Designation: F2262 – 09

Standard Specification for Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene Tubing OD Controlled SDR9[1]

This standard is issued under the fixed designation F2262; 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 establishes requirements for coextruded crosslinked polyethylene multi-layer pressure tubing with a continuously welded aluminum tube construction between inner and outer layers of plastic. The inner and outer crosslinked polyethylene layers are bonded to the aluminum by a melt adhesive. The tubing is outside diameter controlled and made in one standard dimension ratio, SDR9 and is intended to be used for hot and cold water conveyance in applications up to 180°F (82.2°C). Included in this specification is a system of nomenclature for crosslinked polyethylene-aluminum-crosslinked polyethylene (PEX-AL-PEX) tubes, and the requirements and test methods for materials, dimensions of component layers and the finished tubing, layer adhesion test, weld strength, short-term burst pressure, long-term sustained pressure and marking requirements. The tubing covered by this specification is intended for use in potable water distribution systems for residential and commercial applications, water service, hydronic radiant heating (HRH), radiant panel heating, baseboard, and snow melt systems.

1.2 This specification covers only plastic-metal-plastic multi-layer tubes incorporating a continuous welded aluminum tube. Tubing consisting of metallic layers not welded together is outside the scope of this specification.

1.3 *Units*—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 Specifications for connectors for use with pipe meeting the requirements of this specification are given in Annex A1.

1.5 The following precautionary caveat pertains only to the test method portion, Section 9, 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 requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

D883 Terminology Relating to Plastics

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

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

F412 Terminology Relating to Plastic Piping Systems

2.2 *NSF International Standards:*

NSF/ANSI 14 for Plastic Piping Components and Related Materials[3]

NSF/ANSI 61 for Drinking Water System Components-Health Effects[3]

2.3 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)[4]

2.4 *Military Standard:*

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

2.5 *Uniform Classification and Committee Standard:*

Uniform Freight Classification[5]

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.11 on Composite.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

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

[5] Available from the Uniform Classification Committee, Suite 1106, 222 South Riverside Plaza, Chicago, IL 60606.

TABLE 1 Outside Diameters, Tolerances, and Aluminum Thickness for PEX-AL-PEX

Nominal Tubing Size, in.	Average Outside Diameter, in. (mm)	Tolerance on Avg, in. (mm)	Maximum Out-of-Roundness, in. (mm)	Aluminum Thickness Minimum, in. (mm)
½	0.625 (15.88)	± 0.004 (0.10)	0.010 (0.25)	0.0095 (0.24)
¾	0.875 (22.22)	± 0.004 (0.10)	0.010 (0.25)	0.0115 (0.29)
1	1.125 (28.58)	± 0.005 (0.12)	0.010 (0.25)	0.0115 (0.29)

TABLE 2 Wall Thickness for PEX-AL-PEX

Nominal Tubing Size, in.	Total Wall Thickness, min, in. (mm)	Tolerance on Total Wall, in. (mm)	Outer PEX Layer Thickness min, in. (mm)	Inner PEX Layer Thickness min, in. (mm)
½	0.070 (1.78)	+ 0.010 (0.25)	0.010 (0.25)	0.043 (1.09)
¾	0.097 (2.47)	+ 0.010 (0.25)	0.010 (0.25)	0.069 (1.75)
1	0.125 (3.18)	+ 0.013 (0.33)	0.010 (0.25)	0.097 (2.46)

2.6 *National Motor Freight Traffic Association Standard:*
National Motor Freight Classification[6]

3. Terminology

3.1 Definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *tubing, PEX-AL-PEX , n*—multi-layer tubing produced by coextrusion or extrusion of layers of polyethylene/ aluminum/ polyethylene bonded together with a melt adhesive and crosslinked by irradiation or chemical means in combination with applied heat and moisture, or any combination thereof.

3.2.2 *tubing hoop stress, n*— a value of hoop stress based on the assumption of a homogeneous wall cross-section.

3.2.2.1 *Discussion*—Thick walled plastic tubes produced from one material have hoop stresses that vary through the wall thickness, and are usually described by the Lame Theory. The multi-layer nature of PEX-AL-PEX tubing, composed of materials with very different Young's Modulus values, will, on pressurization, not have uniform stress distribution through the thickness of the wall of the tube. PEX-AL-PEX tubes have a hoop stress distribution that differs substantially from both thick and thin walled tubing cases.

3.2.3 *unaided eye, n*—observable without visual enhancement beyond correction for normal vision.

4. Classification

4.1 *General*—This specification covers one type of PEX-AL-PEX tubing with outside diameters corresponding to the outside diameter of the same nominal size as copper tubing (CTS).

4.2 *Tubing Outside Diameter*—The PEX-AL-PEX tubes specified in this standard are classified by the outside diameter in one standard dimension ratio, SDR9.

5. Materials

5.1 *General*—PEX-AL-PEX tubing is comprised of one metallic layer, two layers of polymeric adhesive and two-layers of crosslinked polyethylene. For tubing made to this specification, the constituent materials shall meet the respective requirements of 5.2 – 5.5.

5.2 *Aluminum*—The aluminum shall have a minimum thickness as specified in Table 1. The material shall have a minimum elongation and tensile strength of 20 % and 13 000 psi (90 MPa), respectively. The tests for these properties shall be conducted in accordance with ASTM E8.

5.3 *Crosslinked Polyethylene:*

5.3.1 Polyethylene plastics used to make the PEX layers of the PEX-AL-PEX tubing shall be virgin resin having a minimum density of 0.941 g/cm^3. The outer layer of polyethylene shall be of color code B, C, or E in accordance with Specification D3350. Color code B compounds shall have sufficient ultraviolet (UV) stabilization to protect the tubing from deleterious effects due to outdoor exposure during storage and shipping. The inner layer of polyethylene shall be of color code A, B, or C.

5.3.2 The polyethylene, in the final finished state in the tubing, shall be crosslinked as defined in Terminology D883. The polyethylene layers may be crosslinked by peroxides, Azo compounds, or silane compounds in extrusion, or by electron beam irradiation after extrusion, or by other means such that the tubing meets the performance requirements of Section 6.

5.4 *Melt Adhesive*—The material shall have a density cell of 1, 2, or 3; a melt index cell of 1, 2, or 3; and a color code of A or B, in accordance with Specification D3350.

5.5 *Rework Material*—The use of reclaimed, recycled, or re-work plastics is not permitted.

6. Requirements

6.1 *General*—The requirements and test methods in this specification cover PEX-AL-PEX tubing. Tests on the individual layers that comprise the final multi-layer tubing are outside the scope of this specification. The raw materials used, however, shall conform to the requirements of Section 5.

6.2 *Dimensions and Tolerances:*

6.2.1 The dimensions of the tubing and layers shall be in accordance with Tables 1 and 2 when measured in accordance with 9.1.

6.2.1.1 *Out-of-Roundness*—Maximum out-of-roundness tolerances apply only to measurements made on pipe prior to coiling.

[6] Available from National Motor Freight Traffic Association (NMFTA), 1001 N. Fairfax St., Alexandria, VA 22314, http://www.nmfta.org.

6.2.1.2 *Pipe Wall Thickness*—The minimum wall thickness at any point of measurement around the pipe circumference shall not be less than the value specified in Table 2.

6.2.1.3 *Outer and Inner PEX Layer Thickness*—The thickness of the PEX layers shall have a minimum value and tolerance as specified in Table 2, except for the polyethylene material overlaying the weld, which shall allow half the minimum specified in Table 2.

6.3 *Adhesion*—There shall be no visible delamination or separation of the PEX and aluminum layers, either on the bore side or the outside (see Fig. 1), when examined with the unaided eye in accordance with 9.2.

6.4 *Burst Pressure*—Tubing shall meet or exceed the minimum burst pressure requirements shown in Table 3 when tested in accordance with 9.3.

NOTE 1—*Burst pressure testing,* is intended to be a test which can detect mechanical and material flaws from the construction of the tube. Minimum Burst pressure requirments are generally selected based upon the mechanical strength properties of the materials of construction at the specific temperatures to be tested without regard to the ductile characteristics of the polymer.

6.5 *Sustained Pressure*—Tubing shall not fail, balloon, burst, or weep, as defined in Test Method D1598 when tested for 1000 h at the temperature and pressure listed in Table 3 when tested in accordance with 9.4.

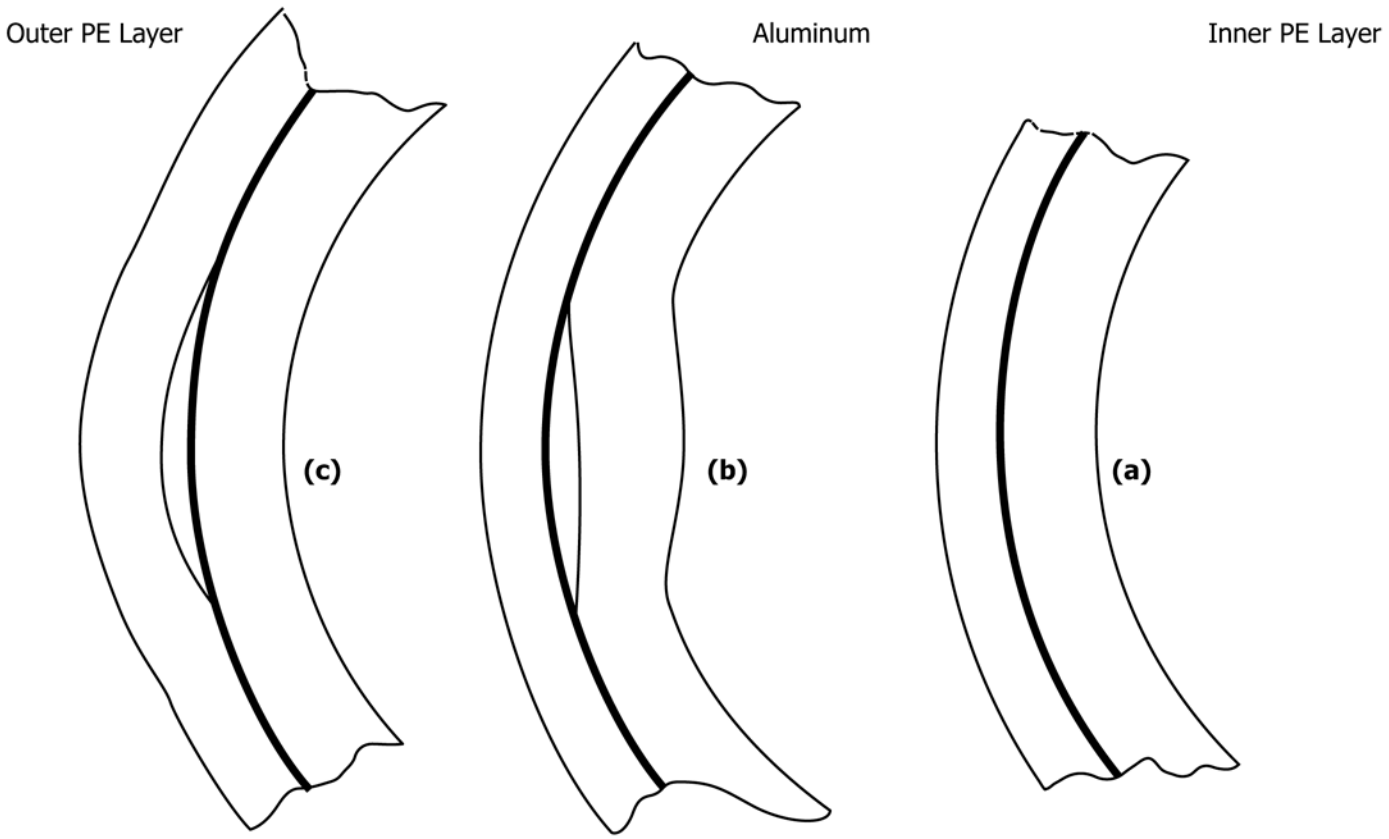
NOTE 2—*Sustained pressure testing*, in thermoplastic pipe and tubing standards relates generally to a short-term validation of the long-term hydrostatic properties that have been previously determined by a minimum of 10 000 h of hydrostatic testing. Generally the sustained hydrostatic pressure selected for the shorter term testing is based upon a lower hoop stress selection than one which would otherwise be expected to generate a rupture failure.

6.6 *Gel Content*—The inner and outer layers of crosslinked polyethylene, when tested in accordance with 9.5, 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.

6.7 *Apparent Ring Tensile Strength*—The pipe rings, when tested in accordance with 9.6, shall meet the minimum strength specifications defined in Table 4.

7. Workmanship, Finish, and Appearance

7.1 The tubing shall be free of visible cracks, blisters, holes, foreign inclusions and other known injurious defects. The



(a) Good pipe showing no delamination.
(b) Delamination between the inner layer and the aluminum.
(c) Delamination between the outer layer and the aluminum.

FIG. 1 Detection of Delamination