INTERNATIONAL

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An American National Standard

Standard Specification for Polyamide 12 Gas Pressure Pipe, Tubing, and Fittings[1]

This standard is issued under the fixed designation F2785; 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 requirements and test methods for the characterization of polyamide 12 pipe, tubing, and fittings for use in fuel gas mains and services for direct burial and reliner applications. The pipe and fittings covered by this specification are intended for use in the distribution of natural gas.

1.1.1 Pipe and fittings covered by this specification shall not be joined using taper pipe threads. Butt fusion joining shall be done in accordance with Practice F3372. Design considerations are discussed in Appendix X1. In-plant quality control programs are specified in Annex A1.

1.2 The text of this specification references notes, footnotes, and appendixes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the specification.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—Pipe and fittings utilizing heat fusion joining techniques produced from compounds meeting the requirements of Group 3, Class 2, and Grade 3 (PA323 or PA11) are intended for use with pipe manufactured from compounds meeting the requirements of Group 3, class 2 and Grade 3. Pipe and fittings utilizing heat fusion joining techniques produced from compounds meeting the requirements of Group 4, Class 2 and Grade 3 (PA 423 or PA12) are intended for use with pipe manufactured from compounds meeting the requirements of Group 4, Class 2 and Grade 3. As per the recommendations of the respective resin manufacturers, no cross fusion between PA 323 (PA11) and PA 423 (PA12) compounds is permitted.

1.5 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents
D618 Practice for Conditioning Plastics for Testing
D648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
D638 Test Method for Tensile Properties of Plastics
D789 Test Method for Determination of Relative Viscosity of Concentrated Polyamide (PA) Solutions
D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
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
D1898 Practice for Sampling of Plastics (Withdrawn 1998)[3]
D1600 Terminology for Abbreviated Terms Relating to Plastics
D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
D2774 Practice for Underground Installation of Thermoplastic Pressure Piping
D2290 Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe
D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
D6779 Classification System for and Basis of Specification for Polyamide Molding and Extrusion Materials (PA)
F412 Terminology Relating to Plastic Piping Systems

[1] This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.60 on Gas.

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

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

F1025 Guide for Selection and Use of Full-Encirclement-Type Band Clamps for Reinforcement or Repair of Punctures or Holes in Polyethylene Gas Pressure Pipe
F1473 Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins
F1733 Specification for Butt Heat Fusion Polyamide(PA) Plastic Fitting for Polyamide(PA) Plastic Pipe and Tubing
F1973 Specification for Factory Assembled Anodeless Risers and Transition Fittings in Polyethylene (PE) and Polyamide 11 (PA11) and Polyamide 12 (PA12) Fuel Gas Distribution Systems
F2138 Specification for Excess Flow Valves for Natural Gas Service
F2145 Specification for Polyamide 11 (PA 11) and Polyamide 12 (PA12) Mechanical Fittings for Use on Outside Diameter Controlled Polyamide 11 and Polyamide 12 Pipe and Tubing
F2767 Specification for Electrofusion Type Polyamide-12 Fittings for Outside Diameter Controlled Polyamide-12 Pipe and Tubing for Gas Distribution
F2897 Specification for Tracking and Traceability Encoding System of Natural Gas Distribution Components (Pipe, Tubing, Fittings, Valves, and Appurtenances)
F3372 Practice for Butt Fusion Joining of PA12 Pipe and Fittings

2.2 *ANSI Standards:*[4]
B 16.40 Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
B 31.8 Gas Transmission and Distribution Piping Systems

2.3 *Federal Standards:*[5]
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)
OPS Part 192 Title 49 ,Title 49 Code of Federal Regulations

2.4 *Military Standards:*[6]
MIL-STD-129 Marking for Shipment and Storage
MIL-STD-1235 (ORD) Single- and Multi-Level Continuous Sampling Procedures and Tables for Inspection by Attributes

2.5 *ISO Standards:*[6]
307 Plastics -- Polyamides -- Determination of viscosity number
3146 Plastics -- Determination of melting behaviour (melting temperature or melting range) of semi-crystalline polymers by capillary tube and polarizing-microscope methods
1183 Plastics -- Methods for determining the density of non-cellular plastics -- Part 1: Immersion method, liquid pyknometer method and titration method
527–1 Plastics -- Determination of tensile properties -- Part 1: General principles
527–2 Plastics -- Determination of tensile properties -- Part 2: Test conditions for moulding and extrusion plastics
178 Plastics -- Determination of flexural properties
179 Plastics -- Determination of Charpy impact properties -- Part 1: Non-instrumented impact test
75–1 Plastics -- Determination of temperature of deflection under load -- Part 1: General test method
75–2 Plastics -- Determination of temperature of deflection under load -- Part 2: Plastics and ebonite
ISO 16486-1 Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 1: General

2.6 *Plastic Pipe Institute:*[7]
PPI TR3 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 TR4 Hydrostatic Design Bases and Maximum Recommended Hydrostatic Design Stresses for Thermoplastic Piping Materials
PPI TN7 Nature of Hydrostatic Stress Rupture Curves

2.7 *Other Standards:*[8]
National Fire Protection Association: NFPA 58 , Storage and Handling Liquefied Petroleum Gases

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 The gas industry terminology used in this specification is in accordance with ANSI B31.8 or CFR OPS Part 192 Title 49, unless otherwise indicated.

3.3 The term *pipe* used herein refers to both pipe and tubing unless specifically stated otherwise.

3.4 *Definitions of Terms Specific to This Standard:*

3.4.1 *re-rounding equipment, n*—equipment used to reform the pipe and permanently reduce ovality to 5% or less.

3.4.2 *rounding equipment, n*—equipment, devices, clamps, and so forth, used to temporarily hold the pipe round while out-of-roundness measurements are made, or a joining procedure (heat fusion, electrofusion, or mechanical) is performed.

3.4.3 *standard thermoplastic material designated code, n*—the pipe material designation code shall consist of the abbreviation for the polyamide (PA) followed by Arabic numerals which describe the short term properties in accordance with Classification D6779, the hydrostatic design stress for water at 73.4 °F (23 °C) in units of 100 psi with any decimal figures dropped. Where the hydrostatic design stress code contains less than two figures, a zero is used before the number. Thus, a complete material designation code shall

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[5] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.
[6] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.
[7] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.
[8] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

consist of two letters and five figures for polyamide pipe materials. For example, PA 42316 is a grade of polyamide 12 with a 1600 psi design stress for water at 73.4 °F (23 °C). The hydrostatic design stresses for gas are not used in this designation code.

3.4.4 *thermoplastic pipe dimension ratio (DR), n*—the ratio of pipe diameter to wall thickness. It is calculated by dividing the specified outside diameter of the pipe, in inches, by the minimum specified wall thickness, in inches. The standard dimension ratio (SDR) is a common numbering system which is derived from the ANSI preferred number series R 10.

3.4.5 *toe-in, n*—a small reduction of the outside diameter at the cut end of a length of thermoplastic pipe.

4. Requirements for Materials

4.1 *General*—The polyamide material used to make pipe and fittings shall be virgin or reworked material (see 4.5) and shall have a Plastics Pipe Institute (PPI) long-term hydrostatic design stress and hydrostatic design basis rating as determined per PPI TR3 and PPI TR4.

4.2 *Classification*—Polyamide materials suitable for use in the manufacturing of pipe and fittings under this specification shall be classified in accordance with Classification D6779, as shown in Table 1.

4.3 *Short- and Long-Term Properties*—Polyamide pipe and fittings shall be made from a PA material which also satisfies the combinations of short- and long-term property requirements shown in Table 2.

4.4 *Resistance to Rapid Crack Propagation (RCP) for Materialsl*—The material classification (formulation) used in the manufacture of pipe and fittings under this specification shall be tested for resistance to failure by RCP in accordance with 6.7. The data obtained shall be made available upon request without limitations on disclosure, and shall not subsequently be subject to disclosure limitations when used by others. The values obtained are applicable to all pipes with the wall thickness of the pipe tested and all thinner wall pipes.

TABLE 2 Short and Long Term Property Requirements

PA Material Designation Code	Short-Term in Accordance with D6779	Long-Term in Accordance with D2837
PA42316	PA423	HDB of 3150 psi for 73 °F (23 °C)

4.5 *Rework Material*—Clean rework material of the same commercial designation, generated from the manufacturer's own pipe and fitting production shall not be used unless the pipe and fittings produced meet all the requirements of this specification.

4.6 *Documentation*—A documentation system to allow for traceability of raw materials including percentage and material classification (or designation, if applicable) of rework materials used in the manufacture of the pipe product meeting the requirements of this specification shall exist and be supplied to the purchaser, if requested.

5. Requirements for Pipe and Fittings

5.1 *General*—Pipe shall be supplied in either coils or straight lengths. Any pipe supplied in coils must meet the same requirements before and after coiling.

5.2 *Workmanship*—The pipe and fittings shall be homogeneous throughout and free of visible cracks, holes, foreign inclusion, blisters, and dents, or other injurious defects. The pipe and fittings shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

5.3 *Pipe and Tubing Dimensions and Tolerances:*

5.3.1 *Dimension*—The dimensions shall be specified by wall thickness and outside diameter.

5.3.1.1 *Diameters*—The outside diameter shall meet the requirements given in Table 3 or Table 4 when measured in accordance with 6.5.

5.3.1.2 *Toe-In*—When measured in accordance with 6.5.1.1, the outside diameter at the cut end of the pipe shall not be more than 1.5 % smaller than the undistorted outside diameter.

TABLE 1 Classification D6779

Classification	ASTM Test Method	ISO Test Method	Designation
PA 4 (group) 2 (class) 3 (grade)			Polyamide PA 12 Heat stabilized
Viscosity number, min.	D789	ISO 307	211
Specific gravity	D792	ISO 1183	1.00–1.06
Tensile strength, min, psi (MPa)	D638	ISO 527–1 and ISO 527–2	5000 (35)
Tensile Modulus, min, psi (MPa)		ISO 527–1 and ISO 527–2	145000 (1000)
Charpy impact resistance, min kJ/m^2		ISO 179	25
Deflection temperature, at 264 psi (1.82 MPa), min °F (°C)	D648	ISO 75–1 and ISO 75–2	95 (35)

TABLE 3 Outside Diameters and Tolerances for PA12 Pipe, in. (mm)

Nominal Pipe Size	Outside Diameter	Tolerance	Maximum out-of-roundness
½	0.840 (21.3)	±0.004 (±0.102)	0.016 (0.41)
¾	1.050 (26.7)	±0.004 (±0.102)	0.02 (0.51)
1	1.315 (33.4)	±0.005 (±0.127)	0.02 (0.51)
1¼	1.660 (42.1)	±0.005 (±0.127)	0.024 (0.61)
1½	1.900 (48.3)	±0.006 (±0.152)	0.024 (0.61)
2	2.375 (60.3)	±0.006 (±0.152)	0.024 (0.61)
3	3.500 (88.9)	±0.008 (±0.203)	0.03 (0.76)
4	4.500 (114.3)	±0.009 (±0.229)	0.03 (0.76)
5	5.563 (141.3)	±0.010 (±0.254)	0.06 (1.52)
6	6.625 (168.3)	±0.011 (±0.279)	0.07 (1.78)
8	8.625 (219)	±0.013 (±0.38)	0.08 (2.0)
10	10.750 (273)	±0.015 (±0.38)	0.1 (2.5)
12	12.750 (324)	±0.017 (±0.43)	0.1 (2.5)

TABLE 4 Tubing Diameters, Wall Thicknesses, and Tolerances, in. (mm)

Nominal Tubing Size (CTS)	Outside Diameter	Tolerance	Minimum[†] Wall Thickness	Wall Thickness Tolerance
½	0.625 (15.9)	±0.004 (±0.10)	0.090 (2.27)	+0.009 (+0.23)
½	0.625 (15.9)	±0.004 (±0.10)	0.104 (2.64)	+0.010 (+0.25)
¾	0.875 (22.2)	±0.004 (±0.10)	0.090 (2.27)	+0.009 (+0.23)
1	1.125 (28.6)	±0.005 (±0.13)	0.090 (2.27)	+0.012 (+0.31)
1	1.125 (28.6)	±0.005 (±0.13)	0.099 (2.51)	+0.011 (+0.28)
1	1.125 (28.6)	±0.005 (±0.13)	0.101 (2.56)	+0.012 (+0.31)
1	1.125 (28.6)	±0.005 (±0.13)	0.121 (3.07)	+0.015 (+0.38)
1¼	1.375 (34.9)	±0.005 (±0.13)	0.090 (2.27)	+0.011 (+0.28)
1¼	1.375 (34.9)	±0.005 (±0.13)	0.121 (3.07)	+0.015 (+0.38)

[†] Editorially corrected in April 2021.

Measurement of the undistorted outside diameter shall be made no closer than 1.5 pipe diameters or 11.8 in. (300 mm), whichever distance is less, from the cut end of the pipe. Undistorted outside diameter shall meet the requirements of Table 3 or Table 4.

5.3.1.3 *Wall Thickness*—The wall thickness shall be as specified in Table 4 or Table 5 when measured in accordance with 6.5.1.2. The minimum wall thickness at any point of measurement shall be not less than the minimum wall thickness specified in Table 4 or Table 5.

5.3.1.4 *Wall Thickness Eccentricity Range*— The wall thickness eccentricity range shall be within 12 % when measured in accordance with 6.5.1.3.

5.3.1.5 *Ovality*—The ovality (cross section) of 3 in. IPS (88.9 mm) and smaller pipe shall not exceed 5 % when measured in accordance with 6.5.3. Measurements of coiled pipe shall be made on a sample cut from the coil, and in case of disagreement, conditioned per 6.3.

NOTE 2—Other factors, that is, installation compaction, static soil loading, and dynamic vehicular loads may increase the ovality; therefore, 5 % was chosen as the limit for the amount contributed by manufacturing, packing, in-plant storage, and shipping.
(1) Before or during installation, coiled pipe larger than 3 in. IPS (88.9 mm) shall be processed by the installer through re-rounding equipment that corrects ovality to 5% or less.

NOTE 3—Ovality is a packaging condition that occurs when roundable pipe is wound into a coil—the pipe flattens out as it is coiled. Ovality is corrected when joining equipment is applied to roundable pipe, or by field processing roundable pipe through re-rounding and straightening equipment during installation.

5.3.1.6 *Length*—The pipe shall be supplied in straight lengths or coils as agreed upon between the manufacturer and the purchaser. The length shall not be less than the minimum length agreed upon when corrected to 73 °F (23 °C).

5.3.1.7 When sizes other than those listed in Table 3, Table 4or Table 5 are used, tolerances shall be: for outside diameter, use same tolerance of next smaller size; for wall thickness, use same tolerance percentage as shown in the tables.

5.4 *Slow Crack Growth Resistance*—PA 12 materials shall meet a slow crack growth resistance requirement of 500 hours when tested in accordance with 6.6.

5.5 *Resistance to Rapid Crack Propagation (RCP)*—Additional testing for resistance to RCP is required when the wall thickness of the pipe being produced in accordance with this standard exceeds that of the pipe used to establish the resistance to RCP. In these circumstances, additional testing for resistance to failure by RCP in accordance with 6.7 shall be conducted. The data obtained shall be made available upon request without limitations on disclosure, and shall not subsequently be subject to disclosure limitations when used by others.

NOTE 4—The requirements and testing for resistance to RCP do not provide information for all possible conditions of use. The user should consult with the manufacturer and other appropriate sources such as resin suppliers, research, academia, etc., to determine that the RCP resistance provided by the pipe producer is sufficient for the intended use.

5.6 *Minimum Hydrostatic Burst Pressure/Apparent Tensile Strength (Quick Burst)*—The pipe or system shall fail in a ductile manner when tested in accordance with Test Method D1599 at a hoop stress greater than 3900 psi (27 MPa). For pipe sizes above 4-in. nominal diameter, the testing laboratory shall be allowed to replace the quick burst test (Test Method D1599) by the apparent ring tensile strength test (Test Method D2290). The minimum apparent tensile strength at yield when determined in accordance with 6.10 shall be 3900 psi (27 MPa).

TABLE 5 Wall Thickness and Tolerances for PA12 Pipe, in. (mm)[A,B]

Nominal Pipe Size (IPS)	DR[C]	Minimum	Tolerance
½	9.33	0.090 (2.29)	+0.011 (+0.28)
¾	[D]	0.090 (2.29)	+0.011 (+0.28)
	11.0	0.095 (2.41)	+0.011 (+0.28)
1	[D]	0.090 (2.29)	+0.011 (+0.28)
1¼	11	0.120 (3.05)	+0.014 (+0.36)
	[D]	0.090 (2.29)	+0.011 (+0.28)
1½	11	0.151 (3.84)	+0.018 (+0.46)
	[D]	0.090 (2.29)	+0.011 (+0.28)
	11	0.173 (4.39)	+0.021 (+0.53)
2	11	0.216 (5.49)	+0.026 (+0.66)
	9.33	0.255 (6.48)	+0.031 (+0.79)
3	13.5	0.259 (6.58)	+0.031 (+0.79)
	11.5	0.304 (7.72)	+0.036 (+0.91)
	11	0.318 (8.08)	+0.038 (+0.96)
	9.33	0.375 (9.53)	+0.045 (+1.14)
4	17	0.265 (6.73)	+0.032 (+0.81)
	13.5	0.333 (8.46)	+0.040 (+1.02)
	11.5	0.391 (9.93)	+0.047 (+1.19)
	11.0	0.409 (10.39)	+0.049 (+1.25)
	9.33	0.482 (12.24)	+0.058 (+1.47)
6	17	0.390 (9.91)	+0.047 (+1.19)
	13.5	0.491 (12.47)	+0.059 (+1.50)
	11.5	0.576 (14.63)	+0.069 (+1.75)
	11.0	0.602 (15.29)	+0.072 (+1.83)
8	17	0.507 (12.90)	+0.061 (+1.549)
	13.5	0.639 (16.23)	+0.077 (+1.956)
	11.5	0.750 (19.05)	+0.090 (+2.286)
	11	0.784 (19.91)	+0.094 (+2.388)
10	17	0.632 (16.05)	+0.076 (+1.930)
	13.5	0.796 (20.22)	+0.096 (+2.438)
	11.5	0.935 (23.75)	+0.112 (+2.845)
	11.0	0.977 (24.82)	+0.177 (+2.972)
12	17	0.750 (19.05)	+0.090 (+2.286)
	13.5	0.944 (23.98)	+0.113 (+2.870)
	11.5	1.109 (28.17)	+0.133 (+3.378)
	11.0	1.159 (29.44)	+0.139 (+3.531)

[A]The sizes listed in Table 5 are those commercially available sizes used by the gas industry.
[B]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.
[C]The DR shown are designations commonly accepted by the gas industry and do not calculate exactly.
[D]The wall thicknesses are minimum and are not a function of the dimension ratios.

5.7 *Sustained Pressure at 73 °F (23 °C)*—The pipe or system shall not fail in less than 1000 h when tested in accordance with Test Method D1598. The hoop stress shall be 2800 psi (19 MPa).

5.8 *Outdoor Storage Stability*—Black PA 12 materials shall contain 2 to 3 percent well dispersed carbon black. Due to the absorptive properties of the carbon black, is considered to be stabilized against deterioration from unprotected exposure to UV for not less than 10 years. Yellow PA 12 material shall be stabilized and protected against deterioration from unprotected UV exposure for not less than 3 years.

NOTE 5—The determination for outdoor storage resistance is often based on measuring the ductility properties of the pipe material exposed to artificial weathering. These requirements and test methods are based on expected UV exposure levels in North America. Alternate requirements and alternate determination methods may be appropriate in other regions of the world. As an example, ISO 4437 standard requires a minimum resistance to an accumulation of 3.6GJ for non-black polyethylene materials.

5.9 *Chemical Resistance*—The weight, yield strength, and relative viscosity requirements for PA 12 pipe when measured in accordance with 6.11 are in Table 6.

5.10 *Elevated Temperature Service*—Polyamide 12 piping materials intended for use at temperatures above 100 °F (38 °C) shall have the PPI hydrostatic design basis (HDB) determined at the specific temperature in accordance with Test Method D2837. The 100 000-h intercept (long-term strength)

TABLE 6 Chemical Resistance

Chemical	Weight Change, Max%	Yield Strength Change, max%	Relative Viscosity, %
Mineral Oil	+0.5	–12	±3
Tertiary-butyl mercaptan (5 %)	+0.5	–12	±3
Methanol	+5	–35	±3
Ethylene glycol	+0.5	–12	±3
Toluene (15 %)	+7	–40	±3

shall be categorized in accordance with Table 7 and be listed as the "hydrostatic design basis of XXX psi at XXX °F (C°) for (compound name)."

NOTE 6—Many design factors for elevated temperature service cannot be covered in this specification. Users should consult applicable codes for limitations on pertinent maximum temperatures.

NOTE 7—In the absence of an HDB established at the specified temperature, the HDB of a higher temperature may be used in determining a design pressure rating at the specified temperature by arithmetic interpolation.

5.11 *Joints:*

5.11.1 *Butt Fusion:*

5.11.1.1 Butt fusion joints of polyamide 12 pipe and fittings shall be made in accordance with Practice F3372.

5.11.1.2 PA 12 butt fusion joining shall be between components (pipes, fittings, or valves) having the same SDR or DR. Butt fusion between unlike SDR or DR components shall be allowed only if it has been demonstrated that long term performance is not adversely affected. The minimum requirement to demonstrate long term performance shall be the requirements of 5.6 of this specification. The Hydrostatic Design Basis (HDB) of the PA 12 material shall be confirmed using specimens containing butt fusion joints resulting from different SDRs or DRs. Pipe/pipe joints of the material that pass shall validate pipe/pipe, pipe/fitting, or fitting/fitting joints of the same SDR ratio for the material.

5.12 *Fittings*—Fittings shall meet the requirements of the applicable ASTM standards.

5.12.1 *Butt Heat Fusion Fittings*—Butt heat fusion fittings intended for use with PA12 piping systems shall conform to the requirements of Specification F1733.

5.12.2 *Electrofusion Fittings*—Electrofusion fittings intended for use with PA12 piping systems shall conform to the requirements contained within Specifcation F2767.

5.12.3 *Mechanical Fittings*—Mechanical fittings intended for use with PA12 piping systems shall conform to the requirements contained within Specification F2145.

5.12.4 *Transition Fittings and Anodeless Risers*— Transition fittings and anodeless risers intended for use with PA12 pipings systems shall conform to the requirements contained within Specification F1973.

5.13 *Valves*—Gas valves shall meet the requirements of ANSI Standard B 16.40.

5.14 *Excess Flow Valves*—Excess flow valves shall meet the requirements of Specification F2138.

6. Test Methods

6.1 *General*—The test methods in this specification cover plastic pipe and fittings to be used for gas distribution. Test methods that are applicable from other specifications will be referenced in the paragraph pertaining to that particular test.

6.2 *Sampling*—Take a representative sample of the pipe and fittings sufficient to determine conformance with this specification. About 40 ft (12 m) of pipe is required to perform all the tests prescribed. The number of fittings required varies, depending upon the size and type of fitting. A sampling plan shall be agreed upon by the purchaser and the manufacturer (see Practice D1898).

6.2.1 *Pipe Test Specimens*—Not less than 50 % of the test specimens required for any pressure test shall have at least a part of the marking in their central sections. The central section is that portion of pipe which is at least one pipe diameter away from an end closure.

6.3 *Conditioning*—Unless otherwise specified, condition the specimens prior to test at 73.4 °F ± 3.6 °F (23 °C ± 2 °C) and 50 % ± 5 % relative humidity for not less than 40 h, in accordance with Procedure A of Practice D618 for those tests where conditioning is required and in all cases of disagreement.

6.4 *Test Conditions*—Conduct the test in the standard laboratory atmosphere of 73.4 °F ± 3.6 °F (23 °C ± 2 °C) and 50 % ± 5 % relative humidity, unless otherwise specified.

6.5 *Dimensions and Tolerances:*

6.5.1 *Pipe*—Any length of pipe is used to determine the dimensions. Coiled pipe shall be measured in the natural springback condition, unless specified otherwise.

6.5.1.1 *Diameter*—Measure the diameter of the pipe in accordance with Test Method D2122. The average outside diameter for nonroundable pipe is the arithmetic average of the maximum and minimum diameters at any cross section on the length of the pipe. For roundable pipe, out-of-roundness tolerance applies to measurements made while the pipe is rounded with the manufacturer's recommended equipment. Measure out-of-roundness within one-half pipe diameter or 2 in. (50 mm), whichever is closer, of the rounding equipment. See Test Method D2122 for definitions of nonroundable and roundable pipe.

(1) The pipe surface shall be free of gross imperfections such as, deep scratches, grooves, or high or low (flat) spots around the pipe circumference.

NOTE 8—Excessive out-of-roundness may be caused by manufacturing irregularities around the circumference of the pipe, such as deep scratches, gouges, flat spots, and high spots. Such defects could detrimentally affect joining. To simulate field joining of roundable pipe, out-of-roundness is checked by fitting a rounding device on the pipe, then measuring diameter.

TABLE 7 Pipe Category

Property	Test Method	Category							
		A	B	C	D	E	F	G	H
Temperature °F (°C)	. . .	100 (38)	120 (49)	140 (60)	160 (71)	180 (82)	...	...	...
Hydrostatic Design Basis, psi (MPa)	D2837	400 (2.8)	500 (3.4)	630 (4.3)	800 (5.5)	1000 (6.9)	1250 (8.6)	1600 (11.0)	2000 (13.8)

Examples: EH – At 140 °F (60 °C) the HDB is 2000 psi (13.8 MPa)

6.5.1.2 *Wall Thickness*—Make a minimum of six measurements at each cross section in accordance with Test Method D2122.

6.5.1.3 *Wall Thickness Eccentricity Range*—Measure in a manner such that the maximum, A, and the minimum, B, wall thickness at single points of each cross section measured are obtained. Calculate the wall thickness eccentricity range, E, in percent for each cross section as follows:

$$E = \left[(A - B)/A \right] \times 100 \quad (1)$$

6.5.1.4 *Length*—Measure pipe length and other linear dimensions with a steel tape or other device, accurate to ±1⁄32 in. (±1 mm) in 10 ft (3 m).

6.5.2 *Fittings*—Measure the dimensions of fittings in accordance with Test Method D2122.

6.5.3 *Ovality:*

6.5.3.1 *Apparatus*—A micrometer or vernier caliper accurate to within ±0.001 in. (±0.02 mm).

6.5.3.2 *Procedure*—Take a series of outside diameter (OD) measurements at closely spaced intervals around the circumference to ensure that the minimum and maximum diameters have been determined.

6.5.3.3 *Calculation*—Calculate the percent ovality as follows:

$$\%\ ovality = \frac{maximum\ OD - minimum\ OD}{OD\ minimum + OD\ maximum} \times 200 \quad (2)$$

6.6 *Slow Crack Growth Resistance*—Test in accordance with Test Method F1473 on compression molded plaques. Stress is 4.8 MPa. Temperature is 80°C. Notch depth in accordance with Table 1 in Test Method F1473.

6.7 *Resistance to Rapid Crack Propagation (RCP)*—Test in accordance with ISO 13478 with the following modification. Temperature of cooling for the crack-initiation groove (10.1 of ISO 13478:1997): 0 °C as prescribed in ISO 16486-1 Annex C.

6.8 *Sustained Pressure Test:*

6.8.1 Select six test specimens of pipe at random, condition at the standard laboratory test temperature and humidity, and pressure test in accordance with Test Method D1598.

6.8.1.1 Test specimens shall be prepared so that the minimum length of pipe is equal to 5 times the diameter of the pipe but in no case less than 12 in. (304 mm) for sizes less than 6 in. For sizes 6 in. and larger, the minimum length shall be equal to 3 times the diameter or 30 in. (762 mm), whichever is shorter.

6.8.1.2 Test pressures shall be calculated using the pipe's actual measured minimum wall thickness, outside diameter, and the applicable fiber stress. Piping intended for use at temperatures of 100 °F (38 °C) and higher shall be tested at both 73 °F (23 °C) and the maximum design temperature. The test fiber stress shall be the hydrostatic design basis (HDB) or 80 % of the 100 000-h intercept of the material, whichever is greater.

NOTE 9—Air, methane, or nitrogen may be substituted for water as the test medium.

6.8.2 Maintain the specimens at the pressures required, held to ±10 psi (0.07 MPa), for a period of 1000 h at the test temperature ±3.6 °F (±2 °C).

6.8.3 Failure of two of the six specimens tested shall constitute failure in the test. Failure of one of the six specimens tested is cause for retest of six additional specimens. Failure of one of the six specimens in retest shall constitute failure in the test. Evidence of failure of the pipe shall be as defined in Test Method D1598.

6.9 *Minimum Hydrostatic Burst Pressure (Quick Burst)*—The test equipment, procedures, and failure definitions shall be as specified in Test Method D1599. Pressures shall be at a stress greater than 3900 psi (27 MPa) or as calculated (using the pipe's actual measured minimum wall thickness, outside diameter, and the applicable fiber stress), whichever is greater.

6.10 *Apparent Tensile Properties*—The procedure and test equipment shall be as specified in Test Method D2290, Procedure B. The speed of testing shall be 0.5 in. (12.7 mm)/min. Cut "ring" specimens from pipe. They shall be ½ in. (12.7 mm) wide with a ¼ in. (6.3 mm) wide reduced section. Test a minimum of five specimens. This method is applicable to all pipe of nominal ¾ in. (19.0 mm) outside diameter and larger.

6.11 *Chemical Resistance*—Determine the resistance to the following chemicals in accordance with Test Method D543. Where available, the test specimen shall be a ring 2 in. SDR 11 pipe cut to the ring dimensions specified in 6.10. For materials that are not readily available as 2 in. SDR 11 pipe, the test specimen shall be a plaque of material ¼ by 2 by 4 in. (6.3 by 50.8 by 101.6 mm) with a 1 in. (25.4 mm) wide reduced section.

Chemicals	Concentration (% by volume)
Mineral oil (USP)	100
Tertiary-butyl mercaptan	5 in mineral oil
Antifreeze agents (at least one shall be used):	
Methanol, or	100
Ethylene glycol	100
Toluene	15 in methanol

Test five specimens with each chemical. Weigh the specimens to the nearest 0.005 g and completely immerse them in the chemicals for 72 h. On removal from the chemicals, wipe the specimens with a clean dry cloth. Condition in air for 2 to 2¼ h and reweigh. Calculate the increase in weight to the nearest 0.01 % on the basis of initial weight. Test the specimen in tension in accordance with 6.10 within ½ h after weighing. Examine the weight and apparent tensile strength of each specimen for conformance to the requirement in 5.6. **Warning—**Because of the possible toxicity of these reagents, refer to the Material Safety Data Sheet on each of these reagents before using or handling them.

7. Marking

7.1 *Pipe*—Required marking shall consist of the word GAS, the designation ASTM F2785, the manufacturer's name or trademark, the nominal pipe size including the sizing system used (IPS, CTS, or OD), DR or minimum wall thickness, material designation, date of manufacture, and shall be legible, visible, and permanent. To ensure permanence, marking shall be applied so it can only be removed by physically removing part of the pipe wall. The marking shall *(1)* not reduce the wall thickness to less than the minimum value for the pipe, *(2)* not