Designation: F3123 – 16

Standard Specification for Metric Outside Diameter Polyethylene (PE) Plastic Pipe (DR-PN)[1]

This standard is issued under the fixed designation F3123; 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.

1. Scope*

1.1 This specification covers metric outside diameter polyethylene (PE) pipe made from polyethylene compound that qualifies for MRS, HDB and HDS ratings and for PE100 and PE4710 designations. Included are requirements for polyethylene compound, workmanship, dimensions, short-term stress and ductility, long-term stress, marking, quality assurance and verification of joining.

1.1.1 Polyethylene pipe in accordance with this specification is intended to be compatible with nominal diameters and nominal pressures in accordance with ISO 161-1 and wall thickness in accordance with ISO 4065.

1.2 Pipes produced under this specification are intended for the pressure or non-pressure conveyance of liquid or gaseous media. Pipes produced under this specification are not intended as enclosures for electrical or communications components. See Appendix X1.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 This international standard was developed in accordance with internationally recognized principles on standardization established in the *Decision on Principles for the Development of International Standards, Guides and Recommendations* issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee. The ANS label on this international standard certifies the development of this international standard in accordance with requirements for openness, balance, consensus and due process in accordance with *ANSI Essential Requirements: Due Process Requirements for American National Standards* and denotes in addition that this international standard is an American National Standard.

1.5 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
D638 Test Method for Tensile Properties of Plastics
D746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
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
D1435 Practice for Outdoor Weathering of Plastics
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
D2290 Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe
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

[1] This test method 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**

D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
D4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique
F412 Terminology Relating to Plastic Piping Systems
F905 Practice for Qualification of Polyethylene Saddle-Fused Joints
F1056 Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings
F1290 Practice for Electrofusion Joining Polyolefin Pipe and Fittings
F1473 Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins
F2620 Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
F2928 Practice for Specimens and Testing Conditions for Testing Polyethylene (PE) Pipe Butt Fusions Using Tensile and Hydrostatic Test Methods
G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

2.2 *ISO Documents*[3]
ISO 161-1 Thermoplastics pipes for the conveyance of fluids—Nominal outside diameters and nominal pressures—Part 1: Metric series
ISO 4065 Thermoplastics pipes—Universal wall thickness table
ISO 9000 Quality management
ISO 9080 Plastics piping and ducting systems—Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation
ISO 12162 Thermoplastics materials for pipes and fittings for pressure applications—Classification and designation—Overall service (design) coefficient
ISO 13477 Thermoplastics pipes for the conveyance of fluids—Determination of resistance to rapid crack propagation (RCP)—Small-scale steady-state test (S4 test)
ISO 13478 Thermoplastics pipes for the conveyance of fluids—Determination of resistance to rapid crack propagation (RCP)—Full-scale test (FST)
ISO 16871 Plastics piping and ducting systems—Plastics pipes and fittings—Method for exposure to direct (natural) weathering
ISO 18553 Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds

2.3 *NSF International Standards:*[4]
NSF/ANSI Standard No. 14 for Plastic Piping Components and Related Materials
NSF/ANSI Standard No. 61 for Drinking Water System Components—Health Effects

2.4 *PPI Documents:*[5]
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
TR-4 Listing of Hydrostatic Design Bases (HDB), Strength Design Bases (SDB), Pressure Design Bases (PDB) and Minimum Required Strength (MRS) Ratings for Thermo plastic Piping Materials or Pipe
TN-30 Requirements for the Use of Rework Materials in Manufacturing of Polyethylene Gas Pipe
Handbook of Polyethylene Pipe, Second Edition

2.5 *Other Documents:*
ANSI Essential Requirements : Due process requirements for American National Standards[6]
Decision on Principles for the Development of International Standards , Guides and Recommendations[7]
Guidelines for Drinking-Water Quality, Third Edition Incorporating the First and Second Addenda, Volume 1: Recommendations, World Health Organization, Geneva, 2008[8]
EU Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption[9]

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *application factor, f_A, n*—a coefficient of 1 or less that accounts for estimated long-term application effects such as chemical effects of fluid media or environment, variation of external or internal temperature or stress, and installation.

3.2.2 *design stress, σ_S, n*—the quotient of MRS divided by C_{min}. Design stress is at 20°C and applicable to the conveyance of water.

3.2.3 *maximum allowable operating pressure, PFA, n*—the maximum operating pressure in bar determined by the designer/user that accounts for polyethylene compound properties, the media being conveyed and the conditions of conveyance.

[3] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.
[4] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48105, http://www.nsf.org.
[5] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.
[6] Available from the American National Standards Institute (ANSI) at https://share.ansi.org/shared%20documents/Standards%20Activities/American%20National%20Standards/Procedures,%20Guides,%20and%20Forms/2016_ ANSI_Essential_Requirements.pdf
[7] Available from the World Trade Organization at https://docs.wto.org/dol2fe/Pages/FE_Browse/FE_B_009.aspx
[8] Available from WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland (tel.: +41 22 791 3264; fax: +41 22 791 4857; e-mail: bookorders@who.int).
[9] Available from Publications Office of the European Union 2, rue Mercier 2985 Luxembourg LUXEMBOURG Tel: +352 2929-1 E-mail: info@publications.europa.eu.

3.2.4 *minimum design coefficient, C_{min}, n*—a factor from ISO 12162 having a value of 1.25 that accounts for the properties of the piping material when transporting water at 20°C.

3.2.5 *minimum required strength, MRS, n*—a property of the material in accordance with ISO 12162 that represents a classification range in MPa of the 97.5% lower confidence limit of the mean long-term strength at 20°C and 50 years.

3.2.6 *nominal pressure, PN, n*—a nominal design rating in bar for internal pressure water at 20°C, but without consideration of media other than water or conditions other than sustained internal pressure and sustained temperature.

NOTE 1—PN is a nominal design rating for sustained internal pressure for water at 20°C that provides for product comparison under specific, limited conditions. Actual allowable operating pressure (*PFA*) is determined by the designer/user in consideration of the media being conveyed and conditions of conveyance such as pressure and temperature stability or variation, installation and quality thereof, and desired degree of reliability. (See 3.2.3, X1.1, and X1.2 for additional information.)

3.2.7 *relation between dimension ratio, MRS and nominal pressure, n*—the following equation is used in this specification to relate pres sure number (*PN*), dimension ratio (*DR*), minimum required strength (*MRS*), minimum design coefficient (C_{min}), and design stress (σ_S):

$$PN = \frac{20}{(DR - 1)} \times \frac{MRS}{C_{\min}} = \frac{20 \times \sigma_S}{(DR - 1)} \quad (1)$$

where:

PN = nominal pressure design rating, bar,
DR = dimension ratio
= D_O/t,
D_O = nominal outside diameter, mm,
t = minimum wall thickness, mm,
MRS = minimum required strength at 20°C, MPa,
C_{min} = minimum design coefficient, and
σ_S = design stress at 20°C.

3.2.8 *relation between nominal pressure and maximum allowable operating pressure, n*—the following equation is used in this specification to relate maximum allowable operating pressure (PFA) and pressure number (PN):

$$PFA = PN \times f_T \times f_A \quad (2)$$

where:

PN = nominal pressure, bar,
PFA = maximum allowable operating pressure, bar,
f_T = temperature factor, and
f_A = application factor.

3.2.9 *temperature factor, f_T, n*—a coefficient that accounts for the long term strength of the polyethylene compound at temperatures other than 20°C.

3.2.10 *lower confidence limit of the predicted hydrostatic strength, σ_{LPL}, n*—a property of the polyethylene compound in accordance with ISO 12162 that represents a stress value in MPa for the 97.5 percent lower confidence limit of the predicted hydrostatic strength at a specified temperature in °C and time in years.

4. Pipe Classification

4.1 *General*—This specification covers 32 mm through 2500 mm metric outside diameter polyethylene pipe having wall thickness in accordance with standard dimension ratios (DR 33 through DR 7.4) and nominal pressures in bar for water at 20°C (PN5 through PN25).

4.2 Pipe manufacturing and verification of compliance with the requirements of this standard are in accordance with a written quality assurance program that specifies policies and procedures for manufacturing, frequency of inspection, sampling and testing of materials and products, and policies and procedures for documenting compliance with the requirements of this specification.

5. Polyethylene Compound and Requirements

5.1 *Polyethylene Compound*—Polyethylene compound for the manufacture of pipe in accordance with this specifi cation shall be designated in accordance with PPI TR-3 as PE100 and as PE4710 ("PE100/PE4710"), and shall comply with the following requirements:

5.1.1 See Table 1.

5.1.2 Polyethylene compound shall contain sufficient antioxidant so that the minimum induction temperature shall not be less than 220°C when tested for thermal stability in accordance with Specification D3350.

TABLE 1 PE100/PE4710 Polyethylene Compound Requirements

Requirement	Required Value or Value Range
MRS at 20°C, per ISO 9080, ISO 12162 and PPI TR-3,[A] MPa	≥ 10
HDB at 23ºC, per Test Method D2837 and PPI TR-3,[A,B] MPa	≥ 11.03
HDB at 60ºC, per Test Method D2837 and PPI TR-3,[A,B] MPa	≥ 6.89
HDS for water at 23°C, per Test Method D2837 and PPI TR-3,[A,B] MPa	≥ 6.89
Melt flow rate (high load) per Test Method D1238, g/10 min	>4.0 to ≤ 20[C]
Nominal natural base resin density per Specification D3350,[D] g/cm^3	>0.947 to ≤ 0.955
Minimum average SCG Resistance (PENT) per Test Method F1473,[E] hr	≥ 500

[A] MRS, HDB and HDS determinations shall be listed in accordance with PPI TR-3.
[B] HDB ratings expressed in inch-pound units are standard in Test Method D2837. Per 1.3, SI units are standard herein; therefore, the SI values specified in Table 1 are the SI equivalent values per Test Method D2837. Inch-pound values for the SI equivalent values in Table 1 are 73°F = 23°C; 140°F = 60°C; 1600 pound/in^2 = 11.03 MPa; 1000 pound/in^2 = 6.89 MPa.
[C] Per 5.1.6.
[D] Per 1.7 excluding carbon black. See Specification D3350 for determination of carbon black content effects on density.
[E] SCG resistance determined in accordance with Test Method F1473 requirements for molded plaque specimens, notching per Test Method F1473 Table 1, and testing at 80°C, 2.4 MPa. Average failure time for two test specimens.

5.1.3 The brittleness temperature shall not be warmer than −60°C when tested in accordance with Test Method D746.

5.1.4 The oxidation induction time at 200°C shall not be less than 20 minutes when tested in accordance with Test Method D3895.

5.1.5 The minimum nominal tensile strength at yield shall be 20.6 MPa, and the failure mode shall be ductile when determined in accordance with Test Method D638. Testing temperature shall be 23°C and the speed of testing shall be 50 mm/min. Specimens shall conform to the dimensions and requirements for Type IV in Test Method D638 with a thickness of 1.9 ± 0.2 mm. Specimens shall be either die cut or machined. The minimum elongation at break shall be 400 percent.

5.1.6 The polyethylene compound melt flow rate (high load) shall be tested in accordance with Test Method D1238, Condition 190/21.6.

5.1.7 The polyethylene compound density in accordance Specification D3350 shall be tested in accordance with Test Method D792 or Test Method D1505.

5.1.8 Black polyethylene compound shall contain 2.0–2.5 percent carbon black when pipe is tested in accordance with 6.1.2.

5.1.9 Polyethylene compound shall be stabilized against deterioration from UV exposure for not less than 18 months for color polyethylene compounds, or for not less than 180 months for black polyethylene compounds.

NOTE 2—UV resistance is typically determined by exposure to actual outdoor (natural sunlight) weathering in accordance with Practice D1435, or by accelerated weathering in accordance with Practice D2565 and Practice G155. Characterization of UV resistance is typically by tension testing (per 5.1.5) for an elongation at break value that is at least 50% of the elongation at break value when compared to unexposed control specimens. Studies of high density polyethylene indicate that exposure to Xenon Arc via Practice G155-A Cycle 1 gives approximately 4.4 times the acceleration of outdoor Florida exposure. Therefore approximately 2000 hours Xenon Arc testing would approximate 1-year outdoor exposure in Florida (approx. 30th degree of latitude) or about 2-years in southern Canada (approx. 50th degree of latitude). A minimum resistance to an accumulation of 3.5 GJ/m^2 per ISO 16871 represents the yearly exposure to sunlight near the 50th degree of latitude.

5.1.10 *Certification*—When required by the purchaser, polyethylene compound shall be evaluated, tested, and certified in accordance with one or more of the following standards by an accredited laboratory that is acceptable to the authority having jurisdiction. The required certification standard(s) shall be by mutual agreement between purchaser and manufacturer.

NOTE 3—Because regulatory requirements vary, it is necessary that the purchaser identify and specify the applicable certification standard(s) to the manufacturer before product purchase.

5.1.10.1 NSF/ANSI Standard No. 61.

5.1.10.2 The health effects portion of NSF/ANSI Standard No. 14.

5.1.10.3 Guidelines for Drinking Water Quality, World Health Organization, Geneva, 2008.

5.1.10.4 EU Council Directive 98/83/EC.

5.1.11 *Listing*—MRS, HDB and HDS ratings for the polyethylene compound shall be listed in accordance with PPI TR-3.

5.2 *Polyethylene Rework Material*—Polyethylene rework material for the manufacture of pipe in accordance with this specification is to be used only when blended with new polyethylene compound that complies with 5.1. Polyethylene rework material shall comply with the following requirements:

5.2.1 Polyethylene rework material shall comply with PPI TN-30 and shall be from production in accordance with this specification that complies with the melt filtration requirements of PPI TN-30.

5.2.2 The melt flow rate in accordance with Test Method D1238, Condition 190/21.6 for polyethylene rework material shall be within ±20 percent of the test value per 5.1.6.

5.2.3 The oxidation induction time at 200°C for polyethylene rework material shall not be less than 20 minutes when tested in accordance with Test Method D3895.

6. Pipe 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. Pipe shall be produced using polyethylene material that complies with Section 5. Pipe shall be produced in accordance with a quality assurance program that complies with Section 9.

6.1.1 Excluding color stripes, the dispersion of carbon black in black pipe and color in solid color pipe shall meet an arithmetic grading mean of 3 or less and an appearance rating not worse than micrograph B when tested in accordance with ISO 18553.

6.1.2 *Carbon Black*—Black pipe shall contain 2.25 ± 0.25 percent carbon black when tested in accordance with Test Method D1603 or Test Method D4218.

6.2 *Dimensions and Tolerances:*

6.2.1 *Outside Diameter*—Outside diameter and tolerance shall be as shown in Table 2 or in accordance with 6.2.1.1 when measured in accordance with Test Method D2122.

6.2.1.1 *Special Size Pipe*—Special size pipe is pipe that is not shown in Table 2 that has diameter dimensions that are mutually agreed upon by purchaser and manufacturer, but otherwise complies with this standard. For minimum diameter, d_n, special size pipe, plus tolerance shall be 0.009 times d_n, and minus tolerance shall be zero. For average diameter special size pipe, the plus tolerance shall be 0.0045 times the average diameter, and the minus tolerance shall be 0.0045 times the average diameter. For average diameter special size pipe, minimum diameter, d_n, shall be average diameter less minus tolerance.

NOTE 4—Special size pipe is intended for the manufacture of pipe to dimensions that are by mutual agreement between the purchaser and the manufacturer and not shown in Table 2, but is not intended for the routine manufacture of pipe to inch-based pipe or tubing sizing conventions or "soft metric" conversions of inch-based pipe or tubing.

6.2.2 *Out-of-roundness*—Out of roundness, OOR, shall be measured in accordance with Test Method D2122 at the time of manufacture, but before packaging, storage and shipment. Out of roundness tolerance shall be in accordance with Table 2 or

TABLE 2 Diameter and Wall Thickness Dimensions and Tolerances, mm

MM Nom. Size	Outside Diameter			Minimum Wall Thickness, t													
				PN 25		PN 20		PN 16		PN 12.5		PN 10		PN 8		PN 6		PN 5	
				DR 7.4		DR 9		DR 11		DR 13.6		DR 17		DR 21		DR 26		DR 33	
	Min. (d_n)	Tol.	OOR Tol.	t	Tol.[A]	t	Tol.[A]	t	Tol.[A]	t	Tol.[A]	t	Tol.[A]	t	Tol.[A]	t	Tol.[A]	t	Tol.[A]
32	32.0	0.3	1.3	4..4	0.6	3.6	0.5	3.0	0.4	...	...	...	...	...	...	...	...	...	...
40	40.0	0.4	1.4	5.5	1.7	4.5	0.6	3.7	0.5	3.0	0.5	...	...	...	...	...	...	...	...
50	50.0	0.4	1.4	6.9	1.8	5.6	0.7	4.6	0.6	3.7	0.5	3.0	0.4	...	...	...	...	...	...
63	63.0	0.4	1.5	8.6	1.0	7.1	0.9	5.8	0.7	4.7	0.5	3.8	0.5	3.0	0.4	...	...	...	...
75	75.0	0.5	1.6	10.3	1.2	8.4	1.0	6.8	0.8	5.6	0.6	4.5	0.6	3.6	0.5	...	...	...	...
90	90.0	0.6	1.8	12.3	1.5	10.1	1.2	8.2	1.0	6.7	0.8	5.4	0.7	4.3	0.6	3.5	0.5	...	...
110	110.0	0.7	2.2	15.1	1.7	12.3	1.4	10.0	1.1	8.1	1.0	6.6	0.8	5.3	0.7	4.2	0.6	...	...
125	125.0	0.8	2.5	17.1	1.9	14.0	1.6	11.4	1.3	9.2	1.1	7.4	0.9	6.0	0.7	4.8	0.6	...	...
140	140.0	0.9	2.8	19.2	2.1	15.7	1.7	12.7	1.4	10.3	1.2	8.3	1.0	6.7	0.8	5.4	0.7	...	...
160	160.0	1.0	3.2	21.9	2.3	17.9	1.9	14.6	1.6	11.8	1.3	9.5	1.1	7.7	0.9	6.2	0.8	...	...
180	180.0	1.1	3.6	24.6	2.6	20.1	2.2	16.4	1.8	13.3	1.5	10.7	1.2	8.6	1.0	6.9	0.8	...	...
200	200.0	1.2	4.0	27.4	2.9	22.4	2.4	18.2	2.0	14.7	1.5	11.9	1.3	9.6	1.1	7.7	0.9	...	...
225	225.0	1.4	4.5	30.8	3.2	25.2	2.7	20.5	2.2	16.6	1.8	13.4	1.5	10.8	1.2	8.6	1.0	...	...
250	250.0	1.5	5.0	34.2	3.6	27.9	4.2	22.7	2.4	18.4	2.0	14.8	1.6	11.9	1.3	9.6	1.1	...	...
280	280.0	1.7	9.8	38.3	4.0	31.3	4.7	25.4	2.7	20.6	2.2	16.6	1.8	13.4	1.5	10.7	1.2	...	...
315	315.0	1.9	11.1	43.1	4.5	35.2	5.3	28.6	3.0	23.2	2.3	18.7	2.0	15.0	1.6	12.1	1.4	9.7	1.1
355	355.0	2.2	12.5	48.5	5.0	39.7	6.0	32.2	4.9	26.1	2.8	21.1	2.3	16.9	1.8	13.6	1.5	10.9	2.2
400	400.0	2.4	14.0	54.7	5.6	44.7	6.8	36.3	5.5	29.4	3.1	23.7	2.5	19.1	2.1	15.3	1.7	12.3	2.4
450	450.0	2.7	15.8	61.5	6.3	50.3	7.6	40.9	6.2	33.1	4.9	26.7	2.8	21.5	2.3	17.2	1.9	13.8	2.7
500	500.0	3.0	17.5	68.4	10.3	55.8	8.4	45.4	6.9	36.8	5.5	29.7	2.9	23.9	2.5	19.1	2.1	15.3	2.7
560	560.0	3.4	19.6	76.6	11.5	62.5	9.4	50.8	7.7	41.2	6.1	33.2	4.9	26.7	2.8	21.4	2.3	17.2	2.9
630	630.0	3.8	22.1	86.1	13.0	70.3	10.6	57.2	8.7	46.3	6.9	37.4	5.6	30.0	4.5	24.1	2.6	19.3	3.1
710	710.0	6.4	24.9	97.1	14.5	79.3	12.0	64.5	9.8	52.2	7.8	42.1	6.3	33.9	5.0	27.2	2.9	21.8	3.3
800	800.0	7.2	28.0	109.3	16.3	89.3	13.5	72.6	11.0	58.8	8.8	47.4	7.1	38.1	5.7	30.6	4.5	24.5	3.6
900	900.0	8.1	31.5	...	...	100.6	15.0	81.7	12.4	66.2	9.9	53.3	7.9	42.9	6.4	34.4	5.1	27.6	3.9
1000	1000.0	9.0	35.0	...	...	111.8	16.7	90.2	13.7	72.5	10.8	59.3	8.8	47.7	7.1	38.2	5.7	30.6	4.5
1200	1200.0	10.8	42.0	...	...	...	...	109.5	16.4	88.2	13.2	67.9	10.1	57.2	8.5	45.9	6.8	36.7	5.5
1400	1400.0	12.6	49.0	...	...	...	...	...	...	102.9	15.4	82.4	12.3	66.7	10.0	53.5	8.0	42.9	6.4
1600	1600.0	14.4	56.0	...	...	...	...	...	...	117.6	17.6	94.1	14.1	76.2	11.4	61.2	9.1	49.0	7.3
1800	1800.0	16.2	63.0	...	...	...	...	...	...	...	...	105.9	15.8	85.7	12.8	69.1	10.3	54.5	8.1
2000	2000.0	18.0	70.0	...	...	...	...	...	...	...	...	117.6	17.6	95.2	14.2	76.9	11.5	60.6	9.0
2100	2100.0	18.9	73.5	...	...	...	...	...	...	...	...	...	...	100.0	15.0	80.8	12.2	63.6	9.6
2300	2300.0	20.7	80.5	...	...	...	...	...	...	...	...	...	...	109.5	16.5	88.5	13.3	69.7	10.5
2500	2500.0	22.5	87.5	...	...	...	...	...	...	...	...	...	...	119.0	17.9	96.2	14.5	75.8	11.4

[A] For minimum wall ≤30.0 mm, tolerance equals 0.1 × minimum wall, rounded up to the nearest 0.1 mm. For minimum wall >30.0 mm, tolerance equals 0.15 × minimum wall, to nearest whole 0.1 mm, with decimal values beyond 0.1 mm dropped.

in accordance 6.2.2.1, 6.2.2.2 or 6.2.2.3 for special size pipe. Out of roundness tolerance shall not apply after packaging, storage or shipment.

6.2.2.1 For $d_n \leq 75$ mm, OOR tolerance = 0.008 d_n +1, rounded up to the nearest 0.1 mm

6.2.2.2 For $d_n > 75$ and ≤ 250 mm, OOR tolerance = 0.02 d_n, rounded up to the nearest 0.1 mm

6.2.2.3 For $d_n > 250$ mm, OOR tolerance = 0.035 d_n, rounded up to the nearest 0.1 mm

6.2.3 *Toe-in*—When measured in accordance with Test Method D2122, the outside diameter at the cut end of the pipe shall not be less than 0.985 times the measured undistorted outside diameter. Measurement of the undistorted outside diameter shall be made no closer than 1.5 pipe diameters or 300 mm, whichever distance is less, from the cut end of the pipe. The undistorted outside diameter shall be in accordance with 6.2.1.

6.2.4 *Wall Thickness*—Minimum wall thicknesses and tolerance shall be as shown in Table 2 or 6.2.4.1 when measured in accordance with Test Method D2122. Wall thickness below minimum shall not be acceptable.

6.2.4.1 *Special Size Pipe*—For special size pipe the minimum wall thickness shall be 3.0 mm, but otherwise minimum wall thickness dimensions that are mutually agreed upon between purchaser and manufacturer shall be acceptable. Unless otherwise mutually agreed upon between purchaser and manufacturer, for wall thickness less than 30 mm, wall thickness tolerance shall be 0.10 times minimum wall thickness plus 0.1 mm, and for wall thickness greater than 30 mm, tolerance shall be 0.15 times the minimum wall thickness. (See Note 4.)

6.3 *Short-term Properties*—Specimens of pipe shall be tested for minimum short-term hoop stress and failure mode by hydrostatic bursting, or by apparent ring tensile strength. Hydrostatic bursting is generally applicable to 110 mm and smaller sizes. Apparent ring tensile strength is generally applicable to 63 mm and larger sizes.

6.3.1 *Hydrostatic Bursting*—The minimum hydrostatic burst pressure hoop stress for pipe shall be 20.6 MPa when determined in accordance with 7.4.1. The failure mode shall be ductile.

6.3.2 *Apparent Ring Tensile Strength*—The minimum appar ent ring tensile strength at yield shall be 20.6 MPa when tested in accordance with 7.4.2. The failure mode shall be ductile.

6.4 *Optional Evaluation for Resistance to Rapid Crack Propagation (RCP):*

6.4.1 Evaluation for resistance to rapid crack propagation is optional for pipes intended for the transport of pressurized gas media. Evaluation for RCP is not applicable to pipes intended for the transport of pressurized liquid media, or for non-pressure pipes. Optional RCP evaluation testing is conducted on one sample size in accordance with 7.5.

6.4.2 When one sample size per 7.5 is tested in accordance with ISO 13477 (Small-Scale-Steady-State, S4), the critical pressure in bar at 0°C shall not be less than PN divided by 3.84. When one sample size per 7.5 is tested in accordance with ISO 13478 (Full-Scale, FS), the critical pressure in bar at 0°C shall not be less than PN divided by 1.07.

NOTE 5—If optional evaluation for resistance to rapid crack propagation (RCP) is being contemplated, it is necessary that the purchaser consult with the manufacturer prior to purchase. Information on resistance to RCP may have value for pipes that transport gaseous media under pressure under certain application conditions such as higher pressures at sub-freezing conditions, but is of limited to no value for pipes that transport liquid media under pressure, and is of no value for non-pressure pipes. Review of technical studies on the potential for an RCP event with the fluid media being conveyed is recommended.

6.5 *Elevated Temperature Sustained Pressure*—Elevated temperature sustained pressure tests shall be conducted per 7.6. The test sample shall be three specimens of a generally representative pipe size that is produced in accordance with this specification.

6.5.1 Passing results for all three specimens are non-failure or not more than one ductile failure and an average time before failure that is greater than the Table 3 minimum average time before failure for the selected Table 3 Condition. Any brittle failure constitutes failure to meet this requirement. For testing that is initially performed at Table 3 Condition 1–4, if more than one ductile failure occurs, one retest at a Table 3 Condition of lower stress and longer minimum average time before failure is permissible, and the retest shall be conducted on three additional specimens of the same size and that were produced within 30 days of the first test specimens. For a retest, any specimen failure, ductile or brittle, at the retest condition constitutes failure to meet this requirement. No retest is permissible for testing that is initially performed at Table 3 Condition 5.

6.6 *Oxidation Induction Time*—The oxidation induction time of the pipe at 200°C shall not be less than 20 minutes when tested in accordance with 7.7.

6.7 *Inside Surface Ductility for Pipe*—The inside surface of pipe shall be ductile as shown by testing in accordance with 7.8. For all specimens, the minimum tensile strength at yield shall be 20.6 MPa and the minimum elongation at break shall be 400 percent.

7. Test Methods

7.1 *Conditioning*—Where conditioning is required before testing, condition pipe test specimens at test temperature without regard to humidity for not less than 24 h in temperature-controlled circulating air equipment that complies with Practice D618, or for not less than 6 hours in temperature-controlled circulating water equipment that complies with Practice D618.

7.2 *Test Conditions*—Conduct laboratory tests in an atmosphere of 23±2°C and 50±10 percent humidity unless otherwise specified in the test methods or this specification. Conduct non-laboratory tests such as routine production floor checks at ambient temperature and humidity conditions.

7.3 *Sampling*—The selection of the polyethylene compound or pipe sample for testing in accordance with this section shall comply with Section 9 Quality Assurance requirements. For referee testing, sample selections shall be by the mutual agreement of the purchaser and the manufacturer. In case of no prior agreement, the testing laboratory shall select samples.

7.4 *Short-term Properties:*

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

7.4.2 *Apparent Ring Tensile Strength*—The procedure and test equipment shall be as specified in Test Method D2290, Procedure D. Test a minimum of five specimens.

7.5 *Resistance to Rapid Crack Propagation (RCP)*—Testing for resistance to rapid crack propagation in accordance with

TABLE 3 Elevated Temperature Sustained Pressure Requirements

Condition	Test Temperature, °C[A]	Test Pressure Hoop Stress,[B] kPa[A]	Minimum Average Time Before Failure, Hours
1	80	5400	165
2	80	5300	256
3	80	5200	399
4	80	5100	629
5	80	5000	1000

[A] Tolerance on test temperature shall be ±2°C. Tolerance on test pressure hoop stress shall be ±35 kPa.
[B] Calculate internal test pressure in accordance with:

$$P = \frac{2S}{\left(\frac{D_O}{t} - 1\right)}$$

where:

P = test pressure, kPa,
S = test pressure hoop stress, kPa,
D_O = measured outside diameter, mm, and
t = measured minimum wall thickness, mm.

ISO 13477 or ISO 13478 is conducted at 0°C on one sample size having $d_n \leq 350$ mm and having minimum wall thickness ≥ 15 mm.

7.6 *Elevated Temperature Sustained Pressure Test*—Select one Table 3 Condition and test in accordance with Test Method D1598 using water as the internal test medium.

7.7 *Oxidation Induction Time*—A sample specimen taken from the pipe wall shall be tested at 200°C in accordance with Test Method D3895. For referee tests, the sample specimen shall be taken within 0.2 mm of the pipe inner wall.

7.8 *Inside Surface Ductility*—Test specimens from the pipe inside surface for tensile strength at yield and elongation at break in accordance with Test Method D638 at 23±2°C and a crosshead separation speed of 50 mm/min. Prepare five Test Method D638 Type IV specimens cut in the longitudinal direction from each one-fifth circumferential segment around the circumference of the pipe. For all specimens, the pipe ID surface shall be left unaltered. All machined specimen surfaces shall be smooth in accordance with Test Method D638 requirements.

8. Marking

8.1 The following information shall be marked along the length of the pipe and shall repeat at internals not exceeding 0.6 m.

8.1.1 Nominal pipe size (for example, "MM 355").

8.1.2 The polyethylene compound designation in accordance with 5.1, for example, "PE100/PE4710".

8.1.3 Thermoplastic pipe dimension ratio in accordance with Table 2 (for example, DR 11). Omission of this marking for special size pipe is permissible.

8.1.4 The pressure number in bar for water at 20°C in accordance with Table 2, shown as the PN followed by the value, for example, PN10. Omission of this marking for special size pipe is permissible.

8.1.5 "ASTM" followed by the designation of this standard, for example, "ASTM F3123".

8.1.6 Manufacturer's name or trademark, manufacturing code, and date of manufacture.

8.1.6.1 The manufacturing code shall provide for the traceability of the polyethylene material per 5.1 and 5.2, and manufacturing in accordance with 9.2. An explanation of the manufacturing code shall be provided to the purchaser upon request.

8.1.6.2 The date of manufacture shall be eight numbers, four for year, two for month and two for day, for example, "2014-05-20". Hyphens or spaces between year, month and day are preferred but optional. The date of manufacture shall be adjacent to but separate from the manufacturing code, and shall precede or follow the manufacturing code.

8.1.7 When certification per 5.1.10 is required, the seal of the accrediting laboratory that provides certification.

NOTE 6—Authorization to use the seal of approval of the accrediting laboratory is obtained by the manufacturer from the accrediting laboratory prior to use.

8.2 Markings that indicate a communication or electrical component are prohibited.

9. Quality Assurance

9.1 When the product is marked with ASTM and the designation of this specification, ASTM F3123, the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

9.2 The manufacturer shall have a written quality assurance program that specifies policies and procedures for manufacturing, frequency of inspection, sampling and testing of materials and products, and policies and procedures for verifying and documenting product compliance with this specification. Documentation of product compliance with this specification in accordance with the manufacturer's quality assurance program shall be provided to the product purchaser when requested at the time of purchase.

NOTE 7—Certification of the manufacturer's quality assurance program in accordance with standards such as the ISO 9000 family of quality management standards is recommended.

9.3 Documentation of certification in accordance with 5.1.10 and listing in accordance with 5.1.11 shall be provided to the product purchaser upon request.

NOTE 8—Documentation requirements should not be construed as requiring unprotected disclosure of confidential or proprietary information.

9.4 Manufacturing records in accordance with this section shall be retained for not less than ten years.

10. Keywords

10.1 DR; HDB; HDPE; HDPE pipe; HDS; metric pipe; metric sized pipe; MRS; non-pressure pipe; OD controlled; PE100; PE4710; PE pipe; plastic pipe; PN; polyethylene pipe; pressure pipe

ANNEX

(Mandatory Information)

A1. VERIFICATION REQUIREMENTS FOR ASSEMBLED JOINTS

A1.1 Scope

A1.1.1 Joints for assembling pipe manufactured in accordance with this specification to compatible pipe and fittings shall be verified by assembling sample joints in accordance with applicable procedures and testing the sample joints for short-term and long-term strength. Verification testing of butt fusion joints shall be the pipe manufacturer's responsibility. Verification testing of fitting joints (fusion saddle and fusion socket coupling, electrofusion saddle and coupling, and mechanical saddle and coupling) shall be the fitting manufacturer's responsibility.

A1.1.2 The requirements in this annex are intended to verify assembled joint strength, but are not intended for the verification of pipe design strength, pipe pressure capacity, pipe performance capabilities, fitting design, fitting design strength, fitting pressure capacity, fitting performance capabilities, or field joints in installed systems.

A1.1.3 The requirements in this annex are limited to testing of assembled joints that connect to the pipe outside diameter or to the end of the pipe. The assembled joints addressed in this Annex include butt fusion joints between pipes and between pipes and fittings, saddle fusion joints between pipes and saddle fittings, socket fusion joints between pipes and socket fusion fittings, electrofusion joints between pipes and electrofusion couplings, electrofusion joints between pipes and electrofusion saddle fittings, longitudinal mechanical joints between pipes and mechanical compression fittings, and mechanical saddle joints between pipes and mechanical saddle fittings.

A1.1.4 Requirements for fitting joints that transition to components other than pipe such as flanges, gasketed mechanical bell and spigot joints, pipe threads, etc., are not within the scope of this annex.

A1.1.5 Documentation of compliance with this annex shall be provided by the appropriate manufacturer to the product purchaser upon request.

A1.2 Test Assemblies

A1.2.1 Unless otherwise specified, test assemblies shall be prepared for the following polyethylene pipe size ranges: <75 mm, ≥75 mm to <250 mm, ≥250 mm to <710 mm, and ≥710 mm.

A1.2.2 A sufficient number of test assemblies shall be prepared so that at least three data points are generated for each test. Test assemblies containing multiple joints shall be acceptable. When a failure in a test assembly containing multiple joints occurs, it shall be acceptable to remove the failed joint and continue testing of the remaining joints. Failed joint removal and reinstating the testing of the remaining joint(s) shall be performed as expeditiously as practical. For tests that require a time to failure result, the time to failure shall be inclusive of the entire time under test conditions, excluding time to remove the failed joint and assemble end closures to the remaining test assembly. Multiple joint test assemblies shall be assembled and reassembled such that distance requirements between joints and end closures are observed.

A1.3 Fusion Joint Tests

A1.3.1 *Butt Fusion:*

A1.3.1.1 Sample butt fusion joints for test assemblies shall be prepared in accordance with Practice F2620 and Practice F2928.

A1.3.1.2 For sizes <75 mm short-term strength testing shall be conducted in accordance with Test Method D1599 at 23°C. For sizes >250 mm, short-term strength testing shall be conducted in accordance with Test Method D638. For sizes 75 mm thorough 250 mm, testing shall be conducted in accordance with Test Method D1599 or Test Method D638.

(1) For testing in accordance with Test Method D1599, failure shall be ductile, failure shall occur between 60 and 70 seconds, and the hoop stress at failure shall not be less than 20.6 MPa.

(2) For testing in accordance with Test Method D638, testing shall be conducted on Type IV specimens taken from each quadrant of the butt fusion test assembly and tested at 50 mm/min grip separation rate and 23°C. The minimum stress at yield shall be 20.6 MPa, and the failure at break shall be ductile.

A1.3.1.3 Long-term testing of butt fusion test assemblies shall be conducted in accordance with 6.5 using free (unrestrained) end closures in accordance with Test Method D1598.

A1.3.2 *Socket Fusion:*

A1.3.2.1 Socket fusion tests shall apply to pipe sizes for which socket fusion fittings are commercially available (typically 110 mm and smaller).

A1.3.2.2 Sample socket fusion joints for test assemblies shall be prepared in accordance with Practice F2620 using tools that comply with Specification F1056 and shall be conditioned in accordance with Practice F2928. Test assemblies shall be prepared using equal outlet socket fittings (such as couplings, elbows, or tees). Pipe joined to each outlet shall be the same DR. The minimum pipe length distance between the end of the socket fitting outlet and the end closure shall be the greater of 2.5 times the pipe diameter or 300 mm. Free (unrestrained) end closures per Test Method D1598 shall be used.

A1.3.2.3 Short-term strength testing shall be conducted in accordance with Test Method D1599 at 23°C. Failure shall be ductile, failure shall occur between 60 and 70 seconds, and the hoop stress at failure shall not be less than 20.6 MPa.

A1.3.2.4 Long-term testing of socket fusion test assemblies shall be conducted in accordance with 6.5 using free (unrestrained) end closures in accordance with Test Method D1598.

A1.3.3 *Saddle Fusion:*

A1.3.3.1 *Test Assemblies*—Assemblies for testing saddle fusion joints for shall be prepared by saddle fusing saddle fittings to main pipe in accordance with Practice F2620. For internal pressure testing per Test Method D1599 and Test Method D1598, the main pipe shall be penetrated and the penetration hole through the main pipe shall be the maximum size for the saddle fitting, but not less than 80% of the outlet bore. For self-tapping (tapping tee) style saddle fittings, the cutter shall be withdrawn from the main after penetrating the main. The saddle fitting outlet shall be joined to a short length of pipe that is sealed with a free (unrestrained) end closure. The main pipe and the pipe joined to the saddle fitting outlet shall be the same DR. For testing in accordance with Practice F905, a main pipe penetration hole for the branch outlet is not required.

A1.3.3.2 For sizes <75 mm short-term strength testing shall be conducted in accordance with Test Method D1599 at 23°C. For sizes >250 mm, short-term strength testing shall be conducted in accordance with Practice F905. For sizes 75 mm thorough 250 mm, testing shall be conducted in accordance with Test Method D1599 or Practice F905.

A1.3.3.3 For testing in accordance with Test Method D1599, failure shall be ductile failure of the main pipe or the pipe joined to the saddle outlet, failure shall occur between 60 and 70 seconds, and the hoop stress at failure shall not be less than 22.9 MPa.

A1.3.3.4 For testing in accordance with Practice F905, pass-fail results shall be as determined in accordance with Practice F905.

A1.3.3.5 Long-term testing of saddle fusion joint test assemblies shall be conducted in accordance with 6.5 using free (unrestrained) end closures in accordance with Test Method D1598.

A1.4 Electrofusion Joint Tests

A1.4.1 Sample electrofusion coupling joints for test assemblies shall be prepared using PE100/PE4710 pipe meeting this specification in accordance with Practice F1290, the manufacturer's recommended joining procedure, and shall be conditioned in accordance with Practice F2928. Test assemblies shall be prepared using equal outlet-electrofusion couplings. Pipe joined to each outlet shall be the same DR. The minimum pipe length distance between the end of the electrofusion coupling and the end closure shall be the greater of 2.5 times the pipe diameter or 300 mm. Free (unrestrained) end closures per Test Method D1598 shall be used.

A1.4.2 Sample electrofusion saddle joints for test assemblies shall be prepared using PE100/PE4710 pipe meeting this specification in accordance with Practice F1290, the manufacturer's recommended joining procedure, and shall be conditioned in accordance with Practice F2928. The minimum pipe length distance between the edge of the electrofusion saddle base and the pipe end closure shall be the greater of 2.5 times the pipe diameter or 300 mm. Free (unrestrained) end closures per Test Method D1598 shall be used. The main shall be perforated, and the saddle branch outlet shall be closed. The penetration hole through the main pipe shall be the maximum size specified by the manufacturer for the saddle branch outlet, but not less than 80% of the outlet bore. For self-tapping (tapping tee) style branch fittings, the cutter shall be withdrawn from the main after penetrating the main. Pipe joined to the main and to the saddle outlet shall be the same DR.

A1.4.3 Testing shall be conducted in accordance with Specification F1055 performance requirements.

A1.5 Mechanical Joint Tests

A1.5.1 Sample mechanical joint test assemblies shall be prepared using PE100/PE4710 pipe meeting this specification and shall be assembled in accordance with the mechanical fitting manufacturer's instructions.

A1.5.1.1 The minimum pipe length distance between the end of a mechanical coupling and the end closure shall be the greater of 2.5 times the pipe diameter or 300 mm. Free (unrestrained) end closures per Test Method D1598 shall be used. Pipe joined to each outlet shall be the same DR.

A1.5.1.2 The minimum pipe length distance between the edge of a mechanical saddle base and the main pipe end closure shall be the greater of 2.5 times the pipe diameter or 300 mm. Free (unrestrained) end closures per Test Method D1598 shall be used. The main shall be penetrated, and the saddle branch outlet shall be closed. The penetration hole through the main pipe shall be the maximum size specified by the manufacturer for the saddle branch outlet, but not less than 80% of the outlet bore. For tapping tee style branch fittings, the cutter shall be withdrawn from the main. Pipe joined to the main and to the saddle outlet shall be the same DR.

A1.5.2 *Resistance to Leakage*—High pressure testing shall be conducted at 1.5 times the pipe PN for 8 hours. Low pressure testing shall be conducted at 0.1 times the pipe PN for 8 hours. Where the same test assemblies are used for both tests, test assemblies shall be de-pressurized for at least 8 hours between tests. High pressure and low pressure testing shall be conducted in accordance with Test Method D1598 at 23°C and at 60°C. No leakage is permissible. For mechanical coupling test assemblies, no disjoining, separation or movement of the pipe relative to the coupling is permissible.

APPENDIX

(Nonmandatory Information)

X1. INTERNAL PRESSURE AND USE

X1.1 Internal Pressure Considerations, *PN* and *PFA*

X1.1.1 This standard provides for nominal pressure (nominal design rating), *PN*, in bar at 20°C as defined in 3.2.6 and Eq 1. *PN* as used in this standard is at 20°C and sustained internal pressure for PE100/PE4710 pipes that transport liquid or gaseous media such as water or other liquids or gases that are chemically benign to PE100 /PE4710 . When an intended use is for temperature other than 20°C, or for liquid or gaseous media that has or may have chemical effects different from water, the internal pressure capacity of the pipe will vary from the nominal pressure, *PN*. To address some sustained internal pressure conditions of use, this standard provides for maximum allowable operating pressure, *PFA*, as defined in 3.2.8 and Eq 2 where *PN* is modified by the application of a temperature factor f_T, as defined in 3.2.9, and an application factor, f_A as defined in 3.2.1.The maximum recommended service temperature for sustained internal pressure service is 60°C. The maximum recommended sustained service temperature for non-pressure service is 82°C.

X1.1.2 *PFA* presumes internal pressure that is sustained and relatively stable. Fatigue effects such as regular or irregular variation of internal pressure or temperature are not addressed within *PFA*. When an intended use involves cyclical or intermittent variation in pressure or temperature, the user should seek guidance from texts, handbooks and technical resources from manufacturers, trade associations, and other industry research organizations.

X1.1.3 Long and short-term mechanical properties related to axial and hoop tension, compression, creep, strain, bending, fatigue, shear and the like will vary with temperature, and with the magnitude and duration of applied stress. Designers should take variation of mechanical properties into account using information from manufacturers and industry technical resources such as the Plastics Pipe Institute.

X1.1.4 Pipe system uses generally involve both a transported internal media and an external environment. This appendix offers some information on internal media effects, but does not address all internal media or installation or external environment effects that may have significant effects on the piping system. It is not a complete design guide for piping systems. Environmental effects that should be accounted for in piping design may include seasonal or daily temperature variation, stress and strain from mechanical constraints or from static or variable surface loads, effects of exposure to chemicals that may be in the environment surrounding the piping system, and the like.

X1.1.5 The methodology herein is one means to estimate maximum allowable operating pressure, *PFA*, for some uses and some internal media for PE100/PE4710 pipe that complies with this standard. This methodology is applicable to the PE100/PE4710 polyethylene compound and pipe per this standard because of the polyethylene compound and pipe requirements in this standard. However, users are cautioned to use appropriate judgment in the use of the information in this appendix especially where the piping system includes components that comply with other standards or are made using other materials. Consultation with polyethylene compound and pipe manufacturers is recommended, as well as the review of texts, handbooks, and technical information from trade associations, manufacturers and other research organizations.

X1.1.6 Other products, appurtenances, or components made using polyethylene or other materials and used within the piping system may be limiting factors in the piping system.

X1.2 Temperature Factor

X1.2.1 Table X1.1 temperature factors, f_T per 3.2.9 are for use in estimating maximum allowable operating pressure, *PFA*, per 3.2.8. Table X1.1 temperature factors are limited to ASTM F3123 PE100/PE4710 piping that complies with this specification. Table X1.1 temperature factors are for sustained use at the temperature. Due diligence and professional judgment in the use of Table X1.1 temperature factors are necessary. The user should consult the manufacturer to verify the applicability of Table X1.1 factors, and to determine if sustained use at elevated temperature will not affect service life beyond limits acceptable to the user. Verification of Table X1.1 temperature factors could be to confirm that the PE100/PE4710 compound meets a σ_{LPL} at 60°C and 50 years of 4.88 MPa or greater per ISO 9080 and ISO 12162 or other suitable methodology. The user should consult the manufacturer if the conditions of conveyance are intermittent or cyclical temperatures.

X1.2.2 Manufacturers of other polyethylene products should be consulted to determine appropriate temperature factors for their products, especially for polyethylene piping products that are manufactured in accordance with other standards. Other methods for estimating polyethylene compound temperature effects may include $CRS_{\Theta,t}$ ratings per ISO 9080 and ISO 12162.

X1.3 Application Factor

X1.3.1 Table X1.2 offers some application factors, f_A, per 3.2.1 for estimating maximum allowable operating pressure, *PFA*, in accordance with 3.2.8 for PE100/PE4710 pipe that complies with this specification. System designers should apply due diligence and reasonable professional judgment in the use of Table X1.2 application factors because conditions of conveyance can vary. Table X1.1 is not an all-inclusive or exclusive list of media. Other media may be suitable or unsuitable for conveyance through polyethylene piping, or may limit conditions of conveyance, or may limit service life. The user should consult the manufacturer to determine if the media being conveyed is compatible with polyethylene pipe and will not affect service life beyond limits acceptable to the user. The

media being conveyed may be subject to statutory codes or regulations that can affect conditions of conveyance. Table X1.2 application factors may or may not be appropriate for piping products manufactured to other specifications or from other polyethylene compounds or from other materials; therefore, the chemical compatibility of other piping system components should be separately evaluated. It is recommended to consult with product and material manufacturers as well as references such as PPI TR-19 or the PPI Handbook of Polyethylene Pipe for guidance in estimating if the conveyed media or anticipated conditions of conveyance are suitable.

X1.3.2 Table X1.2 factors are for concentrated media and sustained exposure. Chemical effects between PE100/PE4710 piping and various media may vary depending on chemical combinations or solutions and concentrations with other chemicals, temperature (especially sustained elevated temperature), applied internal or external stress, variations of temperature or stress, and exposure duration. Testing samples of PE100/PE4710 pipe in the media and under conditions that simulate conditions of conveyance should be considered.

X1.3.3 The potential consequences of internal media release from an unintended event should be taken into account.

TABLE X1.1 Temperature Factor (f_T), for ASTM F3123 PE100/PE4710 Pipe[A]

°C	f_T	°C	f_T	°C	f_T
20	1.00	34	0.85	48	0.71
21	0.99	35	0.84	49	0.71
22	0.98	36	0.83	50	0.70
23	0.97	37	0.82	51	0.69
24	0.96	38	0.81	52	0.68
25	0.95	39	0.80	53	0.67
26	0.93	40	0.79	54	0.66
27	0.92	41	0.78	55	0.65
28	0.91	42	0.77	56	0.64
29	0.90	43	0.76	57	0.63
30	0.89	44	0.75	58	0.62
31	0.88	45	0.74	59	0.62
32	0.87	46	0.73	60	0.61
33	0.86	47	0.72		

[A] Table X1.1 values calculated in accordance with the PPI Handbook of Polyethylene Pipe, Second Edition, Chapter 3, Appendix A.2 using values of 11.03 MPa at 23°C (adjusted to 11.36 MPa at 20°C) and 6.89 MPa at 60°C. See Table 1 for polyethylene compound requirements.

TABLE X1.2 Application Factor (f_A) for PE100/PE4710 Pipe

Media being Transported	f_A
Chemically-compatible industrial process liquids; water; water solutions; water-borne slurries	1.00
Chemically-compatible gaseous media[A,B]	0.63
Chemically-compatible gaseous media[C]	1.00
Liquid hydrocarbons; liquid media containing liquid hydrocarbons;	0.50

[A] Applicable to pipes conveying pressurized gaseous media that is or may be subject to statutory codes or regulations.
[B] Applicable to pipes conveying pressurized gaseous media at temperatures of 3°C and lower and having wall thickness >0.32 mm.
[C] Applicable to pipes conveying pressurized gaseous media at temperatures above 3°C and having any wall thickness, but excluding pipes conveying pressurized gaseous media that is or may be subject to statutory codes or regulations.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F3123–15a) that may impact the use of this standard. (Approved November 1, 2016.)

(1) Added 1.4.
(2) Added referenced documents *ANSI Essential Requirements: Due Process Requirements for American National Standards* and *Decision on Principles for the Development of International Standards, Guides and Recommendations* to 2.5

Committee F17 has identified the location of selected changes to this standard since the last issue (F3123–15) that may impact the use of this standard.

(1) Table 2 was revised.
(2) Table 3 was revised.
(3) 6.5.1 was revised.