



Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter¹

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.*

1.1 This specification covers polyethylene (PE) pipe made in standard inside dimension ratios (SIDR) and pressure rated for water (see appendix). Included are requirements for PE compounds and requirements and test methods for workmanship, dimensions, elevated temperature sustained pressure, burst pressure, and marking.

1.2 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.

1.3 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.

1.4 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.*

NOTE 1—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 D2239, 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.

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

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.

- 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
- 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
- D4218 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 APWA Standard:³
APWA Uniform Color Code
- 2.3 NSF Standards:⁴
NSF/ANSI Standard No. 14 for Plastic Piping Components and Related Materials
Standard No. 61 for Drinking Water Systems Components—Health Effects³—NSF/ANSI Standard No. 61 for Drinking Water Systems Components—Health Effects
- 2.4 PPI Standards:⁵
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*—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 standard dimension ratio, hydrostatic design stress, and pressure rating—the following expression, commonly known as the ISO equation, is used in this specification to relate standard dimension ratio, hydrostatic design stress, and pressure rating:

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

4. Pipe Classification

4.1 General—This specification covers inside diameter controlled PE pipe made from PE compounds in standard inside 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

where: Where:

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

³ APWA, 2345 Grand Boulevard, suite 500, Kansas, City, MO 64108-2641.

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

⁴ Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, <http://www.nsf.org>.

⁵ This 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 W. 51st St., New York, NY 10020.

⁵ Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, <http://www.plasticpipe.org>.

SPR = hydrostatic design stress, MPa (or psi), pressure rating for water, psi (kPa)
PHDS = pressure rating, MPa (or psi), hydrostatic design stress for water at 73°F (23°C), psi (kPa)
D_iS_i = average inside diameter, mm (or in.);
IDR
t = minimum wall thickness, mm (or in.), and
R = standard thermoplastic pipe dimension ratio (*D_i/t* for PE pipe), also known as SIDR: standard inside dimension ratio

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. 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 P14, Grade P23, Grade P24, Grade P33, and Grade P34. 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: <https://standards.iteh.ai/catalog/standards/sist/6b9e8641-064c-45bf-b370-284228a22d2a/astm-d2239-12>

5.3 Hydrostatic Design Stresses—This specification covers PE pipe made from PE plastics as defined by four hydrostatic design stresses developed on the basis of long-term tests (2—PR and HDS must have the same units. See Appendix X1).

5.4 Compound—The PE plastic extrusion compound shall meet the requirements of either Grade P14, Class B or C; 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. The PE plastics can also be described in accordance with the appropriate cell classification as defined in Specification for maximum pressure ratings for water.

5. Materials

5.1 Polyethylene Compound —Polyethylene compounds suitable for use in the manufacture of pipe under this specification shall meet thermoplastic materials designation codes PE1404 or PE2708 or PE3608 or PE4608 or PE4710, and shall meet Table 1 requirements for PE1404 or PE2708 or PE3608 or PE4608 or PE4710, and shall meet thermal stability, brittleness temperature and elongation at break requirements in accordance with Specification D3350.

5.4.1 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

5.1.1 Color and Ultraviolet (UV) Stabilization—Per Table 1, polyethylene compounds shall meet 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 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 pipe from deleterious UV exposure effects during unprotected outdoor shipping and storage for at least eighteen (18) months.

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

TABLE 4 176°F (80°C) Minimum Burst Pressure Requirements for Water SDR Pipe A^B

PSIDR	Mipe Test Category ^C		Base Resin Melt Index, D1238 (g/10 min)		Base Resin Density, D1505 (g/cm ³)		Minimum Average Hours to Failure	
	SDR	S = 725 psi (5 MPa)	S = 580 psi (4 MPa)	S = 435 psi (3 MPa)	PE2708	PE3608, PE4608, PE4710	PE2708	PE3608, PE4608, PE4710
C1404								
PE1404								
psi	0.05	0.941–0.948	100	200	....		
psi (kPa)								
C2	<0.05	0.935–0.940	100	200	....	921	6352	
5.3	400	(2759)	800	(5517)		921	(6352)	
C3	–0.05–0.25	0.941–0.948	–60	150	....	725	(5000)	
7	320	(2207)	630	(4345)		725	(5000)	
C4	–0.05–0.25	0.935–0.940	–60	150	....	580	(4000)	
9	250	(1724)	504	(3476)		580	(4000)	
C5	>0.25	0.941–0.948	–45	100	....	464	(3200)	
11.5	...	...	403	(2779)		464	(3200)	
C6	>0.25	0.935–0.940	–45	100	....	363	(2503)	
15	...	...	315	(2174)		363	(2503)	
C7	>0.50	0.926–0.940	...	80		15738	290	
19	...	0.926–0.940	...	252		(1738)	290	(2000)

^AFor inside diameter controlled pipe, calculate internal pressure in accordance with the following formula:

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

^BFor outside diameter controlled pipe, calculate internal pressure in accordance with the following formula:

$$P = \frac{2S}{\frac{D_{ei}}{t} - 1} + 1$$

Where:

- P^B = burst test pressure, psig (MPa);
- S = minimum hoop fiber stress, psi (MPa);
- $\frac{D_i}{S}$ = average inside diameter (8690 kPa) for, in. (PE1404 comm); pound
- S = 2520 psi (17,370 kPa) for PE2708 compound
- S = 2900 psi (20,000 kPa) for PE3608, PE4608 and PE4710 compound
- D_{ei} = measured average outside diameter, in. (mm); and
- t = measured minimum wall thickness, in. (mm).

^CSupplier to determine pipe test category appropriate for his product.

^DPipe categories for water pipe $\pm 3.6^\circ\text{F}$ ($\pm 2^\circ\text{C}$). 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 ± 5 psi (± 35 kPa).

stabilizer in Code E color 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 *Potable Water Requirement*—PE compound 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 regulatory 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 pipe production that met 5.1 through 5.2 as new PE compound is suitable for re-extrusion into pipe when blended with new PE compound having the same material designation. Pipe containing rework material 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. See 5.1.2.

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—Subject to 6.2.3, wall thickness and tolerance shall be as shown in Table 3 when measured in accordance with Test Method D2122:

6.2.3 when measured in accordance with 7.4. Wall thickness shall be inclusive of all extruded concentric layers.

6.2.3 *Wall Thickness Range*—The wall thickness range shall be within 12% when measured in accordance with Test Method D2122—The wall thickness variation shall not exceed 12 % when measured in accordance with 7.4.

TABLE 6 1 Sustained Polyethylene Terephthalate Compound Requirements for Water for SDR-PR PE Plastic Pipements

SID Requirement	Material Designation					
	Requirement	PE1404	PE2708	PE3608	PE4608	PE4710
PE1404		PE2708	PE3608	PE4608	PE4710	
Required Value						
HDB at 140°F (60°C), PE2406- PE3306- PE3406			PE2305			PE1404 PE3408
HDB at 140°F (60°C), psi (MPa), per Test Method D2837 and PPI TR-3406			PE2305			PE1404 PE3408
	MPa	psi	MPa ^B			
	MPa ^B					
	psi	MPa	psi	MPa		
psi Test Pressures at 23°C (73°F) ^A						
HDS for water at 73°F (23°C) psi (MPa), per Test Method D2837 and PPI TR-3 ^C						
5.3	2.86	415	2.28	330	1.839	
5.3	400 (2.76)	800 (5.5)	800 (5.5)	800 (5.5)	1000 (6.9)	
	265	364	508			
			508			
7	2.28					
7						
330	1.83	265	1.45	210	2.76400	
Melt flow rate per Test Method D1238	1.0 to 0.4 g/10 min Cond. 190/2.16	≤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	
9	1.83	265	1.45	210	1.14	
Specification D3350 Cell Classification Property Requirement						
Density (natural base resin)	165	220	320			
Density (natural base resin)	1	2	320			
11.5	1.45	2104				
11.5	4	4				
	1.14	165	...	...	1.76	256
					1.76	256
15	1.14	165	...	...	...
SCG Resistance	4	7	6	6	7	
	...	1.38	200			
			200			
19	...	...	...	...
19	...	...	...	...
Color and UV Stabilizer Code ^D	C	C, D or E	C, D or E	C, D or E	1.10	160
					1.10	160C, D or E

^AThe fiber sHDB at 140°F (60°C) not necessarily required. Contact manufacturer about pipe use at temperatures other than 73°F (23°C).

^BHDB at 73°F (23°C) MPa

	^B HDB psi	
PE2306, PE2406, PE3306, PE3406	PE3408	11.2
°C) required. Contact manufacturer or see PPI TR-4 for listed value.	9.10	1320
^C Contact manufacturer or see PPI TR-406	9 for listed value. 10	1320
PE230	1050	
57.24		
PE230	1050	
See 5.24		
PE1404	5.65	820
PE 1404	5.65	820

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

Nominal Pipe Size	Average Inside Diameter	Tolerances
1/2	0.622	+0.010
1/2	0.622	+0.010
		-0.010
		-0.010
3/4	0.824	+0.010
3/4	0.824	+0.010
		-0.015
		-0.015
1	1.049	+0.010
1	1.049	+0.010
		-0.020
1 1/4	1.380	+0.010
1 1/4	1.380	+0.010
		-0.020
1 1/2	1.610	+0.015
1 1/2	1.610	+0.015
		-0.020
		-0.020
2	2.067	+0.015
2	2.067	+0.015
		-0.020
		-0.020
2 1/2	2.469	+0.015
3	3.068	+0.015
3	3.068	+0.015
		-0.035
4	6.065	+0.020
6	6.065	-0.035

TABLE 3 Wall Thicknesses and Tolerances for SIDR-PR PE Plastic Pipe, in.

Nominal Pipe Size	Wall Thickness ⁴											
	SIDR 19		SIDR 15		SIDR 11.5 ⁶		SIDR 9		SIDR 7		SIDR 5.3	
	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance
1/2-1/2	0.060	+0.020	0.060	+0.020	0.060	+0.020	0.069	+0.020	0.089	+0.020	0.117	+0.020
1/2 1/2	0.060	+0.020	0.060	+0.020	0.060	+0.020	0.069	+0.020	0.089	+0.020	0.117	+0.020
3/4	0.060	+0.020	0.060	+0.020	0.072	+0.020	0.092	+0.020	0.118	+0.020	0.155	+0.020
3/4	0.060	+0.020	0.060	+0.020	0.072	+0.020	0.092	+0.020	0.118	+0.020	0.155	+0.020
1	0.060	+0.020	0.070	+0.020	0.091	+0.020	0.117	+0.020	0.150	+0.020	0.198	+0.024
1	0.060	+0.020	0.070	+0.020	0.091	+0.020	0.117	+0.020	0.150	+0.020	0.198	+0.024
1 1/4	0.073	+0.020	0.092	+0.020	0.120	+0.020	0.153	+0.020	0.197	+0.024	0.260	+0.031
1 1/4	0.073	+0.020	0.092	+0.020	0.120	+0.020	0.153	+0.020	0.197	+0.024	0.260	+0.031
1 1/2-1/2	0.085	+0.020	0.107	+0.020	0.140	+0.020	0.179	+0.020	0.230	+0.028	0.304	+0.036
1 1/2 1/2	0.085	+0.020	0.107	+0.020	0.140	+0.020	0.179	+0.020	0.230	+0.028	0.304	+0.036
2	0.109	+0.020	0.138	+0.020	0.180	+0.022	0.230	+0.028	0.295	+0.035	0.390	+0.047
2	0.109	+0.020	0.138	+0.020	0.180	+0.022	0.230	+0.028	0.295	+0.035	0.390	+0.047
2 1/2	0.130	+0.020	0.165	+0.020	0.215	+0.025	...	...	...	...	...	...
2 1/2	0.130	+0.020	0.165	+0.020	0.215	+0.025	...	...	...	...	...	...
3	0.164	+0.020	0.205	+0.020	0.267	+0.032	...	...	...	...	...	...
3	0.164	+0.020	0.205	+0.020	0.267	+0.032	...	...	...	...	...	...
4	0.212	+0.025	0.268	+0.032	0.350	+0.042	...	...	...	...	...	...
4	0.212	+0.025	0.268	+0.032	0.350	+0.042	...	...	...	...	...	...
6	0.319	+0.038	0.404	+0.048	0.527	+0.063	...	...	...	...	...	...

⁴ The minimum is the lowest wall thickness of the pipe 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. The 2 1/2 Wall to 6-hickn-pipe with a pressu vare riating of 0.70 MPa (100 ps) shall be included with 6.2.3.

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.) (0.5 mm) 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 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 pipe extrusion compound shall contain at least 2% carbon black when tested in