



Standard Specification for Polyethylene (PE) Plastic Tubing¹

This standard is issued under the fixed designation D2737; 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.

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.*~~

1.1 This specification covers polyethylene (PE) plastic tubing in outside diameters and SDR's that are pressure rated for water. Included are requirements for PE compounds, and requirements and test methods for PE plastic tubing workmanship, dimensions, elevated temperature sustained pressure, burst pressure and marking.

1.2 The text of this specification references notes, footnotes, and appendixes which provide explanatory material. These notes and footnotes shall not be considered as requirements of the specification. Notes and footnotes in tables and figures, and Supplementary Requirements are 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.

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 D3140 1—Joining PE plastic tubing with fittings that require flaring the tubing is not recommended because Practice D3140, the technique used to make the flare has been withdrawn (discontinued).

NOTE 2—References and PE compound descriptions for PE2305, PE2406, PE3306, PE3406, and PE3408 have been removed due to changes in Specification D3350 and PPI TR-3. For removed designations, refer to previous editions of Specification D2737, Specification D3350, PPI TR-3 and PPI TR-4. The removal of these PE compounds does not affect pipelines that are in service. PE compounds and material designations resulting from changes in Specification D3350 and PPI TR-3 are addressed in Section 5.

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:²

D618 Practice for Conditioning Plastics for Testing

~~D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement~~ ~~638 Test Method for Tensile Properties of Plastics~~

~~D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer~~ ~~D1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable~~

~~D1505 Test Method for Density of Plastics by the Density-Gradient Technique~~

¹ This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.26 on Olefin Based Pipe.

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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.

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

- 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
- D1603 Test Method for Carbon Black Content in Olefin Plastics
- D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
- D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
- D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
- D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials
- D3140 Practice for For Flaring Polyolefin Pipe and And Tubing³
- D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials⁴ 218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique
- F412 Terminology Relating to Plastic Piping Systems Terminology Relating to Plastic Piping Systems
- G154 Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials
- G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials
- 2.2 ~~NSF Standard:~~ APWA Standard:⁴
APWA Uniform Color Code
- 2.3 NSF Standards:⁵
NSF/ANSI Standard No. 14 for Plastic Piping Components and Related Materials
NSF/ANSI Standard No. 61 for Drinking Water Systems Components—Health Effects
- 2.4 PPI Standards:⁶
PPI TR-3 Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe
PPI TR-4 HDB/SDB/PDB/MRS Listed Materials, 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
- 3.1 Definitions—Unless otherwise specified, definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, 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, is used in this specification to relate dimensions, hydrostatic design stress, and pressure rating:

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

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

4. Tubing Classification

4.1 General—This specification covers PE plastic tubing made from PE compounds in three standard dimension ratios and pressure rated for water. Pressure ratings for water are dependent on the PE compound in accordance with the following relationship:

$$PR = \frac{2 \times HDS}{(SDR + 1)} \quad (1)$$

PR

³ Available from the National Sanitation Foundation, P.O. Box 1468, Ann Arbor, MI 48106.

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

⁴ ISO R161-1960, Pipes of Plastics Materials for the Transport of Fluids (Outside Diameters and Nominal Pressures) Part 1, Metric Series.

⁴ APWA, 2345 Grand Boulevard, suite 500, Kansas, City, MO 64108-2641.

⁵ This test method is based on the use of "Igepal CO-630," a trademark for a nonylphenoxy poly(ethyleneoxy)ethanol, which may be obtained from GAF Corp., Dyestuff and Chemical Div., 140 West 51st St., New York, NY 10020.

⁵ Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, <http://www.nsf.org>.

⁶ Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, <http://www.plasticpipe.org>.

where:

Where:

PR = hydrostatic design stress, psi (or MPa);

$P_{pressure}$

rat-

ing

for

wa-

ter,

73°F

(23°C),

psi

(kPa)

HDS = pressure rating, psi (or MPa);

D_0 hydrostatic

de-

sign

stress

for

water

at

73°F

(23°C),

psi

(kPa)

SDR = 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);
standard dimension ratio

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).

TABLE 1.2 Outside Diameters and Tolerances for PE Plastic Tubing

Nominal Tubing Size, in.	Outside Diameter, in. in. (mm)	Tolerance	
		For Av Outside Diameter- Tolerance, in. (mm)	Out-or-Max-of-Round-Minuss, (out-of-round- ness), ^A in. (mm)
1/2	0.625	±0.004	±0.015
1/2	0.625 (15.87)	±0.004 (±0.10)	0.030 (0.76)
3/8	0.750	±0.004	±0.015
3/8	0.750 (19.05)	±0.004 (±0.10)	0.030 (0.76)
3/4	0.875	±0.004	±0.015
3/4	0.875 (22.23)	±0.004 (±0.10)	0.030 (0.76)
1	1.125	±0.005	±0.015
1	1.125 (28.58)	±0.005 (±0.13)	0.030 (0.76)
1 1/4	1.375	±0.005	±0.015
1 1/4	1.375 (34.93)	±0.005 (±0.13)	0.030 (0.76)
1 1/2	1.625	±0.006	±0.015
1 1/2	1.625 (41.23)	±0.006 (±0.15)	0.030 (0.76)
2	2.125	±0.006	±0.015
2	2.125 (53.98)	±0.006 (±0.15)	0.030 (0.76)

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

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 D1248, 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 D1248 or D3350. 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.

NOTE2—Committee F-17 has requested that Committee D20 add the 80°C sustained pressure performance requirements to Specifications D1248 and D3350. 3—PR and HDS must have the same units. See Appendix X1 for maximum pressure ratings for water.

4.2 This specification covers PE tubing in standard dimension ratios SDR 7.3, SDR 9, and SDR 11.

5. Materials

5.1 Polyethylene Compound—Polyethylene compounds suitable for use in the manufacture of tubing under this specification shall meet thermoplastic materials designation codes PE2708 or PE3608 or PE4608 or PE4710, and shall meet Table 1 requirements for PE2708 or PE3608 or PE4608 or PE4710, and shall meet thermal stability, brittleness temperature and elongation at break requirements in accordance with Specification D3350.

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 D1248.

5.4.1 Class B compounds shall have sufficient UV stabilizer to protect pipe from deleterious effects 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 D3350.

5.1.1 Color and Ultraviolet (UV) Stabilization—Polyethylene compounds shall meet Specification D3350 code C, D or E. In addition, Code C polyethylene compounds shall have 2 to 3 percent carbon black, and Code D or E polyethylene compounds shall have sufficient UV stabilizer to protect tubing from deleterious UV exposure effects during unprotected outdoor shipping and storage for at least eighteen (18) months.

NOTE3—Pipe users should consult with the pipe manufacturer about the outdoor exposure life of the product under consideration.

5.5 4—Pipe users should consult with the pipe manufacturer about the outdoor exposure life of the product under consideration. Evaluation of UV stabilizer in Code D or E PE compound using Practice D2565 or Practice G154 or Practice G155 may be useful for this purpose.

5.1.2 Colors for solid color, an external color layer or color stripes—In accordance with the APWA Uniform Color Code, blue shall identify potable water service; green shall identify sewer service; and purple (lavender) shall identify reclaimed water service. Yellow identifies gas service and shall not be used.

5.2 Products intended for contact with potable water shall be evaluated, tested and certified for conformance with NSF/ANSI Standard No. 61 or the health effects portion of NSF/ANSI Standard No. 14 by a certifying organization acceptable to the authority having jurisdiction.

5.3 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. —Clean polyethylene compound from the manufacturer’s own tubing production that met 5.1 through 5.2 as new PE compound is suitable for re-extrusion into tubing when blended with new PE compound having the same material designation. Tubing containing rework material 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. See 5.1.2.

6.2 Dimensions and Tolerances:

6.2.1 Outside Diameters—The outside diameters and tolerances shall be as shown in Table 1–Table 2 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.

6.2.1.1 Out-of-roundness—Out of roundness shall be in accordance with Table 2 as extruded, but before coiling for packaging when measured in accordance with 7.4.

TABLE 5 1 – SusPolyetaihylene Compound Wat Rer Pressuire Tmest Conditions for PE Plastic Tubing

NoRequirement	Material Designation			
	PE2708	PE3608	PE4608	PE4710
Required Value				
HDB at 140°F (60°C), psi (MPa), Tubing Size, in. HDB at 140°F (60°C), psi (MPa), per Test Method D2837 Size, in. At (23°C)	Material	nd PPI TR-3 ^A Required for Test, psi (MPa)		
		Pressure ^A Required for Test, psi (MPa)		
All sizes	PE2305	(2.28)	330	
All sizes ^B	PE2306	(2.28)	330	
HDS for water at 73°F (23°C) psi (MPa), per Test Method D2837 and PPI TR-3 ^C	PE2406	(2.28)	800 (5.5)	330
	800 (5.5)	800 (5.5)	800 (5.5)	1000 (6.9)
Melt flow rate per Test Method D1238	PE3306	(2.28)	330	
	PE3406	(2.28)		330
	≤0.40 g/10 min Cond. 190/2.16 or ≤20 g/10 min Cond. 190/21.6	≤0.15 g/10 min Cond. 190/2.16 or ≤20 g/10 min Cond. 190/21.6	≤0.15 g/10 min Cond. 190/2.16 or ≤20 g/10 min Cond. 190/21.6	≤0.15 g/10 min Cond. 190/2.16 or ≤20 g/10 min Cond. 190/21.6
Specification D3350	PE3408	(2.76)	400	
Cell Classification Property Requirement Specification D3350		(SDR 9)		
Cell Classification Property Requirement				
Density (natural base resin)	PE3408	(2.21)	320	
	2	3	320	
	(SDR 11)			
	(SDR 11)			

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

	MPa	psi
At 23°C (73.4°F):		
— PE2305	7.24	1050
SCG Resistance	7	1050
— PE2306	9.10	1320
— PE2306	6	7
— PE2406	9.10	1320
— PE3306	9.10	1320
— PE3306		
— PE3406	9.10	1320
Color and UV Stabilizer Code ^D	C, D or E	1320
— P E3408	11.0	1600
— PC, D or E	C, D or E	C, D or E

^A HDB at 140°F (60°C) not required. Contact manufacturer about pipe use at temperatures other than 73°F (23°C).

^B HDB at 140°F (60°C) required. Contact manufacturer or see PPI TR-4 for listed value.

^C Contact manufacturer or see PPI TR-4 for listed value.

^D See 5.1.1.

NOTE 5—Coiling may increase out-of-roundness, depending on the coiling method and coil dimensions.

6.2.2 *Wall Thicknesses*—The wall thicknesses and tolerances shall be as shown in Table 23 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. Wall thickness shall be inclusive of all extruded concentric layers.

6.2.3 *Wall Thickness Variation*—The wall thickness variation shall not exceed 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. For tubing produced by simultaneous multiple extrusion, the outer concentric layer shall be at least 0.020 in (0.5 mm) 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 cleanly separate any two layers with 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. Polyethylene tubing produced using Code C polyethylene compound per 5.1.1 shall contain 2 to 3% 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 D1248.

6.6

6.5 *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. The minimum burst pressure for tubing shall be as given in Table 4, when tested in accordance with 7.11.1, when determined in accordance with 7.6 using a minimum hoop stress of 2520 psi (17.4 MPa) for Table 1 density cell 2 polyethylene compound or 2900 psi (20.0 MPa) for Table 1 density cell 3 or 4 polyethylene compound. In addition, the failure shall be ductile.

6.6 *Elevated Temperature Sustained Pressure*—Elevated temperature sustained pressure tests for each polyethylene compound designation per Table 1 used in production at the facility shall be conducted twice annually per 7.7.

6.8.2 *Sustained Pressure*—The tubing shall not fail, balloon, burst, or weep as defined in Test Method D1598, at the test pressures given in Table 5, when tested in accordance with 7.9.

6.7 *Inside Surface Ductility for Tubing*—Tubing shall be tested for inside surface ductility in accordance with 7.8 or 7.9.

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.

NOTE 6—Tensile elongation testing per 7.9 provides a quantifiable result and is used for referee testing and in cases of disagreement.

TABLE 2 3 Wall Thickness and Tolerances for PE Plastic Tubing

Nominal Tubing Size, in.	Wall Thickness, in. ^A											
	PE2305SDR 7.3				PE2306, PE2406, PE3306 PE3406, PE3408SDR 9				PE3408SDR 11			
	in.		(mm)		in.		(mm)		in.		(mm)	
	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance
1/2	0.086	+0.010	(2.18)	(0.25)	0.069	+0.010	(1.75)	(0.25)	0.062	+0.010	(1.57)	(0.25)
5/8	0.103	+0.010	(2.62)	(0.25)	0.083	+0.010	(2.11)	(0.25)	0.068	+0.010	(1.73)	(0.25)
3/4	0.120	+0.012	(3.05)	(0.30)	0.097	+0.010	(2.46)	(0.25)	0.080	+0.010	(2.03)	(0.25)
1	0.154	+0.015	(3.91)	(0.38)	0.125	+0.012	(3.18)	(0.30)	0.102	+0.010	(2.59)	(0.25)
1 1/4	0.188	+0.019	(4.78)	(0.48)	0.153	+0.015	(3.89)	(0.38)	0.125	+0.012	(3.18)	(0.30)
1 1/2	0.233	+0.022	(5.92)	(0.56)	0.181	+0.018	(4.60)	(0.46)	0.148	+0.015	(3.76)	(0.38)
2	0.291	+0.029	(7.39)	(0.74)	0.236	+0.024	(5.99)	(0.61)	0.193	+0.019	(4.90)	(0.48)

^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. Wall thickness variation shall be in accordance with 6.2.3.