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An American National Standard

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

This standard is issued under the fixed designation D3035; 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 thermoplastic pipe dimension ratios based on outside diameter and pressure rated for water (see Appendix X1). 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 All pipes produced under this specification may be used for the transport of water, industrial process liquids, effluents, slurries, municipal sewage, etc. The user should consult the manufacturer to determine whether the material being transported is compatible with polyethylene pipe and will not affect the service life beyond limits acceptable to the user.

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.

1.4 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
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
D2290 Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe by Split Disk Method
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

2.2 *NSF International Standards:*

ANSI/NSF Standard No. 14 for Plastic Piping Components and Related Materials[3]
ANSI/NSF Standard No. 61 for Drinking Water System Components—Health Effects[3]

2.3 *PPI Documents:*

TR-4 Listing of Hydrostatic Design Bases (HDB), Strength Design Bases (SDB), Pressure Design Bases (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe[4]
TR-9 Recommended Design Factors for Thermoplastic Pressure Pipe[4]

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[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 the National Sanitation Foundation, P.O. Box 1468, Ann Arbor, MI 48106.

[4] Available from the Plastics Pipe Institute, Inc., 1825 Connecticut Ave., NW, Suite 680 Washington, DC 20009.

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

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *hydrostatic design stress*— the estimated maximum tensile stress in the wall of the pipe in the circumferential orientation due to internal hydrostatic water pressure that can be applied continuously with a high degree of certainty that failure of the pipe will not occur.

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

3.2.3 *relation between dimension ratio, hydrostatic design stress, and pressure rating*—the following expression, commonly known as the ISO equation,[5] is used in this specification to relate dimension ratio, hydrostatic design stress, and pressure rating:

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

where:

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

3.2.4 *thermoplastic pipe dimension ratio (DR)*—the ratio of pipe diameter to wall thickness. For PE pipe covered by this specification it is calculated by dividing the average outside diameter of the pipe, in inches, by the minimum wall thickness, in inches. If the wall thickness calculated by this formula is less than 0.062 in. (1.6 mm), it shall be arbitrarily increased to 0.062 in.

3.2.5 *thermoplastic pipe materials designation code*—the polyethylene pipe materials designation code shall consist of the abbreviation PE for the type of plastics, 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 zero 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 PE plastic pipe materials in various dimension ratios and water pressure ratings.

4.2 *Thermoplastic Pipe Dimension Ratios (DR)*—This specification covers PE pipe in various dimension ratios such as, but not limited to, DR 11, DR 13.5, DR 17, and DR 21. The pressure rating is uniform for all nominal sizes of pipe for a given PE pipe material and DR. (See Table X1.1.)

4.3 *Special Sizes*—Where existing system conditions or special local requirements make other diameters or dimension ratios necessary, other sizes or dimension ratios, or both, shall be acceptable in engineered products when mutually agreed upon by the customer and manufacturer if (*1*) the pipe is manufactured from plastic compounds meeting the material requirements of this specification and (*2*) the strength and design requirements are calculated on the same basis as those used in this specification.

5. Materials

5.1 *Classification*—Polyethylene compounds suitable for use in the manufacture of pipe under this specification shall meet

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

TABLE 1 Specification D3350 Cell Classifications for Polyethylene Pipe Materials

PE Material Designation Code	PE 1404	PE 2606	PE 2708	PE 3608	PE 3708	PE 3710	PE 4608	PE 4708	PE 4710
Physical Property:	Cell Classifications								
Density	1	2	2	3	3	3	4	4	4
Melt Index	2	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4
Flexural Modulus	3	3 or 4	3 or 4	4 or 5	4 or 5	4 or 5	4 or 5	4 or 5	4 or 5
Tensile Strength at Yield	1	3 or 4	3 or 4	4 or 5	4 or 5	4 or 5	4 or 5	4 or 5	4 or 5
Slow Crack Growth Resistance	1[A]	6[B]	7	6[B]	7	7	6	7	7
Hydrostatic strength Classification	1	3	3	4	4	4	4	4	4
Color and UV Stabilizer[C]	C	C or E	C or E	C or E	C or E	C or E	C or E	C or E	C or E

[A] Test Method D1693 ESCR.
[B] Test Method F1473 PENT.
[C] Code C compounds shall contain 2 to 3 % carbon black when tested in accordance with Test Method D1603 or Test Method D4218. Code C and E compounds shall have sufficient antioxidants to meet requirements in Specification D3350. Pipe produced from Code E compounds is not suitable for continuous use in exposed outdoor applications. Code E compounds shall have sufficient UV stabilizer to protect pipe from deleterious effects due to continuous outdoor exposure during shipping and unprotected outdoor storage for up to 18 months.

TABLE 2 Outside Diameters and Tolerances for DR-PR PE Plastic Pipe

Nominal Pipe Size, in.	Outside Diameter, in. (mm)	Tolerances, in. (mm)
½	0.840 (21.34)	±0.004 (0.10)
¾	1.050 (26.7)	±0.004 (0.10)
1	1.315 (33.4)	±0.005 (0.13)
1¼	1.660 (42.2)	±0.005 (0.13)
1½	1.900 (48.3)	±0.006 (0.15)
2	2.375 (60.3)	±0.006 (0.15)
3	3.500 (88.9)	±0.008 (0.20)
4	4.500 (114.3)	±0.009 (0.23)
6	6.625 (168.28)	±0.011 (0.28)
8	8.625 (219.08)	±0.013 (0.33)
10	10.750 (273.05)	±0.015 (0.38)
12	12.750 (323.85)	±0.017 (0.43)
14	14.000 (355.60)	±0.063 (1.60)
16	16.000 (406.40)	±0.072 (1.83)
18	18.000 (457.20)	±0.081 (2.06)
20	20.000 (508.00)	±0.090 (2.29)
22	22.000 (558.80)	±0.099 (2.51)
24	24.000 (609.60)	±0.108 (2.74)

Specification D3350 and shall be classified in accordance with Specification D3350 and as shown in Table 1.

NOTE 1—Piping intended for use in the transport of potable water should be evaluated and certified as safe for this purpose by a testing agency acceptable to the local health authority. The evaluation should be in accordance with requirements for chemical extraction, taste, and odor that are no less restrictive than those included in ANSI/NSF Standard No. 14 or ANSI/NSF Standard No. 61. The seal or mark of the laboratory making the evaluation should be included on the piping.

NOTE 2—Pipe users should consult with the pipe manufacturer about the outdoor exposure life of the product under consideration.

5.2 *Long-term Property Requirements*—Polyethylene compounds that are suitable for use in the manufacture of pipe under this specification shall meet Specification D3350 classification and property requirements in Table 1 and shall have PPI TR-4 HDB listings at 73°F (23°C). In addition, all pipe materials other than PE1404 that are intended to be suitable for use at temperatures from 80°F (27°C) through 140°F (60°C) shall have a minimum HDB at 140°F (60°C) of 630 psi (4.34 MPa). Materials that do not have an HDB at 140°F shall be limited to 80°F (27°C) and lower service temperatures. See 9.1.5.

NOTE 3—Additional information about long term stress ratings (HDB) for polyethylene compounds suitable for use in the manufacture of pipe under this specification is available in PPI TR-4.

NOTE 4—PPI TR-4 lists the maximum recommended hydrostatic design stress at 73°C for water; for PE 1404 materials as 400 psi; for PE 2606 materials as 630 psi; for PE 2708, PE 3708, PE 4608, and PE 4708 materials as 800 psi; and for PE 3710 and PE 4710 materials as 1000 psi.

5.3 *Rework Material*—Clean, rework material having the same cell classification or materials designation code and generated from the manufacturer's own pipe production, may be used by the same manufacturer, as long as the pipe produced meets all of the requirements of this specification.

6. Requirements

6.1 *Workmanship*—The pipe shall be homogeneous throughout and free from 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 *Outside Diameters*—The outside diameters and tolerances shall be as shown in Table 2 when measured in accordance with Test Method D2122. For diameters not shown in Table 2, the tolerances shall be the same percentage of the outside diameter as those for the closest listed diameter.

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. For wall thicknesses (DRs) not shown in Table 3, the tolerances shall be the same percentage of the calculated minimum wall as for the closest listed minimum wall thickness.

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

6.3 *Short-term Properties*—Specimens of pipe shall be tested in accordance with either Test Method D1599 or Test Method D2290. The test method used, Test Method D1599 or Test Method D2290, is determined by the pipe size and the availability of appropriate test equipment. Test Method D1599 is generally used for 4 in. (114 mm) and smaller sizes and Test Method D2290 for 2 in. (60 mm) and larger sizes. Short-term hoop stress and failure mode data is provided by either test.

6.3.1 *Burst Pressure*—The minimum burst pressure for PE plastic pipe shall be as given in Table 4, when determined in accordance with Test Method D1599 and 7.6. The failure mode shall be ductile.

6.3.2 *Apparent Ring Tensile Strength*~~—The minimum apparent ring tensile strength at yield shall be 1250 psi (8.62 MPa) for PE 1404 and 2520 psi (17.37 MPa) for all other pipe materials when tested in accordance with Test Method~~ —The minimum

TABLE 3 Wall Thicknesses and Tolerances[A] for DR-PR PE Plastic Pipe

Nominal Pipe Size, IPS, in.	DR 32.5				DR 26				DR 21				DR 17				DR 15.5			
	Minimum		Tolerance		Minimum		Tolerance		Minimum		Tolerance		Minimum		Tolerance		Minimum		Tolerance	
	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)
½	0.062	(1.57)	0.020	(0.51)	0.062	(1.57)	0.020	(0.51)	0.062	(1.57)	0.020	(0.51)	0.062	(1.57)	0.020	(0.51)	0.062	(1.57)	0.020	(0.51)
¾	0.062	(1.57)	0.020	(0.51)	0.062	(1.57)	0.020	(0.51)	0.062	(1.57)	0.020	(0.51)	0.062	(1.57)	0.020	(0.51)	0.068	(1.73)	0.020	(0.51)
1	0.062	(1.57)	0.020	(0.51)	0.062	(1.57)	0.020	(0.51)	0.063	(1.60)	0.020	(0.51)	0.077	(1.96)	0.020	(0.51)	0.084	(2.13)	0.020	(0.51)
1¼	0.062	(1.57)	0.020	(0.51)	0.064	(1.63)	0.020	(0.51)	0.079	(2.01)	0.020	(0.51)	0.098	(2.49)	0.020	(0.51)	0.107	(2.72)	0.020	(0.51)
1½	0.062	(1.57)	0.020	(0.51)	0.073	(1.85)	0.020	(0.51)	0.090	(2.29)	0.020	(0.51)	0.112	(2.84)	0.020	(0.51)	0.123	(3.12)	0.020	(0.51)
2	0.073	(1.85)	0.020	(0.51)	0.091	(2.31)	0.020	(0.51)	0.113	(2.87)	0.020	(0.51)	0.140	(3.56)	0.020	(0.51)	0.153	(3.89)	0.020	(0.51)
3	0.108	(2.74)	0.020	(0.51)	0.135	(3.43)	0.020	(0.51)	0.167	(4.24)	0.020	(0.51)	0.206	(5.23)	0.025	(0.64)	0.226	(5.74)	0.027	(0.69)
4	0.138	(3.51)	0.020	(0.51)	0.173	(4.39)	0.021	(0.53)	0.214	(5.44)	0.026	(0.66)	0.265	(6.73)	0.032	(0.81)	0.290	(7.37)	0.035	(0.89)
5	0.171	(4.34)	0.021	(0.53)	0.214	(5.44)	0.026	(0.66)	0.265	(6.73)	0.032	(0.81)	0.327	(8.31)	0.039	(0.99)	0.359	(9.12)	0.043	(1.09)
6	0.204	(5.18)	0.024	(0.61)	0.255	(6.48)	0.031	(0.79)	0.315	(8.00)	0.038	(0.97)	0.390	(9.91)	0.047	(1.19)	0.427	(10.85)	0.051	(1.30)
8	0.265	(6.73)	0.032	(0.81)	0.332	(8.43)	0.040	(1.02)	0.411	(10.44)	0.049	(1.24)	0.507	(12.88)	0.061	(1.55)	0.556	(14.12)	0.067	(1.70)
10	0.331	(8.41)	0.040	(1.02)	0.413	(10.49)	0.050	(1.27)	0.512	(13.00)	0.061	(1.55)	0.632	(16.05)	0.076	(1.93)	0.694	(17.63)	0.083	(2.11)
12	0.392	(9.96)	0.047	(1.19)	0.490	(12.45)	0.059	(1.50)	0.607	(15.42)	0.073	(1.85)	0.750	(19.05)	0.090	(2.29)	0.823	(20.90)	0.099	(2.51)
14	0.431	(10.95)	0.052	(1.32)	0.538	(13.67)	0.065	(1.65)	0.667	(16.94)	0.080	(2.03)	0.824	(20.93)	0.099	(2.51)	0.903	(22.94)	0.108	(2.74)
16	0.492	(12.50)	0.059	(1.50)	0.615	(15.62)	0.074	(1.88)	0.762	(19.35)	0.091	(2.31)	0.941	(23.90)	0.113	(2.87)	1.032	(26.21)	0.124	(3.15)
18	0.554	(14.07)	0.066	(1.68)	0.692	(17.58)	0.083	(2.11)	0.857	(21.77)	0.103	(2.62)	1.059	(26.90)	0.127	(3.23)	1.161	(29.49)	0.139	(3.53)
20	0.615	(15.62)	0.074	(1.88)	0.769	(19.53)	0.092	(2.34)	0.952	(24.18)	0.114	(2.90)	1.176	(29.87)	0.141	(3.58)	1.290	(32.77)	0.155	(3.94)
22	0.677	(16.94)	0.081	(2.06)	0.846	(21.49)	0.102	(2.59)	1.048	(26.62)	0.126	(3.20)	1.294	(32.87)	0.155	(3.94)	1.419	(36.04)	0.170	(4.32)
24	0.738	(18.75)	0.089	(2.26)	0.923	(23.44)	0.111	(2.82)	1.143	(29.03)	0.137	(3.48)	1.412	(35.86)	0.169	(4.29)	1.548	(39.32)	0.186	(4.72)

Nominal Pipe Size, IPS, in.	DR 13.5				DR 11				DR 9.3				DR 9				DR 7			
	Minimum		Tolerance		Minimum		Tolerance		Minimum		Tolerance		Minimum		Tolerance		Minimum		Tolerance	
	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)
½	0.062	(1.57)	0.020	(0.51)	0.076	(1.93)	0.020	(0.51)	0.090	(2.29)	0.020	(0.51)	0.093	(2.36)	0.020	(0.51)	0.120	(3.05)	0.020	(0.51)
¾	0.078	(1.98)	0.020	(0.51)	0.095	(2.41)	0.020	(0.51)	0.113	(2.87)	0.020	(0.51)	0.117	(2.97)	0.020	(0.51)	0.150	(3.81)	0.020	(0.51)
1	0.097	(2.46)	0.020	(0.51)	0.120	(3.05)	0.020	(0.51)	0.141	(3.58)	0.020	(0.51)	0.146	(3.71)	0.020	(0.51)	0.188	(4.78)	0.023	(0.58)
1¼	0.123	(3.12)	0.020	(0.51)	0.151	(3.84)	0.020	(0.51)	0.178	(4.52)	0.021	(0.53)	0.184	(4.67)	0.022	(0.56)	0.237	(6.02)	0.028	(0.71)
1½	0.141	(3.58)	0.020	(0.51)	0.173	(4.39)	0.021	(0.53)	0.204	(5.18)	0.024	(0.61)	0.211	(5.36)	0.025	(0.64)	0.271	(6.88)	0.033	(0.84)
2	0.176	(4.47)	0.021	(0.53)	0.216	(5.49)	0.026	(0.66)	0.255	(6.48)	0.031	(0.79)	0.264	(6.71)	0.032	(0.81)	0.339	(8.61)	0.041	(1.04)
3	0.259	(6.58)	0.031	(0.79)	0.318	(8.08)	0.038	(0.97)	0.376	(9.55)	0.045	(1.14)	0.389	(9.88)	0.047	(1.19)	0.500	(12.70)	0.060	(1.52)
4	0.333	(8.46)	0.040	(1.02)	0.409	(10.39)	0.049	(1.24)	0.484	(12.29)	0.058	(1.47)	0.500	(12.70)	0.060	(1.52)	0.643	(16.33)	0.077	(1.96)
5	0.412	(10.46)	0.049	(1.24)	0.506	(12.85)	0.061	(1.55)	0.598	(15.19)	0.072	(1.83)	0.618	(15.70)	0.074	(1.88)	0.795	(20.19)	0.095	(2.41)
6	0.491	(12.47)	0.059	(1.50)	0.602	(15.29)	0.072	(1.83)	0.712	(18.08)	0.085	(2.16)	0.736	(18.69)	0.088	(2.24)	0.946	(24.03)	0.114	(2.90)
8	0.639	(16.23)	0.077	(1.96)	0.784	(19.91)	0.094	(2.39)	0.927	(23.55)	0.111	(2.82)	0.958	(24.33)	0.115	(2.92)	1.232	(31.29)	0.147	(3.73)
10	0.796	(20.22)	0.096	(2.44)	0.977	(24.82)	0.117	(2.97)	1.156	(29.36)	0.139	(3.53)	1.194	(30.33)	0.143	(3.63)	1.536	(39.01)	0.184	(4.67)
12	0.944	(23.98)	0.113	(2.87)	1.159	(29.44)	0.139	(3.53)	1.371	(34.82)	0.165	(4.19)	1.417	(35.99)	0.170	(4.32)	1.821	(46.25)	0.219	(5.56)
14	1.037	(26.34)	0.124	(3.15)	1.273	(32.33)	0.153	(3.89)	1.505	(38.23)	0.181	(4.60)	1.556	(39.52)	0.187	(4.75)	2.000	(50.80)	0.240	(6.10)
16	1.185	(30.10)	0.142	(3.61)	1.455	(36.96)	0.175	(4.45)	1.720	(43.69)	0.206	(5.23)	1.778	(45.16)	0.213	(5.41)	2.286	(58.06)	0.274	(6.96)
18	1.333	(33.86)	0.160	(4.06)	1.636	(41.55)	0.196	(4.98)	1.935	(49.15)	0.232	(5.89)	2.000	(50.80)	0.240	(6.10)	2.571	(65.30)	0.309	(7.85)
20	1.481	(37.62)	0.178	(4.52)	1.818	(46.18)	0.218	(5.54)	2.151	(54.64)	0.258	(6.55)	2.222	(56.44)	0.267	(6.78)	2.857	(72.57)	0.343	(8.71)
22	1.630	(41.40)	0.196	(4.98)	2.000	(50.80)	0.240	(6.10)	2.366	(60.10)	0.284	(7.21)	2.444	(62.08)	0.293	(7.44)	3.143	(79.83)	0.377	(9.58)
24	1.778	(45.16)	0.213	(5.41)	2.182	(55.42)	0.262	(6.65)	2.581	(65.56)	0.310	(7.87)	2.667	(67.74)	0.320	(8.13)	3.429	(87.10)	0.411	(10.44)

[A] The minimum is the lowest wall thickness of the pipe allowable 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.

apparent ring tensile strength at yield shall be 1250 psi (8.62 MPa) for PE 1404, 2520 psi (17.37 MPa) for Table 1 density cell 2 polyethelylene pipe materials, and 2900 psi (20.00 MPa) for Table 1 density cell 3 and 4 polyethylene pipe materials when tested in accordance with Test Method D2290, Procedure B and 7.7. The failure shall be ductile.

6.4 *Sustained Pressure at Ambient and Elevated Temperature for PE1404*—PE1404 pipes shall be tested in accordance with 7.4 at the stresses and temperatures specified in Table 6. Tests may be conducted on any pipe size, but tests conducted on 6 in. (168 mm) nominal size pipe shall be considered representative of all pipe sizes. At 176°F (80°C) pipes shall be tested at either stress. If ductile failures occur at the higher stress at 176°F (80°C), testing shall be repeated at the lower stress. Acceptable results are non-failure at the minimum average test time, or brittle failure at times exceeding the minimum average test time.

6.5 *Elevated Temperature Sustained Pressure for Pipes Other Than PE1404*—Elevated temperature sustained pressure tests for each Table 1 polyethylene pipe material (material designation) used in production at the facility shall be conducted twice annually per 7.5.

NOTE 5—Elevated temperature sustained pressure tests are intended to verify extrusion processing and are conducted in accordance with the manufacture's quality program.

6.5.1 Passing results are *(1)* non-failure for all three specimens at a time equal to or greater than the Table 7 "minimum average time before failure" for the selected Table 7 Condition, or *(2)* not more than one ductile specimen failure and the average time

TABLE 4 Burst Pressure Requirements for Water at 73°F (23°C) for DR-PR PE Plastic Pipe

Dimension Ratio	Min Burst Pressure,[A] psi (MPa)					
	PE 3608, PE 3708, PE 3710, PE 4608, PE 4708, PE 4710		PE 2606, PE 2708		PE 1404	
	psi	(MPa	psi	(MPa)	psi	(MPa)
7	967	(6.67)	840	(5.79)	417	(2.87)
9	725	(5.00)	630	(4.34)	313	(2.16)
9.3	699	(4.82)	607	(4.19)	301	(2.08)
11	580	(4.00)	504	(3.47)	250	(1.72)
13.5	464	(3.20)	403	(2.78)	200	(1.38)
15.5	400	(2.76)	348	(2.40)	172	(1.19)
17	363	(2.50)	315	(2.13)	156	(1.08)
21	290	(2.00)	252	(1.74)	125	(0.86)
26	232	(1.60)	202	(1.39)	100	(0.69)
32.5	184	(1.27)	160	(1.10)	79	(0.55)

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

	psi	(MPa)
PE 3608, PE 3708, PE 3710, PE 4608, PE 4708, PE 4710	2900	(20.00)
PE 2606, PE 2708	2520	(17.37)
PE 1404	1250	(8.62)

TABLE 5 Apparent Tensile Strength at Yield of Ring Specimens Cut from Pipe

Material	psi	(MPa)
PE 2606, PE 2708,	2520	(17.37)
~~PE 3608, PE 3708, PE 3710, PE 4608, PE 4708, PE 4710~~	~~2520~~	~~(17.37)~~
PE 3608, PE 3708, PE 3710, PE 4608, PE 4708, PE 4710	2900	(20.00)
PE 1404	1250	(8.62)

TABLE 6 Stress and Time Requirements for Sustained Pressure Test[A]

Pipe Material	Minimum Hours Before Failure at 73°F (23°C)	Minimum Average Hours to Failure at 176°F (80°C)		
	S = 800 psi (5.5 MPa)	S = 670 psi (4.6 MPa)	S = 580 psi (4 MPa)	S = 435 psi (3 MPa)
PE 1404	1000		80	150

[A] 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_o = average outside diameter, in. (mm), and
t = minimum wall thickness, in. (mm).

before failure for all three specimens shall be greater than the specified "minimum average time before failure" for the selected Table 7 Condition. If more than one ductile failure occurs before the "minimum average time before failure", it is permissible to conduct one retest at a Table 7 Condition of lower stress and longer minimum average time before failure for the material designation except that for Table 7 Condition 6 no retest is permissible. Brittle failure of any specimen in the test sample when tested at Table 7 Condition 1 through 6 constitutes failure to meet this requirement and no retest is allowed.

6.5.2 *Provision for retest (if needed)*—The retest sample shall be three specimens of the same pipe or tubing size and material designation from the same time frame as the test sample per 7.5. For the retest, any specimen failure before the Table 7 "minimum

TABLE 7 Elevated Temperature Sustained Pressure Test Requirements

	PE, 2606, PE2706, PE2708, PE3608, PE3708, PE4608, PE4708			PE3710, PE4710	
Condition	Test Temperature °F (°C)[A]	Test Pressure Hoop Stress[B] psi (kPa)[A]	Minimum Average Time Before Failure Hours	Test Pressure Hoop Stress[B] psi (kPa)[A]	Minimum Average Time Before Failure Hours
1	176 (80)	670 (4620)	170	750 (5170)	200
2	176 (80)	650 (4480)	340	730 (5020)	400
3	176 (80)	630 (4345)	510	705 (4870)	600
4	176 (80)	610 (4210)	680	685 (4715)	800
5	176 (80)	590 (4070)	850	660 (4565)	1000
6	176 (80)	580 (4000)	1000	640 (4415)	1200

[A]Test temperature tolerance ± 3.6ºF (+/- 2ºC). Test pressure tolerance ± 5 psi (±35 kPa); test pressure hoop stress values are rounded to the nearest 5 psi or 5 kPa.

Note: Table 2 conditions are based on PE validation requirements per PPI TR-3 with Condition 6 being 85% of Condition 1 test pressure hoop stress and six times greater minimum average time before failure. Conditions 2 through 5 are linear stress and time interpolations between Conditions 1 and 6. The intent of multiple conditions is to maintain equivalent performance criteria, but provide for retest in the event of ductile failure. The test pressure hoop stress levels for Conditions 2-5 are linear interpolations for arbitrarily chosen time increments. An equivalent performance requirement, however, may be determined by arbitrarily choosing a test pressure hoop stress between Conditions 1 and 6 and linearly interpolating the minimum average time before failure. For example for PE3710 and PE4710 material, at 670 psi test pressure hoop stress, the minimum average time before failure would be 927 hours (200 + (750 – 670) · ((1200 – 200) / (750 – 640)) = 927).

[B]Calculate internal test pressure in accordance with:

$$P = \frac{2s}{\left(\frac{D_o}{t} - 1\right)}$$

where:

P = test pressure, psig (kPa)
S = test pressure hoop stress, psi. (kPa)
D_o = measured outside diameter, in. (mm)
t = measured minimum wall thickness, in (mm)

average time before failure" at the retest condition of lower stress and longer minimum average time before failure constitutes failure to meet this requirement.

7. Test Methods

7.1 *Conditioning*—Condition the test specimens for not less than 40 h prior to test in accordance with Procedure A of Practice D618, for those tests where conditioning is required.

7.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of 73 ± 3.6°F (23 ± 2°C), unless otherwise specified in the test methods or in this specification.

7.3 *Sampling*—The selection of the sample or samples of pipe shall be as agreed upon by the purchaser and the seller. In case of no prior agreement, random samples as selected by the testing laboratory shall be deemed adequate.

7.4 *Sustained Pressure Test at Ambient and Elevated Temperature*—Select three specimens of pipe at random and test each specimen individually with water at controlled temperatures under the stresses given in Table 6. Each specimen shall be at least ten times the nominal diameter in length, but not less than 10 in. (250 mm) or more than 3 ft (1000 mm) between end closures and containing the permanent marking on the pipe. Condition the specimens for at least 2 h at test temperature ± 3.6°F (2°C) prior to test. Test for the minimum failure time specified in Table 6 in accordance with Test Method D1598, at the stress and temperature values given in Table 6. Maintain the specimens at the test pressures ±10 psi (±70 kPa) and the test temperatures ± 3.6°F (± 2°C). Failure of one of the three specimens tested is cause for retest of three additional specimens. Failure of one of three specimens tested in retest constitutes failure in the test. Test and retest specimens shall be from the same production lot. Failure of the pipe test specimen shall be as defined in Test Method D1598. When testing at 176 ± 3.6°F (80 ± 2°C) at the higher stress, if ductile failure occurs before the minimum time, rerunning the test at the lower stress condition is not considered a retest.

7.5 *Elevated Temperature Sustained Pressure Test*—The "test sample" shall be three specimens of a generally representative pipe or tubing size produced at the manufacturer's facility using the Table 1 polyethylene pipe material (material designation). Select one Table 7 Condition for the Table 1 polyethylene pipe material (material designation) and test the three specimen test sample in accordance with Test Method D1598 using water as the internal test medium.

7.6 *Hydrostatic Burst Pressure*—The test equipment, procedures, and failure definitions shall be as specified in Test Method D1599.

7.7 *Apparent Ring Tensile Strength at Yield*—The method and test equipment shall be as specified in Test Method D2290, Procedure B. Test a minimum of five specimens.

8. Retest and Rejection

8.1 Except as specified in 6.4, 6.5, 6.5.1 and 6.5.2, if the results of any test(s) do not meet the requirements of this specification, the test(s) may be conducted again in accordance with an agreement between the purchaser and the seller. There shall be no agreement to lower the minimum requirement of the specification by such means as omitting tests that are a part of the specification, substituting or modifying a test method, or by changing the specification limits. In retesting, the product requirements