubing (Withdrawn 2018)[3]

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

F2080 Specification for Cold-Expansion Fittings with Metal Compression-Sleeves for Crosslinked Polyethylene (PEX) Pipe and SDR9 Polyethylene of Raised Temperature (PE-RT) Pipe

F2159 Specification for Plastic Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing

F2434 Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Cross-linked Polyethylene/Aluminum/Cross-linked Polyethylene (PEX-AL-PEX) Tubing

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

F2735 Specification for Plastic Insert Fittings For SDR9 Cross-linked Polyethylene (PEX) and Polyethylene of Raised Temperature (PE-RT) Tubing

F3347 Specification for Metal Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing

F3348 Specification for Plastic Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing

2.2 *AWWA Standard:*[4]

Manual M-11, Steel Pipe Design and Installation

2.3 *Federal Standard:*[5]

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

2.4 *ISO Standards:*[6]

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 17455 Plastics piping systems — Multilayer pipes — Determination of the oxygen permeability of the barrier pipe

ISO R161-1690 Pipes of Plastic Materials for the Transport of Fluids (Outside Diameters and Nominal Pressures) Part 1, Metric Series

2.5 *Military Standard:*[5]

MIL-STD-129 Marking for Shipment and Storage

2.6 *NSF Standard:*[7]

NSF/ANSI Standard No. 14 for Plastic Piping Components and Related Materials

2.7 *PPI Standard:*[8]

PPI TR-3 Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Hydrostatic Design Stresses (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), Minimum Required Strength (MRS) Ratings, and Categorized Required Strength (CRS) 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 The terminology used in this specification is in accordance with Terminology F412, Terminology D1600, and Symbols D2749, unless otherwise specified. The abbreviation for crosslinked polyethylene is PEX.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *barrier layer*—a very thin polymeric film within the tube wall or around the circumference of the tubing which provides a means for greatly reducing the transmission of oxygen from the atmosphere and into the fluid within the tube.

3.2.2 *hydrostatic design basis (HDB)*—As defined by Terminology F412 is 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.

3.2.2.1 *Discussion*—A voluntary listing of HDB, and HDS values are contained in PPI publication PPI TR-4.

3.2.3 *hydrostatic design stress (HDS)*—As defined by Terminology F412 is 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; $HDS = HDB \times DF$. For this specification, the design factor is less than or equal to 0.50.

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

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

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

[6] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

[7] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, http://www.nsf.org.

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

3.2.4 *hydrostatic strength equivalency (HSE)*—a pressure testing evaluation methodology where hydrostatic testing is conducted on PEX tubing that is constructed with a barrier layer or layers in the middle or outside wall of the tubing, and is constructed with PEX material that has an established HDB. HSE methodology is applied where the barrier layer or layers reduce the thickness of the HDB rated PEX material in the wall such that the PEX wall thickness excluding the barrier layer(s) is slightly less than that required for SDR 9.0.

3.2.4.1 *Discussion*—HSE testing is conducted to confirm that the pressure rating of the PEX tubing having a barrier layer or layers as described herein is at least equal to comparable SDR 9.0 PEX tubing that does not have a barrier layer or layers. When PEX tubing has a barrier layer(s) that does not reduce the thickness of the HDB-rated PEX material below that required for SDR 9.0, it is not necessary to conduct HSE testing because pressure rating is determined using the ISO equation (3.2.6).

3.2.5 *HSE-SDR 9*—an identifying term for the tubing where the minimum PEX wall thickness falls outside the calculated SDR 9 values yet the tubing as constructed meets the pressure rating requirements of this standard as demonstrated by HSE evaluation testing.

3.2.6 *ISO equation and pressure rating (PR)*—The relationship between dimensions, hydrostatic design basis, hydrostatic design stress, and pressure rating as defined by Terminology F412 is illustrated as follows specific to this specification. The following is commonly referred to as the ISO equation (See ISO R161-1690.) :

$$S = P(OD - t)/2t \quad \text{(For outside diameter controlled pipe)} \qquad (1)$$

where:

S = hoop stress,
P = pressure,
OD = average outside diameter,
t = minimum wall thickness

The pressure rating (PR) and HDS/HDB are related by the following equation:

$$PR = 2(HBD)(DF)/(SDR - 1) = 2(HDS)/(SDR - 1) \qquad (2)$$

(being specific to this specification with DF=0.50 and SDR 9)

$$PR = 2(HDB)(0.50)/(9 - 1) = 2(HDS)/8 \qquad (3)$$

Example: PEX with HDB of 800 PSI at 180 °F made according to this specification to SDR 9

$$PR = 2(800)(0.50)/(9 - 1) = 100 \text{ PSI} \qquad (4)$$

3.2.7 *manifold*—an appurtenance that has at least one inlet and multiple outlets

3.2.8 *standard dimension ratio (SDR)*—the ratio of outside diameter to wall thickness as defined by Terminology F412 except this standard uses the minimum total wall thickness, inclusive of layers, to establish SDR. When the total wall thickness calculated by the given formula is less than 0.070 in. (1.78 mm) then the total wall thickness is arbitrarily increased to 0.070 in. except for NTS 5⁄16 and smaller which are prescriptively assigned.

3.2.9 *standard thermoplastic tubing materials designation code*—This material designation code consists of the abbreviation for the type of plastic (PEX) followed by four Arabic digits that describe those properties in accordance with applicable ASTM standards and as shown in Table 1. This material designation code solely addresses the PEX material and does not address any other polymeric materials which might be used in the construction of oxygen barrier tubing.

3.2.9.1 *Discussion*—The first digit is for chlorine resistance. Since this standard is specific to hydronic distribution systems, chlorine resistance is not a mandatory requirement of this application and the default "0" is used if oxidative stability is evaluated only per 6.1.9.1 (stabilizer functionality). If oxidative stability is evaluated per 6.1.9.2 (chlorine resistance), this digit is defined by Specification F876 as follows:

(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 6.1.9.2 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 6.1.9.2 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 6.1.9.2 for minimum chlorine resistance at end use conditions of 100 % of the time at 140 °F.

3.2.9.2 *Discussion*—The second digit is for demonstrated UV resistance of PEX material when tested in accordance with Test Method F2657. For this specification it is one of the classification digits listed in Table 1 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%. Alternately, the second digit may be one of the classification digits from Table 1 for the Nominal Exposure Time Period from Table 1 of Test Method

TABLE 1 Material Designation Code Cells

Property	Standard	0	1	2	3	4	5	6	7	8	9
Chlorine Resistance	F2023	Not tested or rated	(See Specification F876) 25 % at 140 °F 75 % at 73 °F	Reserved	(See Specification F876) 50 % at 140 °F 50 % at 73 °F	(See Specification F876) Reserved	(See Specification F876) 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	...