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An American National Standard

Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter[1]

This standard is issued under the fixed designation D2239; 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) pipe made in standard thermoplastic pipe dimension ratios and pressure rated for water (see appendix). Included are criteria for classifying PE plastic pipe materials and PE plastic pipe, a system of nomenclature for PE plastic pipe, and requirements and test methods for materials, workmanship, dimensions, sustained pressure, burst pressure, and environmental stress cracking. Methods of marking are also given.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 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.

1.4 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

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

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

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

F412 Terminology Relating to Plastic Piping Systems

2.2 *NSF Standards:*

Standard No. 14 for Plastic Piping Components and Related Materials[3]

Standard No. 61 for Drinking Water Systems Components—Health Effects[3]

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 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.

[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.

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

TABLE 1 176°F (80°C) Sustained Pressure Requirements for Water Pipe[A,B]

Pipe Test Category[C]	Base Resin Melt Index, D1238 (g/10 min)	Base Resin Density,[D] D1505 (g/cm³)	Minimum Average Hours to Failure		
			S = 725 psi (5 MPa)	S = 580 psi (4 MPa)	S = 435 psi (3 MPa)
C1	0.05	0.941–0.948	100	200	.....
C2	<0.05	0.935–0.940	100	200	....
C3	0.05–0.25	0.941–0.948	60	150	...
C4	0.05–0.25	0.935–0.940	60	150	...
C5	>0.25	0.941–0.948	45	100	...
C6	>0.25	0.935–0.940	45	100	...
C7	>0.50	0.926–0.940	...	80	150

[A] For inside diameter controlled pipe, calculate internal pressure in accordance with the following formula:

$$P = \frac{2S}{\frac{D_i}{t} + 1}$$

[B] For outside diameter controlled pipe, calculate internal pressure in accordance with the following formula:

$$P = \frac{2S}{\frac{D_o}{t} - 1}$$

where:
P = pressure, psig (MPa),
S = hoop stress, psi (MPa),
D_i = average inside diameter, in. (mm),
D_o = average outside diameter, in. (mm), and
t = minimum wall thickness, in. (mm).

[C] Supplier to determine pipe test category appropriate for his product.
[D] Pipe categories for water pipe with resin density below 0.926 g/cm³ or above 0.948 g/cm³ will be added to this table when the data are available.

3.2.3 *relation between standard dimension ratio, hydrostatic design stress, and pressure rating*—the following expression, commonly known as the ISO equation,[4] is used in this specification to relate standard dimension ratio, hydrostatic design stress, and pressure rating:

$$2S/P = R + 1 \text{ or } 2S/P = (D_i/t) + 1 \quad (1)$$

where:
S = hydrostatic design stress, MPa (or psi),
P = pressure rating, MPa (or psi),
D_i = average inside diameter, mm (or in.),
t = minimum wall thickness, mm (or in.), and
R = standard thermoplastic pipe dimension ratio (D_i/t for *PE* pipe), also known as SIDR.

3.2.4 *standard thermoplastic pipe dimension ratio (SIDR)*—the ratio of pipe diameter to wall thickness. For PE pipe it is calculated by dividing the average inside diameter of the pipe in millimetres or in inches by the minimum wall thickness in millimetres or in inches. If the wall thickness calculated by this formula is less than 1.52 mm (0.060 in.), it shall be arbitrarily increased to 1.52 mm. The SIDR values shall be rounded to the nearest 0.1.

3.2.5 *standard thermoplastic pipe materials designation code*—the pipe 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 stress code contains less than two figures, a cipher shall be used before the number. Thus a complete material code shall consist of two letters and four figures for PE plastic pipe materials (see Section 5).

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

4. Pipe Classification

4.1 *General*—This specification covers PE pipe made from four PE plastic pipe materials in six standard dimension ratios and six water pressure ratings.

4.2 *Standard Thermoplastic Pipe Dimension Ratios (SIDR)*—This specification covers PE pipe in six standard dimension ratios, namely, 5.3, 7, 9, 11.5, 15, and 19. These are referred to as SIDR 5.3, SIDR 7, SIDR 9, SIDR 11.5, SIDR 15, and SIDR 19, respectively. The pressure rating is uniform for all nominal pipe sizes for a given PE pipe material and SIDR (see Table X1.1, appendix).

5. Materials

5.1 *General*—Polyethylene plastics used to make pipe 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 pipe made from four PE plastics as defined in Specification D1248, in which the requirements are based on short-term tests. These are Grade P 14, Grade P 23, Grade P 24, Grade P 33, and Grade P 34. The PE plastics can also be described in accordance with the appropriate cell classification as defined in Specification D3350. The 80°C sustained pressure performance requirements of 6.8.3 (pipe test category in Table 1) are not currently in PE material Specifications D1248 or D3350. To identify the correct pipe test category (C1 to C7), the PE material base resin density and melt index must be obtained from the PE material supplier.

NOTE 1—Committee F17 has requested that Committee D20 add the 80°C sustained pressure performance requirements to Specifications D1248 and D3350.

TABLE 2 Inside Diameters and Tolerances for SIDR-PR PE Plastic Pipe, in.

Nominal Pipe Size	Average Inside Diameter	Tolerances
½	0.622	+0.010 −0.010
¾	0.824	+0.010 −0.015
1	1.049	+0.010 −0.020
1¼	1.380	+0.010 −0.020
1½	1.610	+0.015 −0.020
2	2.067	+0.015 −0.020
2½	2.469	+0.015 −0.025
3	3.068	+0.015 −0.030
4	4.026	+0.015 −0.035
6	6.065	+0.020 −0.035

5.3 *Hydrostatic DesignStresses*—This specification coversPE pipe made from PE plastics as defined by four hydrostatic design stresses developed on the basis of long-term tests (Appendix X1).

5.4 *Compound*—The PE plastic extrusion compound shall meet the requirements of either Grade P 14, Class B or C; Grade P 23, Class B or C; Grade P 24, Class B or C; Grade P 33, Class B or C; or Grade P 34, Class B or C material as described in Specification D1248. The PE plastics can also be described in accordance with the appropriate cell classification as defined in Specification D3350.

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 the requirements in Specification D3350.

5.4.2 Class C compounds use carbon black for UV stabilization. There is evidence that indicates the type, particle size, and dispersion quality of the carbon black affect the weatherability of the pipe.

5.4.3 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 pipe 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 *Dimensions and Tolerances*:

6.2.1 *Inside Diameters*—The inside diameters and tolerances shall be as shown in Table 2 when measured in accordance with Test Method D2122.

6.2.2 *Wall Thicknesses*—The wall thicknesses and tolerances shall be as shown in Table 3 when measured in accordance with Test Method D2122.

6.2.3 *Wall Thickness Range*—The wall thickness range shall be within 12 % when measured in accordance with Test Method D2122.

6.2.4 *Thickness of Outer Layer*—For pipe produced by simultaneous multiple extrusion, that is, pipe containing two or more concentric layers, the outer layer shall be at least 0.50-mm (0.020-in.) thick.

6.3 *Bond*—For pipe 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 a probe or point of a knife blade so that the layers separate cleanly at any point.

6.4 *Carbon Black*—Class C polyethylene pipe extrusion compound shall contain at least 2 % carbon black when tested in accordance with 7.4. For pipe produced by simultaneous multiple extrusion, this requirement shall apply to the outer layer.

NOTE 2—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.

6.5 *Density*—The polyethylene base resin (uncolored PE) in the pipe compound shall have a density in the range from 0.910 to 0.925 g/cm^3 for pipe made from Grade P 14 of Specification D1248, 0.926 to 0.940 g/cm^3 for pipe made from Grade P 23 and Grade P 24 of Specification D1248, 0.941 to 0.965 g/cm^3 for pipe made from Grade P 33 of Specification D1248, and 0.941 to 0.965 g/cm^3 for pipe made from Grade P 34 of Specification D1248 when determined in accordance with 7.5.

6.6 *Burst Pressure*—The minimum burst pressure for PE plastic pipe shall be as given in Table 4, when determined in accordance with 7.10.

6.7 *Environmental Stress Cracking*—There shall be no loss of pressure in the pipe when tested in accordance with 7.8.

6.8 *Sustained Pressure*—Pipe made from PE materials designated PE2406, PE3406 or PE3408 shall meet the requirements 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 5 when tested in accordance with 7.9.1.

6.8.2 *Sustained Pressure*—The pipe shall not fail, balloon, burst, or weep as defined in Test Method D1598, at the test pressures given in Table 6 when tested in accordance with 7.7.

6.8.3 *Elevated Temperature Sustained Pressure*—The average failure time must meet or exceed the specified minimum average failure time in Table 1 for both hoop stresses of a given pipe test category when tested in accordance with 7.9.

7. Test Methods

7.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) prior to test in accordance with Procedure A of Practice D618, for those tests where conditioning is required.