Designation: F2945 – 12

Standard Specification for Polyamide 11 Gas Pressure Pipe, Tubing, and Fittings[1]

This standard is issued under the fixed designation F2945; 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 11 pipe, tubing, and fittings for use in fuel gas piping. The pipe and fittings covered by this specification are intended for use in the transport of fuel gases.

1.1.1 This specification does not cover threaded pipe. Generic fusion guidelines are given in Appendix X1. Design considerations are discussed in Appendix X2. 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 The following is an index of the annexes and appendixes in this specification:

Annexes	Subject
Annex A1	In-Plant Quality Control for sizes up to 12 in.
Annex A2	PA-11 Butt Fusion Fittings
Appendixes	Subject
Appendix X1	Butt Fusion Guidelines for PA-11 Piping
Appendix X2	Design Consideration

1.5 *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]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D618 Practice for Conditioning Plastics for Testing

D638 Test Method for Tensile Properties of Plastics

D789 Test Methods for Determination of Solution Viscosities of Polyamide (PA)

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

D1898 Practice for Sampling of Plastics (Withdrawn 1998)[3]

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

D2774 Practice for Underground Installation of Thermoplastic Pressure Piping

D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

F412 Terminology Relating to Plastic Piping Systems

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

[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.

F2600 Specification for Electrofusion Type Polyamide-11 Fittings for Outside Diameter Controlled Polyamide-11 Pipe and Tubing

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 Specifications:*[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:*[7]

ISO 22621 Part 1 Plastics piping systems for the supply of gaseous fuels for maximum operating pressure up to and including 2 MPa (20 bar)–Polyamide (PA): General

2.6 *Plastic Pipe Institute:*[8]

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

PPI TR9 Recommended Design Factors for Pressure Applications of Thermoplastic Pipe Materials

PPI TR-45 Butt Fusion Joining Procedures for Field Joining of Polyamide-11

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 Classifications from Table 2 followed by 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 consist of two letters and five figures for polyamide 11 materials. For example, PA 32316 is a grade of polyamide 11 with a 3150 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 11 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 11 materials suitable for use in the manufacturing of pipe and fittings under this specification shall be classified in accordance with Classifications, as shown in Table 2.

4.3 *Short- and Long-Term Properties*—Polyamide 11 pipe and fittings shall be made from a Polyamide 11 material which also satisfies the combinations of short- and long-term property requirements shown in Table 3.

4.4 *Resistance to Rapid Crack Propagation (RCP) for Materials*—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

TABLE 1 Sustained Pressure

Test Temperature	Min Hr.	PA 32312 Hoop Stress	PA 32316 Hoop Stress
73 ± 3.6 F (23 ± 2 C)	1000 hr	2800 psi (19 MPa)	3200 psi (22 MPa)
176 ± 3.6F (80 ± 2 C)	100 hr	1850 psi (12.7 MPa)	1850 psi (12.7 MPa)

[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 Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.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.

TABLE 2 Classifications (dry as molded)

Classification	ASTM Test Method	ISO Test Method	Designation
PA			Polyamide
3 (group)			PA11
2 (class)			Heat stabilized
3 (grade)			
Viscosity Number, (mL/g)		ISO 307	150–300
Melt point, °C	D789	ISO 11357	180–195
Specific gravity	D792	ISO 1183	1.00–1.06
Tensile strength, min, (MPa)	D638	ISO 527-1 and ISO 527-2	40
Tensile modulus, min, (MPa)	D638	ISO 527-1 and ISO 527-2	1150
Tensile Elongation (ultimate), min, (%)	D638	ISO 527-1 and ISO 527-2	150
Charpy Impact Resistance, kJ/m^2, min		ISO 179/ 1eA	6.0
Deflection temperature, min at 1.82 Mpa, min °C	D648	ISO 75-1 and 75-2	40

TABLE 3 Short and Long Term Property Requirements

PA Material Designation Code	Short-Term in Accordance with Table 2	Long-Term in Accordance with D2837
PA32312	PA323	HDB of 2500 psi for 73°F (23°C)
PA32316	PA323	HDB of 3150 psi for 73°F (23°C)

others. The values obtained are applicable to all pipes with the wall thickness of the pipe tested and all thinner wall pipes.

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 4 or Table 5 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. 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 4 or Table 5.

5.3.1.3 *Wall Thickness*—The wall thickness shall be as specified in Table 5 or Table 6 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 5 or Table 6.

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.

TABLE 4 Outside Diameters and Tolerances for PA11 Pipe, in. (mm)

Nominal Pipe Size	Outside Diameter	Tolerance	Maximum out-of-roundness (SDR 13.5 SDR 11)
½	0.840 (21.3)	±0.004 (±0.102)	0.016 (0.406)
¾	1.050 (26.7)	±0.004 (±0.102)	0.02 (0.508)
1	1.315 (33.4)	±0.005 (±0.127)	0.02 (0.508)
1¼	1.660 (42.1)	±0.005 (±0.127)	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 (0.762)
4	4.500 (114.3)	±0.009 (±0.229)	0.03 (0.762)
5	5.563 (141.3)	±0.010 (±0.254)	0.06 (1.524)
6	6.625 (168.3)	±0.011 (±0.279)	0.07 (1.778)
8	8.625 (219.1)	±0.013 (±0.330)	0.08 (2.04)
10	10.750 (273.0)	±0.015 (±0.381)	0.1 (2.5)
12	12.750 (323.8)	±0.017 (±0.432)	0.1 (2.5)

TABLE 5 Tubing Diameters, Wall Thicknesses, and Tolerances, in. (mm)

Nominal Tubing Size (CTS)	Outside Diameter	Tolerance	Maximum 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)

TABLE 6 Wall Thickness and Tolerances for PA11 Pipe, in. (mm)[A,B]

Nominal Pipe Size (IPS)	DR[C]	Minimum	Tolerance
½	9.33	0.090 (2.29)	+0.011 (+0.279)
¾	D	0.090 (2.29)	+0.011 (+0.279)
	11.0	0.095 (2.41)	+0.011 (+0.279)
1	Sch 40	0.113 (2.87)	+0.014 (+0.356)
	D	0.090 (2.29)	+0.011 (+0.279)
	17	0.112 (2.85)	+0.013 (+0.330)
	13.5	0.141 (3.58)	+0.017 (+0.432)
	Sch 40	0.145 (3.68)	+0.017 (+0.432)
	11	0.173 (4.39)	+0.021 (+0.533)
2	11	0.216 (5.49)	+0.026 (+0.660)
	9.33	0.255 (6.48)	+0.031 (+0.787)
3	13.5	0.259 (6.58)	+0.031 (+0.787)
	11.5	0.304 (7.72)	+0.036 (+0.914)
	11	0.318 (8.08)	+0.038 (+0.965)
	9.33	0.375 (9.53)	+0.045 (+1.143)
4	17	0.265 (6.73)	+0.032 (+0.813)
	13.5	0.333 (8.46)	+0.040 (+1.016)
	11.5	0.391 (9.93)	+0.047 (+1.194)
	11.0	0.409 (10.39)	+0.049 (+1.246)
	9.33	0.482 (12.24)	+0.058 (+1.473)
6	17	0.390 (9.91)	+0.047 (+1.194)
	13.5	0.491 (12.47)	+0.059 (+1.499)
	11.5	0.576 (14.63)	+0.069 (+1.753)
	11.0	0.602 (15.29)	+0.072 (+1.829)
8	21	0.411 (10.44)	+0.049 (+1.245)
	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	21	0.512 (13.00)	+0.061 (+1.549)
	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	0.977 (24.82)	+0.117 (+2.972)
12	21	0.607 (15.42)	+0.073 (+1.854)
	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	1.159 (29.44)	+0.139 (+3.531)

[A] The sizes listed in Table 6 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.

NOTE 1—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 2—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 4, Table 5 or Table 6 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 *Conditioning*—For those tests where conditioning is required, or unless otherwise specified, condition the specimens prior to testing for a minimum of 1 h in water or 4 h in air at 73.4 ± 3.6°F (23 ± 2°C) or in accordance with 6.3. The conditioning requirements of 6.3 shall be used in all cases of disagreement.

5.5 *Slow Crack Growth Resistance*—PA 11 materials shall meet a slow crack growth resistance requirement of 500 hours when tested in accordance with 6.6.

5.6 *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 3—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.

5.7 *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).

5.8 *Sustained Pressure*—Using one of the two test conditions in Table 1, the pipe or system shall not fail in less than the prescribed hours when tested in accordance with Test Method D1598.

5.9 *Outdoor Storage Stability*—Black polyamide 11 materials shall contain 2 to 3 percent well dispersed carbon black, and 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 polyamide 11 material shall be stabilized and protected against deterioration from unprotected UV exposure for not less than 3 years.

NOTE 4—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.

5.10 *Chemical Resistance*—The weight, yield strength, and relative viscosity requirements for PA11 pipe when measured in accordance with 6.11 are in Table 7.

5.11 *Elevated Temperature Service*—Polyamide 11 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) shall be categorized in accordance with Table 8 and be listed as the "hydrostatic design basis of XXX psi at XXX °F (C°) for (compound name)."

5.12 *Squeeze Off*—This requirement is limited to pipe sizes, wall thicknesses, squeeze procedures, and conditions deemed suitable for squeeze-off in service by the pipe manufacturer. There shall be no leakage or visual evidence of splitting, cracking, breaking, or reduction in Sustained Pressure requirements when pipe is tested as follows:

5.12.1 Prepare six randomly selected pipe specimens in accordance with Test Method D1598, except they shall be unfilled.

5.12.2 The squeeze-off shall be affected at the midpoint of the test specimen, 90° to the point of the measured minimum wall thickness. Close the squeeze bars to the gap stop in Specification F1563 and hold in constraint for 4 h. Remove squeeze bars and reround pipe by closing squeeze bars at a point 90° for the squeeze area.

5.12.3 Immediately upon removal of the squeeze-off tool, fill the specimens with ambient temperature water that is 67 ± 10°F (19.4 ± 5.0°C), condition, and test in accordance with 5.8.

NOTE 5—Many design factors for elevated temperature service cannot be covered in this specification. Users should consult applicable codes for limitations on pertinent maximum temperatures.

5.13 *Joints:*

5.13.1 *Butt Fusion:*

5.13.1.1 Butt fusion joints of polyamide 11 pipe and fittings should be made in accordance with the manufacturer's recommendations and the user's written procedure.

5.13.1.2 PA 11 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 5.7 of this specification. The Hydrostatic Design Basis (HDB) of the PA11 material shall be confirmed using specimens containing butt fusion joints resulting from different SDRs or DRs. Pipe/pipe joints of the material that

TABLE 7 Chemical Resistances

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
Toulene (15%)	+7	–40	±3

TABLE 8 Pipe Categories

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: CH – At 140°F the HDB is 2000 psi (13.8 MPa)									

pass shall validate pipe/pipe, pipe/fitting, or fitting/fitting joints of the same SDR ratio for the material.

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

5.14.1 *Butt Heat Fusion Fittings*—Butt heat fusion fittings intended for use with PA11 piping systems shall conform to the requirements of Annex A2 of this standard.

5.14.2 *Electrofusion Fittings*—Electrofusion fittings intended for use with PA11 piping systems shall conform to the requirements contained within Specification F2600.

5.14.3 *Mechanical Fittings*—Mechanical fittings intended for use with PA11 piping systems shall conform to the requirements contained within Specification F2145.

5.14.4 *Transition Fittings and Anodeless Risers*—Transition fittings and anodeless risers intended for use with PA11 piping systems shall conform to the requirements contained within Specification F1973.

5.15 *Valves*—PA-11 thermoplastic gas valves shall meet the requirements of ANSI Standard B 16.40.

5.16 *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 the transport of fuel gas . 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 ± 3.6°F (23 ± 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 ± 3.6°F (23 ± 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 6—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.

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:

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

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:

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