



Standard Specification for Polyethylene (PE) Plastic Tubing¹

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers polyethylene (PE) tubing pressure rated for water (see appendix). Included are criteria for classifying PE plastic tubing materials and PE plastic tubing, and requirements and test methods for materials, workmanship, dimensions, sustained pressure, burst pressure, and environmental stress cracking. This specification differs from the pipe specifications in their outside diameters. Methods of marking 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 the standard. The values given in parentheses are for information only.

NOTE 1—PE plastic tubing is often used with fittings that require flaring the tubing. The technique used to make the flare is highly important to produce leak-free joints. For further information, refer to Practice D 3140.

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:

- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing²
- D 792 Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement²
- D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer²
- D 1248 Specification for Polyethylene Plastics Molding and Extrusion Materials²

D 1505 Test Method for Density of Plastics by the Density-Gradient Technique²

D 1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure³

D 1599 Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings³

D 1600 Terminology for Abbreviated Terms Relating to Plastics²

D 1603 Test Method for Carbon Black in Olefin Plastics²

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings³

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials³

D 3140 Practice for Flaring Polyolefin Pipe and Tubing³

D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials⁴

F 412 Terminology Relating to Plastic Piping Systems³

2.2 NSF Standard:

Standard No. 14 for Plastic Piping Components and Related Materials⁵

3. Terminology

3.1 *Definitions:* Definitions are in accordance with Terminology F 412 and abbreviations are in accordance with Terminology D 1600, unless otherwise specified. The abbreviation for polyethylene plastic is PE.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *hydrostatic design stress*—the estimated maximum tensile stress the material is capable of withstanding continuously with a high degree of certainty that failure of the pipe will not occur. This stress is circumferential when internal hydrostatic water pressure is applied.

3.2.2 *pressure rating (PR)*—the estimated maximum water pressure the pipe is capable of withstanding continuously with a high degree of certainty that failure of the pipe will not occur.

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

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² *Annual Book of ASTM Standards*, Vol 08.01.

³ *Annual Book of ASTM Standards*, Vol 08.04.

⁴ *Annual Book of ASTM Standards*, Vol 08.03.

⁵ Available from the National Sanitation Foundation, P.O. Box 1468, Ann Arbor, MI 48106.

⁶ ISO R 161-1960, Pipes of Plastics Materials for the Transport of Fluids (Outside Diameters and Nominal Pressures) Part 1, Metric Series.

to relate dimensions, hydrostatic design stress, and pressure rating:

$$2S/P = (D_0/t) - 1 \text{ or } 2S/P = R - 1$$

where:

- S = hydrostatic design stress, psi (or MPa),
- P = pressure rating, psi (or MPa),
- D_0 = average outside diameter, in. (or mm),
- t = minimum wall thickness, in. (or mm), and
- R = standard thermoplastic pipe dimension ratio (D_0/t for PE tubing).

3.2.4 *standard dimension ratio (SDR)*—the average outside diameter in inches divided by the minimum wall thickness in inches, rounded to the nearest 0.5.

3.2.5 *standard thermoplastic tubing materials designation code*—the tubing materials designation code shall consist of the abbreviation PE for the type of plastic, followed by the ASTM grade in Arabic numerals and the hydrostatic design stress in units of 100 psi with any decimal figures dropped. Where the hydrostatic design code contains less than two figures, a cipher shall be used before the number. Thus a complete material code consists of two letters and four figures for PE plastic tubing materials (see Section 5).

3.2.6 *tubing*—for the purpose of this specification, pipe made to specific outside diameters as shown in Table 1.

4. Tubing Classification

4.1 *General*—This specification covers PE tubing made from four PE plastic tubing materials in three standard dimension ratios and three water pressure ratings (appendix).

4.2 *Standard Thermoplastic Pipe Dimension Ratios (SDR)*—This specification covers PE tubing in three standard dimension ratios, namely, 7.3, 9, and 11. These are referred to as SDR 7.3, SDR 9, and SDR 11, respectively. The pressure rating is uniform for all nominal tubing sizes for a given PE pipe material and SDR with the exception of SDR 9 with PE-3408 material (appendix).

5. Materials

5.1 *General*—Polyethylene plastics used to make tubing meeting the requirements of this specification are categorized by means of two criteria, namely, (1) short-term strength tests, and (2) long-term strength tests.

5.2 *Basic Materials*—This specification covers PE tubing made from three PE plastics as defined in Specification

D 1248, in which the requirements are based on short-term tests of Grade P23, Grade P24, Grade P33, and Grade P34. The 80°C sustained pressure performance requirements of 6.9 are not currently in PE material Specifications D 1248 or D 3350. To identify the correct tubing test category (C1 to C7), the PE material base resin density and melt index must be obtained from the PE material supplier.

NOTE 2—Committee F-17 has requested that Committee D-20 add the 80°C sustained pressure performance requirements to Specifications D 1248 and D 3350.

5.3 *Hydrostatic Design Stresses*—This specification covers PE tubing made from three PE plastics as defined by hydrostatic design stresses developed on the basis of long-term tests (appendix).

5.4 *Compound*—The PE plastic extrusion compound shall meet the requirements of either Grade P23, Class B or C; Grade P24, Class B or C; Grade P33, Class B or C; or Grade P34, Class B or C, material as described in Specification D 1248.

5.4.1 Class B compounds shall have sufficient UV stabilizer to protect pipe from deleterious affects due to continuous outdoor exposure during storage and shipping. Pipe produced from Class B compounds are not suitable for exposed outdoor application. Class B and C compounds shall have sufficient antioxidants to meet requirements in Specification D 3350.

NOTE 3—Pipe users should consult with the pipe manufacturer about the outdoor exposure life of the product under consideration.

5.5 *Rework Material*—The manufacturers shall use only their own clean rework pipe material and the pipe produced shall meet all the requirements of this specification.

6. Requirements

6.1 *Workmanship*—The tubing shall be homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other defects. The tubing shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

6.2 *Dimensions and Tolerances:*

6.2.1 *Outside Diameters*—The outside diameters and tolerances shall be as shown in Table 1 when measured in accordance with 7.4 and 7.4.1. Out-of-roundness (deviations of maximum and minimum outside diameters from the average outside diameter) shall be ± 0.015 in. (± 0.38 mm) as extruded. Coilings increase the out-of-roundness to some degree, depending on the coiling method and coil dimensions.

6.2.2 *Wall Thicknesses*—The wall thicknesses and tolerances shall be as shown in Table 2 when measured in accordance with 7.4 and 7.4.2.

6.2.3 *Wall Thickness Range*—The wall thickness range shall be within 12 % when measured in accordance with 7.4 and 7.4.3.

6.2.4 *Thickness of Outer Layer*—For tubing produced by simultaneous multiple extrusion, that is, tubing containing two or more concentric layers, the outer layer shall be at least 0.5 mm (0.020 in.) thick.

6.3 *Bond*—For tubing produced by simultaneous multiple extrusion, the bond between the layers shall be strong and uniform. It shall not be possible to separate any two layers with

TABLE 1 Outside Diameters and Tolerances for PE Plastic Tubing

Nominal Tubing Size, in.	Outside Diameter, in.	Tolerance	
		For Average, in.	For Max and Min (out-of-roundness), ^A in.
1/2	0.625	± 0.004	± 0.015
5/8	0.750	± 0.004	± 0.015
3/4	0.875	± 0.004	± 0.015
1	1.125	± 0.005	± 0.015
1 1/4	1.375	± 0.005	± 0.015
1 1/2	1.625	± 0.006	± 0.015
2	2.125	± 0.006	± 0.015

^A The maximum and minimum (out-of-roundness) tolerances apply only to tubing as extruded.



TABLE 2 Wall Thickness and Tolerances for PE Plastic Tubing

Nominal Tubing Size, in.	Wall Thickness, in. ^A					
	PE2305 SDR 7.3			PE2306, PE2406, PE3306 PE3406, PE3408 SDR 9		PE3408 SDR 11
	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance
1/2	0.086	+0.010	0.069	+0.010	0.062	+0.010
5/8	0.103	+0.010	0.083	+0.010	0.068	+0.010
3/4	0.120	+0.012	0.097	+0.010	0.080	+0.010
1	0.154	+0.015	0.125	+0.012	0.102	+0.010
1 1/4	0.188	+0.019	0.153	+0.015	0.125	+0.012
1 1/2	0.233	+0.022	0.181	+0.018	0.148	+0.015
2	0.291	+0.029	0.236	+0.024	0.193	+0.019

^A The minimum is the lowest wall thickness of the tubing 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.

a probe or point of a knife blade so that the layers separate cleanly at any point.

6.4 *Carbon Black*—Class C polyethylene tubing extrusion compound shall contain at least 2 % carbon black when tested in accordance with 7.5. For tubing produced by simultaneous extrusion, this requirement shall apply only to the outer layer.

NOTE 4—The amount of pigment in Class B polyethylene is not established by this specification other than the compound shall meet all other requirements and the tubing shall meet all long- and short-term requirements of this specification.

NOTE 5—There is evidence that indicates that type, particle size, and dispersion quality of the carbon black affects the long-term stability and weatherability of the tubing. The problem is being investigated and when reliable test methods are developed, requirements for long-term stability and weatherability, or other suitable requirements to cover this property, will be included in a revision of this specification.

6.5 *Density*—When determined in accordance with 7.6, the polyethylene base resin (uncolored PE) in the tubing compound shall have a density in the range from 0.926 to 0.940 Mg/m³ for tubing made from Grade P23 and Grade P24; 0.941 to 0.965 Mg/m³ for tubing made from Grade P33; and 0.941 to 0.965 Mg/m³ for tubing made from Grade P34 of Specification D 1248.

6.6 *Burst Pressure*—The minimum burst pressure for PE plastic tubing shall be as given in Table 3, when determined in accordance with 7.9.

6.7 *Environmental Stress Cracking*— There shall be no loss of pressure in the tubing when tested in accordance with 7.10.

6.8 *Sustained Pressure*—Pipe made from PE materials designated PE2406, PE3406 or PE3408 shall meet the requirement of 6.8.1. Pipe made from other PE materials shall meet the requirements of 6.8.2 and 6.8.3.

6.8.1 The average failure time and the failure time of two of the three specimens shall meet or exceed the minimum values shown in Table 4, when tested in accordance with 7.11.1.

6.8.2 *Sustained Pressure*—The tubing shall not fail, balloon, burst, or weep as defined in Test Method D 1598, at the test pressures given in Table 5, when tested in accordance with 7.8.

6.8.3 *Elevated Temperature Sustained Pressure*—The average failure time must meet or exceed the specified minimum average failure time in Table 6 for both hoop stresses of a given tubing test category when tested in accordance with 7.11.

7. Test Methods

7.1 *Conditioning*—Condition the test specimens at 73 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 40 h prior to the test in accordance with Procedure A of Practice D 618, for those tests where conditioning is required. In cases of disagreement the tolerances shall be ±1°C (±1.8°F) and ±2 % relative humidity.

7.2 *Test Conditions*—Conduct tests 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*—The selection of the sample or samples of tubing shall be as agreed upon by the purchaser and seller. In case of no prior agreement, any sample 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 pipe which is at least one pipe 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 D 2122.

7.4.1 *Outside Diameter*—Measure the outside diameter of

TABLE 3 Burst Pressure Requirements for Water at 23°C (73.4°F) for PE Plastic Tubing

Nominal Tubing Size, in.	Minimum Burst Pressures ^A
	PE2305, PE2306, PE2406, PE3306, PE3406, PE3408
SDR 7.3 and 9	630 psi (4.34 MPa)
SDR 11	504 psi (3.47 MPa)

^A The fiber stresses used to derive these test pressures are as follows:

PE2305	2000 psi (13.8 MPa)
PE2306, PE2406, PE3306, PE3406, PE3408	2520 psi (17.4 MPa)

TABLE 4 Minimum Average Time to Failure (h) versus Test Hoop Stress

Base Resin Density (g/cc)	Minimum Average Failure Time (h)	
	S = 580 psi (4 MPa)	S = 670 psi (4.6 MPa)
>0.935	1000	170