Designation: F2785 – 12

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 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 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—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.

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 Methods for Determination of Solution Viscosities of Polyamide (PA)
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
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

[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**

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)

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:*[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 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:*[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 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

[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.

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.

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.

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)

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. 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.

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, MPa	D638	ISO 527–1 and ISO 527–2	35
Tensile Modulus, min, MPa		ISO 527–1 and ISO 527–2	1000
Charpy impact resistance, min		ISO 179	25
Deflection temperature, at 1.82 Mpa, min °C	D648	ISO 75–1 and ISO 75–2	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(0.406)
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)
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(0.762)
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)

TABLE 4 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 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 (+0.279)
¾	[D]	0.090 (2.29)	+0.011 (+0.279)
	11.0	0.095 (2.41)	+0.011 (+0.279)
1	[D]	0.090 (2.29)	+0.011 (+0.279)
1¼	11	0.120 (3.05)	+0.014 (+0.356)
	[D]	0.090 (2.29)	+0.011 (+0.279)
1½	11	0.151 (3.84)	+0.018 (+0.457)
	[D]	0.090 (2.29)	+0.011 (+0.279)
	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)

[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.

5.3.1.4 *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 *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 12 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 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.

5.7 *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 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).

5.9 *Outdoor Storage Stability*—PA 12 pipe stored outdoors and unprotected for at least two years from date of manufacture shall meet all the requirements of this specification. PA 12 pipe stored outdoors for over two years from date of manufacture is suitable for use if it meets the requirements of this specification.

5.10 *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.

5.11 *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) 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 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.

NOTE 6—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.

5.12 *Joints:*

5.12.1 *Butt Fusion:*

5.12.1.1 Butt fusion joints of polyamide 12 pipe and fittings should be made in accordance with the manufacturer's recommendations and the user's written procedure.

5.12.1.2 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 5.7 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.

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

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

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

TABLE 6 Chemical Resisitance

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 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 the HDB is 2000 psi (13.8 MPa)									

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

5.13.4 *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.

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

5.15 *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 ± 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 7—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:

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

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 22621-1 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 8—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 5.7. **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*—All required marking 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 have any effect on the long-term strength of the pipe, and *(3)* not provide leakage channels when elastomeric gasket compression fittings are used to make the joints. These marking shall consist of the word GAS, the designation ASTM F2785, the manufacturer's name or trademark, the normal pipe size including the sizing system used (IPS, CTS, or OD), DR or minimum wall thickness, material designation, and date of manufacture.

7.1.1 In addition to 7.1, the pipe marking shall include a coding that will enable the manufacturer to determine the location of manufacture, pipe production and resin lots, and any additional information which is agreed upon between the manufacturer and purchaser. The manufacturer shall maintain such records for fifty years or for the design service life of the pipe, whichever is longer.

7.1.2 All the markings in 7.1 and 7.1.1 shall be repeated at intervals not exceeding 5 ft (1.5 m). For indented printing, either the indented print line shall be in a color that contrasts with that of the pipe, or a separate print line shall be in a color that contrasts with the pipe. When color is applied to identify gas service, such as with color stripes, a color shell or solid color pipe, yellow color shall be used.

NOTE 9—Using color to identify piping service is not mandatory, but if used, yellow color is required.

7.2 Pipe intended for natural gas service at elevated temperatures greater than 73°F (23°C) shall be marked with additional code letters from Table 7 (the first code letter to identify the temperature of pressure rating, the second code letter to identify HDB at highest rated temperature).

NOTE 10—The non-mandatory, preferred order for all the items required in the print line in the marking sections 7.1 and 7.2 are:
(1) Pipe size including sizing system (IPS, CTS or OD),
(2) SDR (DR) or minimum wall thickness,
(3) Manufacturer's name or trademark,
(4) GAS,
(5) Pipe material designation code, (that is, PA 42316)
(6) Elevated temperature code from Table 7 as per 7.2 where applicable,
(7) ASTM F2785,
(8) Manufacturer's lot code (includes date of manufacture in some cases), and
(9) Additional information, including date of manufacture, coil number, sequential footage, third party certification mark etc.

7.2.1 Where applicable, PA 42316 pipe shall be marked with the elevated temperature code letters EG CH in accordance with Table 7 in addition to the marking requirements of 7.1.
E = maximum temperature of 180°F (82°C),
G = 1600 psi HDB at 180°F (82°C),
C = temperature of 140°F (60°C), and
H = 2000 psi HDB at 140°F (60°C)

7.3 *Fittings*—Fittings shall be marked F2785, as well as with the applicable fitting specification. All fittings shall be marked on the body or hub. The markings shall consist at least the manufacturer's name or trademark, or both, the size, the symbol for the type of material, and the letter code from Table 7 (as described in 7.2). In addition, the fittings markings shall include code that will enable the manufacturer to determine the date of manufacture, the location of manufacture, fitting production and resin lots, and any additional information which may be agreed upon between the manufacturer and purchaser. The manufacturer shall maintain such records for 50 years or for the design service life of the fittings, whichever is longer.

7.4 All PA12 pipe, tubing and fusion fittings meeting the requirements of this specification for gas distribution system shall be marked with the 16–character gas distribution component tracking and traceability indentifier in accordance with Specification F2897. The 16-character code shall be expressed in alpha-numeric format and Code 128 bar code format with a minimum bar thickness value of 0.005 in. or an alternative 1D or 2D bar code symbology as agreed upon between manufacturer and end user. All fittings shall have the 16-character codes marked or affixed to the product, product packaging, or any manner agreed upon between manufacturer and end user.

8. Quality Assurance

8.1 When the product is marked with this designation, F2785, 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.

SUPPLEMENTARY REQUIREMENTS

These requirements apply only to federal/military procurement, not domestic sales or transfers.

S1.*Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for performance of all inspection and test requirements specified herein. The producer shall use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless the purchaser disapproves. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

NOTE 11—In U.S. federal contracts, the contractor is responsible for inspection.

S2.*Packaging and Marking for U.S. Government Procurement: (1) Packaging* —Unless otherwise specified in the contract, the materials shall be packaged in accordance with the supplier's standard practices in a manner ensuring arrival at destination in satisfactory condition and which will be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification rules or National Motor Freight Classification rules.*(2) Marking*—Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD 129 for military agencies.

NOTE 12—The inclusion of U.S. Government procurement requirements should not be construed as an indication that the U.S. Government uses or endorses the products described in this specification.

ANNEX

(Mandatory Information)

A1. IN-PLANT QUALITY CONTROL PROGRAM FOR PLASTIC PIPE AND FITTINGS UP TO AND INCLUDING 12 IN. NOMINAL DIAMETER

A1.1 *Quality Control*:

A1.1.1 The following in-plant quality control program shall be used to assure compliance with this specification. The pipe and fittings producers shall maintain records on all aspects of this program and supply these to the purchaser, if requested.

A1.1.2 *In-Plant Quality Control Test Methods*—Test methods other than those specified in Section 6 are used as long as they provide equivalent results. In case of disagreement, those test methods in the applicable ASTM standard shall be used.

A1.2 *Pipe Tests*:

A1.2.1 *Material and Extrusion Process Qualification*—Sustained pressure tests shall be made on one pipe size in the range of 2 in., or less, and on one pipe size in the range of 2½ in., or greater. This test shall also be made on pipe from each particular commercial plastic resin initially and at least twice a year thereafter for material and extrusion process qualification and not as a quality control on the product. This test shall be made in accordance with 6.8.

A1.2.2 *Product Quality Control*—The tests in Table A1.1 shall be made per size per extrusion die at the denoted frequencies and the test results recorded and filed for inspection on request.

NOTE A1.1—When the pipe fails to meet this specification in any test, additional tests shall be made on the pipe produced back to the previous acceptable result to select the pipe produced in the interim that does pass the requirement. Pipe that does not meet the requirement shall be rejected.

NOTE A1.2—For pipe sizes above 4-in. nominal diameter, the quick burst test (Test Method D1599) may be replaced by the Apparent Ring Tensile Strength Test (Test Method D2290) if agreed to between the purchaser and the manufacturer.

A1.2.3 *Burst Pressure Multilevel Plan (see Fig. A1.1)*—This multilevel plan is based on MIL-STD-1235 (ORD), and is used only when the same product is extruded continuously under the same operating conditions and production is at a steady rate. Before this reduced sampling plan is considered, steady production conditions must be carefully chosen to ensure a continuous and consistent high quality output. Any interruption (shutdown) or change in resin lot number, percentage rework, or production conditions outside normal operating variations shall cause sampling to revert to Level 1. A sampling level change is considered only when approved by a production supervisor or authorized quality control personnel. Level 1 Test one specimen every 8 h. If 16 consecutive specimens have met requirements, proceed to Level 2. Level 2 Collect one specimen every 8 h. After 72 h (3 days) or portion thereof, test two randomly selected specimens. If both pass, discard the remaining 7 specimens. If any specimen fails to meet requirements, revert to Level 1 (see also Note A1.1). Product for which a specimen has been collected shall not be shipped until after the 72-h time period and randomly selected samples have been tested. Continue to test 2 out of 9 specimens for 16 three-day periods (48 days of production), then proceed to Level 3. Level 3 Collect one specimen every 8 h. After 21 days or portion thereof, test three randomly selected specimens. If all three pass, discard the remaining specimens. If any specimen fails to meet requirements, revert to Level 1 (see also Note A1.3). Product for which a specimen has been collected shall not be shipped until after the 21-day time period. Continue testing at Level 3 until production conditions necessitate reverting to Level 1.

TABLE A1.1 Product Quality Control Tests

Property	Frequency
Diameter	once every hour or every coil, whichever is less frequent
Wall thickness	once every hour or every coil, whichever is less frequent
Ring tensile or burst pressure	Once every 8 h or once every coil, whichever is less frequent, or multilevel plan described in A3.2.3

A1.3 Fittings Tests [9]

A1.3.1 The fittings tests listed in the following subparagraphs shall be conducted at the frequencies indicated.

NOTE A1.3—When any fitting fails to meet the requirements of this specification, or the applicable referenced fitting specification, additional tests should be made on fittings produced back to previous acceptable result to select the fittings produced in the interim that do meet the requirements. Fitting that do not meet the requirements shall be rejected.

A1.3.2 *Dimensions:*

A1.3.2.1 *Butt Fusion Fittings:*

(1) Outside Diameter and Wall Thickness —Once an hour or one out of ten fittings, whichever is less frequent.

A1.3.3 *Other Tests:*

A1.3.3.1 At the start of each production run, whenever production conditions have changed or when the resin lot is changed, but not less frequently than once per 500 fittings thereafter, the following tests shall be made:

*(1)*The knit line strength for at least one fitting from each cavity shall be demonstrated by one of the following tests:

(1a) Crushing a fitting, or a portion of a fitting, in a manner that applies load in the direction normal to the knit line. See Note A1.4.

(1b) Apparent tensile strength tests of a ring cut from a fitting, with the load oriented normal to the knit line. See Note Note A1.5.

(1c) Burst testing of the fitting. See Note A1.5.

(2) The integrity of at least one part from each mold cavity shall be verified, using a method selected by the manufacturer as appropriate for this specific product and process.

NOTE A1.4—Separation in the knit constitutes a failure.

NOTE A1.5—In tests 2 and 3 the strength requirements shown in the annexes must be met.

[9] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F17-1018.

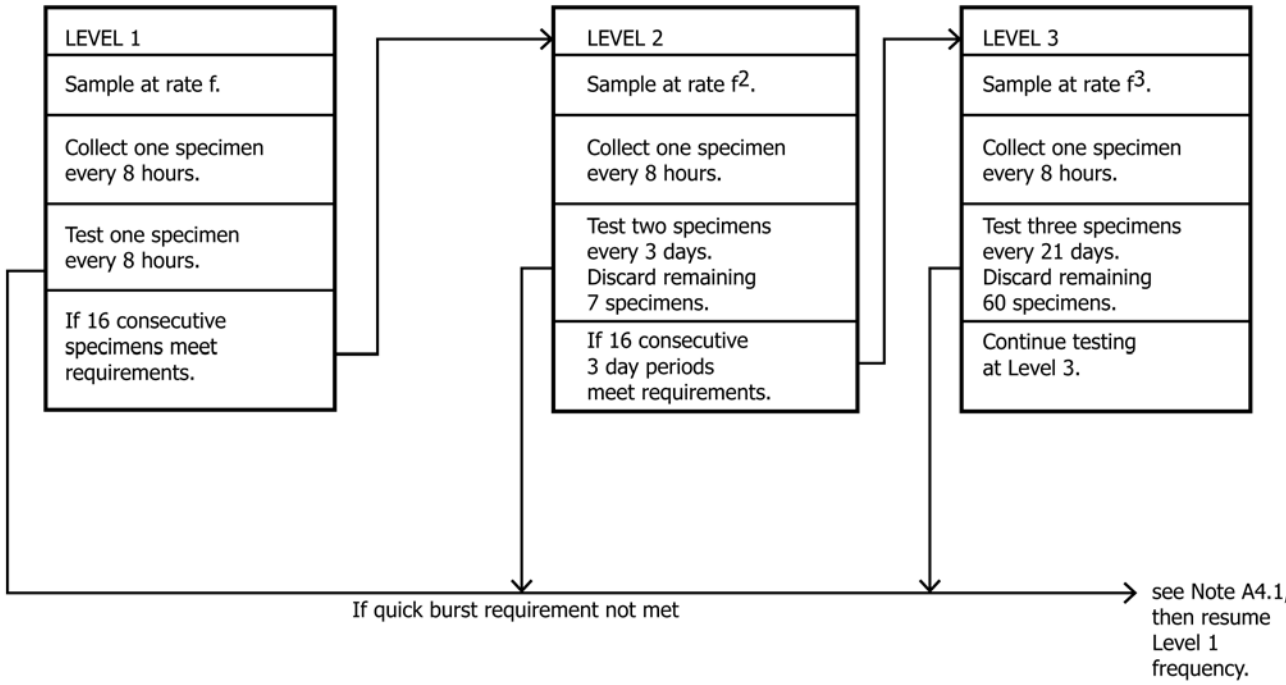

FIG. A1.1 Quick Burst Multilevel Sampling Plan

APPENDIXES

(Nonmandatory Information)

X1. GENERIC FUSION GUIDELINES FOR POLYAMIDE 12

X1.1 General

X1.1.1 The following butt fusion procedures are intended to be used for jointing polyamide pipes. Critical parameters in the butt fusion process are heater iron surface temperature, heat soak time, interfacial pressure during the initial contact of the molten pipe ends and during cooling and cooling time. The heat soak time and cooling time parameters vary as a function of pipe size and wall thickness. As a general guideline, the heat soak time for should be sufficiently long to produce a melt bead of approximately 1⁄16 – 1⁄8 in. The pipe should be held under pressure until cooled to the touch.

X1.2 Butt Fusion Procedure Parameters

X1.2.1 The following parameters should be used:
Interface pressure range: 60-90 psi
Heater surface temperature range: 460 – 500 ± 10°F.

X1.3 Butt Fusion Procedures

X1.3.1 Principle The principle of the heat fusion is to heat two surfaces to a designated temperature, then fuse them together by application of a sufficient force. This force causes the melted materials to flow and mix, thereby resulting in fusion. When fused according to the proper procedures, the joint area becomes as strong as or stronger than the pipe itself in both tensile and pressure properties. Field-site butt fusions may be carried out readily by trained operators using butt fusion machines that secure and precisely align the pipe ends for the fusion process. The seven steps involved in performing a butt fusion joint are the following:

(1) clean the pipe ends;
(2) securely fasten the components to be joined;
(3) face the pipe ends;
(4) align the pipe profile;
(5) melt the pipe interfaces without pressure;
(6) join the two profiles together;
(7) hold under pressure until cooling.

X1.3.2 *Clean the pipe ends*— Clean the inside and outside of the pipe to be joined by wiping with a clean lintfree cloth. Remove all foreign matter.

X1.3.3 Secure fasten the components Clamp the components in the machine. Check alignment of the ends and adjust as needed.

X1.3.4 *Face the pipe ends*— The pipe ends must be faced to establish clean, parallel mating surfaces. Most, if not all, equipment manufacturers have incorporated the rotating planer block design in their facers to accomplish this goal. Facing is continued until a minimal distance exists between the fixed and movable jaws of the machine and the facer is locked firmly and squarely between the jaw bushings. This operation provides for a perfectly square face, perpendicular to the pipe centreline on each pipe end and with no detectable gap.

X1.3.5 *Align the pipe profile*— Remove any pipe chips from the facing operation and any foreign matter with a clean, untreated, lint-free cotton cloth. The pipe profiles must be rounded and aligned with each other to minimize mismatch (high-low) of the pipe walls. This can be accomplished by adjusting clamping jaws until the outside diameters of the pipe ends match. The jaws must not be loosened or the pipe may slip during fusion.

X1.3.6 *Melt the pipe interfaces without pressure*— Heating tools that simultaneously heat both pipe ends are used to accomplish this operation. These heating tools are normally furnished with thermometers to measure internal heater temperature so the operator can monitor the temperature before each joint is made. However, the thermometer can be used only as a general indicator because there is some heat loss from internal to external surfaces, depending on factors such as ambient temperatures and wind conditions. A pyrometer or other surface temperature-measuring device should be used periodically to insure proper temperature of the heating tool face. Additionally, heating tools are usually equipped with suspension and alignment guides that centre them on the pipe ends. The heater faces that come into contact with the pipe should be clean, oil-free and coated with a nonstick coating as recommended by the manufacturer to prevent molten plastic from sticking to the heater surfaces. Remaining molten plastic can interfere with fusion quality and must be removed according to the tool manufacturer's instructions. Plug in the heater and bring the surface temperatures up to the temperature range. Install the heater in the butt fusion machine and bring the pipe ends into full contact with the heater. To ensure that full and proper contact is made between the pipe ends and the heater, the initial contact should be under moderate pressure. After holding the pressure very briefly, it should be released without breaking contact. Continue to hold the components in place, without force, while a bead of molten polyamide 12 develops between the heater and the pipe ends. When the proper bead size is formed against the heater surfaces, the heater should be removed. The bead size is dependent on the pipe size. For dn ≤ 1¼ in, a bead size of approximately 1⁄32-1⁄16 in should be present, for dn 1 ¼ - 3 in, a bead size of 1⁄16 in should be present and for dn 3- 8 in., a bead size 1⁄8-3⁄16 in should be formed before removing the heater.

X1.3.7 *Joining the two profiles together*— After the pipe ends have been heated for the proper time, the heater tool is removed and the molten pipe ends are brought together with sufficient force to form a bead against the pipe wall. The fusion force is determined by multiplying the interfacial pressure by the pipe area. For manually operated fusion machines, a torque wrench may be used to accurately apply the proper force. For manual machines without force reading capability of a torque wrench, the correct fusion joining force is the force required to form a homogeneous bead during joining. For hydraulically operated fusion machines, the fusion force can be divided by the total effective piston area of the carriage cylinders to give a hydraulic gauge reading. The gauge reading is theoretical; the internal and external drags need to be added to this figure to obtain the actual fusion pressure required by the machine.

X1.3.8 *Hold under pressure until cooling*— The molten joint must be held immobile under pressure until cooled adequately to develop strength. Allowing proper times under pressure for cooling prior to removal from the clamps of the machine is important in achieving joint integrity. The fusion force should be held between the pipe ends until the surface of the bead is cool to the touch. The pulling, installation or rough handling of the pipe should be avoided until the joint cools to ambient temperature (roughly an additional 30 min).

X1.3.9 *Visual Inspection*— Visually mitered (angled, off-sets) joints should be cut out and re-fused (straight or coiled pipe). Coiled pipe may leave a bend in some pipe size that must be addressed in the preparation of the butt heat fusion process. There are several ways to address this situation.

(1) Straighten and re-round coiled pipe before the butt fusion process

(2) If there is still curvature present, install the pipe ends in the machine in an "*S*" configuration with the print lines approximately 180° apart in order to help gain proper alignment and help produce a straight joint.

(3) If there is still a curvature present, another option would be to install a straight pipe of pipe between the two coiled pipes. Every effort should be made to make the joint perpendicular to the axis of the pipe.

X2. DESIGN CONSIDERATIONS

X2.1 General

X2.1.1 The design of a plastic piping system for natural gas service must include consideration of the combined effects of time, internal and external stress, and environment as an overall basis for selecting a specific kind and size of plastic pipe. The design stress for plastic pipe used for distribution of natural gas and petroleum fuels is regulated by the U.S. Department of Transportation as published in OPS Part 192 Title 49 of the Code of Federal Regulations. The American Gas Association Plastic Materials Committee, the Fuel Gas Division of PPI, and members of ASTM Committee F17 are cooperating with the ASME Gas Piping Technology Committee to provide assistance in selecting safe design stress levels for the various kinds of plastic pipe.

X2.2 Design Equations

X2.2.1 *Relationship Between Pipe Stress and Pressure*— The following expression is used to relate stress, pressure, pipe size, and wall thickness:

$$P = 2S/(DR - 1) \; or \; 2S/[(D_o/t) - 1] \quad (X2.1)$$

where:

S = stress in the circumferential or hoop direction, psi (MPa),
P = internal pressure, psig (MPa),
DR = dimension ratio,
D_o = average outside diameter, in. (mm), and
t = minimum wall thickness, in. (mm)

X2.2.2 The following expression can be used to determine the burst pressure or sustained pressures needed in testing:

$$P_b = 2S_y/(DR - 1) \quad (X2.2)$$

where:

P_b = burst pressure, psig (MPa),
S_y = yield stress, psi (MPa), and
DR = dimension ratio,

$$P_s = 2S_f/(DR - 1) \quad (X2.3)$$

where:

P_s = sustained pressure, psig (MPa),
S_f = fiber stress psi (MPa), and
DR = dimension ratio,

X2.2.3 *Relation between Hydrostatic Design Basis (HDB) and Hydrostatic Design Stress (HDS)*—The HDS is determined by multiplying the *HDB* by a design factor, *f*. The design factor, *f*, has a value less than 1.0.

$$HDS = (HDB)\,(f) \quad (X2.4)$$

NOTE X2.1—The actual choice of design factor for a given installation must be reviewed by the design engineer taking into account federal, state, and local code requirements. For example, the design factor for gas pipelines under the jurisdiction of the Department of Transportation is 0.32.

X2.3 Design Stress and Internal Pressure for Natural Gas

X2.3.1 The design stresses for natural gas pipe are based on the hydrostatic design basis at 73°F (23°C) obtained in accordance with Test Method D2837. The hydrostatic design basis of the polyamide 12 is 3150 psi at 73°F.

X2.3.2 The design stresses for natural gas at service temperatures above 73°F (23°C) should be based on hydrostatic design basis of the pipe that are applicable for the particular use temperature.

X2.3.3 The design stresses for natural gas are obtained by multiplying the hydrostatic design basis by design factors or service factors according to the class of location as described in Chapter IV of the American National Standard Code for Pressure Piping ANSI B31.8, or, for gas operators in the United States, Subpart C of the Minimum Federal Safety Standards for Transportation of Natural and Other Gas by Pipeline, Title 49, Code of Federal Regulations.

X2.4 Thermal Stress

X2.4.1 Calculate the longitudinal stress (theoretical) induced in a pipe member between fixed points as follows:

$$S = E \times C \times \Delta t \quad (X2.5)$$

where:

S = stress, psi (MPa),
E = modulus of elasticity, psi (MPa), instantaneous, at 73°F (23°C),
C = coefficient of expansion, in./in./°F, (mm/mm/°C), and
Δt = maximum temperature minus minimum temperature, °F (°C).

X2.4.1.1 The measured stress has been determined to be less than that calculated. This difference is caused by the stress relaxation in viscoelastic materials.

X2.4.2 Calculate the theoretical force sustained at the fixed points (typically joints) in a pipe member as follows:

$$F = S \times A \quad (X2.6)$$

where:

F = force, lbf (N),
S = stress, psi (MPa), and
A = cross-sectional pipe wall area, in.^{2} (mm^2).

X2.4.3 Calculate pipe contraction in unrestrained pipe caused by a reduction in temperature as follows:

$$\Delta L = k \times L \times C \times \Delta t \quad (X2.7)$$

where:

ΔL = change in length,
k = 1000 for ΔL (mm), L (m), C (°C^{-1}), Δt (°C), or
k = 12 for ΔL (in.), L (ft), C (°F^{-1}), Δt (°F),
L = original length,
C = coefficient of linear expansion, and
Δt = temperature change.

X2.5 Installation Procedure

X2.5.1 It is recognized that certain minimum requirements exist for the support of earth loads from backfill and other external forces. Proper installation techniques can be used with flexible conduit to support relatively large earth loads without excessive deflection by mobilizing lateral passive soil forces. Proper installation technique ensures that the necessary passive soil pressure at the side of the pipe will be developed and maintained. It is also recognized that internal pressures may be valuable in minimizing the deflection caused by earth loads. Installation procedures described in Recommended Practice D2774, ANSI B31.8, and the AGA Plastic Pipe Manual for Gas Service[10]are recommended.

X2.5.2 Unrestrained plastic pipe expands and contracts from thermal change significantly more than metallic pipe. This ratio may be of the magnitude of ten to one. The typical coefficient of thermal expansion for unrestrained polyamide 12 pipe is 11.0 x 10-5 (in/in)/°F. Mains and service lines installed by insertion are considered to approximate unrestrained conditions inside the casing pipe except at end connections. Direct-burial pipe is considered to be partially restrained by passive soil pressures except in the vicinity of joints.

X2.5.3 Internal pressure, earth settlement, ground movement, and thermal contraction impose stresses on the pipe that can be transmitted to joints. These stresses are additive. Installation practices should reflect the need for continuous

[10] Available from American Gas Association 400 N. Capitol St. (4th Floor) Washington, DC 20001

support and containment of the pipe through suitable bedding and backfilling procedures. Attention should be given to all joints, particularly to transition joints between polyamide 12 and metal pipe.

X2.5.4 It is desirable to have pipe joints that are as strong as the pipe itself in the longitudinal (axial) direction. The joint strength is a function of the assembly procedure, the design of the fitting, and the pipe material and dimensions.

X2.5.5 For those mechanical devices that are not designed to restrain the pipe against pullout forces, provisions must be made in the field to prevent pullout, keeping in mind that mechanical joints are vulnerable to the effects of internal pressure, temperature changes, earth settlement, and ground movement. A somewhat limited alternative is to use long sleeve-type fittings that permit limited movement without loss of pressure seal. Otherwise, provisions must be made in the field to prevent pullout through suitable anchoring at the joint.

X2.5.6 Kinks found in the pipe shall be cut out. Pipe with kinks shall not be placed in service.

X2.6 Repair Considerations

X2.6.1 Repairs may be made to plastic pipe under appropriate circumstances. Selection and installation considerations for the use of ful encirclement band clamps are available in Guide F1025. Additional information on repair of plastic pipe may be found in manufacturers' literature, the AGA Plastic Pipe Manual for Gas Service[10], ANSI B31.8 Gas Transmission and Distribution Piping Systems, and in the ASME Guide for Gas Transmission and Distribution Piping Systems[11]

[11] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F2785–10a) that may impact the use of this standard.

(1) References to D4066 were deleted from Section 2, 3.4.3, 4.2, Table 1, and Table 2.
(2) Table 1 was revised to reference the appropriate properties and requirements of D6779.
(3) References to Test Methods D256, D790, and Test Method D3418 were deleted from Section 2.
(4) References to F2785 were added to 7.1, 7.3, 8.1, and Note 10.
(5) References to Specification F2897 were added to Section 2.
(6) Section 7.4 on tracking and traceability was added.