’99 Edition	‘09a Edition	Comments
Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings[1] This standard is issued under the fixed designation D 2513; 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 re-approval. A superscript epsilon (ε) indicates an editorial change since the last revision or re-approval. ***This standard has been approved for use by agencies of the Department of Defense.***	**Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings**[1] This standard is issued under the fixed designation D2513; 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 re-approval. A superscript epsilon (ε) indicates an editorial change since the last revision or re-approval. *This standard has been approved for use by agencies of the Department of Defense.*	
1. Scope 1.1 This specification covers requirements and test methods for material (see Appendix X1) dimensions and tolerances, hydrostatic burst strength, chemical resistance, and impact resistance of plastic pipe, tubing, and fittings for use in fuel gas mains and services for direct burial and reliner applications. The annexes provide specific requirements and test methods for each of the materials currently approved. If and when additional materials are available, specific annex requirements will be added. The pipe and fittings covered by this specification are intended for use in the distribution of natural gas. Requirements for the qualifying of polyethylene systems for use with liquefied petroleum gas are covered in Annex A1. 1.1.1 This specification does not cover threaded pipe. Design considerations are discussed in Appendix X2. In-plant quality control programs are specified in Annex A3 and Annex A4. 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. Scope** 1.1 This specification covers requirements and test methods for material dimensions and tolerances, hydrostatic burst strength, chemical resistance, and rapid crack resistance of polyethylene 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. Requirements for the qualifying of polyethylene systems for use with liquefied petroleum gas are also covered. 1.1.1 This specification does not cover threaded pipe. Design considerations are discussed in Appendix X1. In-plant quality control programs are specified in Annex A1 and Annex A2. 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	Added “rapid crack resistance”, deleted “impact resistance” – *crack resistance is the critical parameter and impact resistance of PE is given.* Changed “plastic pipe” to “polyethylene pipe” – *this is the major change so that D2513 is for PE only and other materials are covered by other standards.* Reference to Annex requirements for additional materials deleted-*not required as this is now a one material standard.* Reference to Annex A1 deleted - *the requirements are now in the body of the standard.* Appendix X2 renumbered to Appendix X1 and Annex A3 & A4 changed to Annex A1 & A2 –*appendices and annex’s consolidated as a result of the elimination of all materials except PE.*

---

[1] This specification is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.60 on Gas.
Current edition approved May 10, 1999. Published July 1999. Originally published as D 2513 – 66. Last previous edition D 2513 – 98b.

[2] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.60 on Gas.
Current edition approved Dec. 1, 2009. Published January 2010. Originally approved in 1966. Last previous edition approved in 2009 as D2513 – 09. DOI: 10.1520/D2513-09A.

’99 Edition	‘09a Edition	Comments
1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information purposes only. 1.4 The following is an index of the annexes and appendixes in this specification: Annex Subject A1 Polyethylene (PE) Pipe and Fittings A2 Poly (Vinyl Chloride) (PVC) Pipe and Fittings A3 In-Plant Quality Control for all materials up to 12 in. A4 In-Plant Quality Control for PE materials between 14 and 24 in. A5 Polyamide (PA) Pipe and Fittings Appendixes Subject X1 New Materials X2 Design Consideration 1.5 *The following precautionary caveat pertains only to the test method portion, Section 6, of this specification. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*	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 appendix in this specification: Annex Subject Annex A1 In-Plant Quality Control for all materials up to 12 in. Annex A2 In-Plant Quality Control for PE materials between 14 and 24 in. Appendixes Subject Appendix X1 Design Consideration 1.5 *The following precautionary caveat pertains only to the test method portion, Section 6, of this specification. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*	Eliminated Annex’s A1, A2 & A5 and renumbered A3 as A1 and A4 as A2-*due to elimination of all materials other than PE.* Eliminated Appendix X1 and renumbered X2 as X1-*due to elimination of new materials.*
3. Terminology 3.1 *Definitions*—Definitions are in accordance with Terminology F 412, and abbreviations are in accordance with Terminology D 1600, unless otherwise specified. 3.2 The gas industry terminology used in this specification is in accordance with ANSI B31.8 or 49 CFR Part 192, unless otherwise indicated. 3.3 The term *pipe* used herein refers to both pipe and tubing unless specifically stated otherwise. 3.4 *re-rounding equipment*—equipment used to reform the pipe and permanently reduce ovality to 5% or less.	**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 OPS 49 CFR Part 192, unless otherwise indicated. 3.3 The term *pipe* used herein refers to both pipe and tubing unless specifically stated otherwise. 3.4 *re-rounding equipment*—equipment used to reform the pipe and permanently reduce ovality to 5% or less.	

’99 Edition	‘09a Edition	Comments
3.5 *rounding equipment*—equipment, devices, clamps, etc., 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. 3.6 *standard thermoplastic material designated code*—the pipe material designation code shall consist of the abbreviation for the type of plastic (PE, PVC, or PA) followed by Arabic numerals which describe the short term properties in accordance with applicable ASTM standards, 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 or three letters and four figures for plastic pipe materials. For example, PE 2406 is a grade P24 polyethylene with a 630 psi design stress for water at 73.4°F (23°C). The hydrostatic design stresses for gas are not used in this designation code. 3.7 *thermoplastic pipe dimension ratio (DR)*—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. 3.8 *toe-in*—a small reduction of the outside diameter at the cut end of a length of thermoplastic pipe.	3.5 *rounding equipment*—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. 3.6 *pipe material designated code*—the pipe material designation code shall consist of the abbreviation for the type of plastic (PE) followed by Arabic numerals which describe the short term properties in accordance with applicable Specification D3350, 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 PE and four figures for PE materials. For example, PE2708 is a grade PE27 polyethylene with an 800psi design stress for water at 73.4°F (23°C). The hydrostatic design stresses for gas are not used in this designation code. 3.7 *dimension ratio (DR)*—the ratio of pipe diameter to wall thickness. It is calculated by dividing the specified outside diameter of the pipe, in inches (mm), by the minimum specified wall thickness, in inches (mm). The standard dimension ratio (SDR) is a common numbering system which is derived from the ANSI preferred number series R 10. 3.8 *toe-in*—a small reduction of the outside diameter at the cut end of a length of thermoplastic pipe.	Changed “standard thermoplastic material” to “pipe material” – *due to focus on PE only*. Eliminated example reference to PVC and PA-*these materials no longer in this specification*. Changed “applicable ASTM standards” to Specification D3350-*PE only so the specific standard is referenced*. Eliminated “two or three letters” – *PE only so this option is not needed.* Changed reference material and stress from “PE 2406” and “ 630 psi” to “PE 2708” and “ 800” psi – *material designations and reference stress changed to reflect new, high performance PE material.* “Thermoplastic pipe” eliminated-*this comment was redundant.*
4. Materials 4.1 *General*—The plastic used to make pipe and fittings shall be virgin plastic or reworked plastic (see 4.2) as specified in the Annexes and shall have a Plastics Pipe Institute (PPI) long-term hydrostatic design stress and hydrostatic design basis rating. 4.2 *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 fitting produced meet all the requirements of this specification. NOTE 1—References and material descriptions for ABS, CAB, PB, PE2306, PE3306 and PE3406 have been removed from D 2513. Elimination of these materials does not affect the pipelines that are in service. They can still be used for gas distribution. The main reason for removing these materials from	**4. Materials** 4.1 *General*—The PE used to make pipe and fittings shall be PE or reworked PE (see 4.2 and 4.4) and shall have a Plastics Pipe Institute (PPI) long-term hydrostatic design stress and hydrostatic design basis rating. 4.2 *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 fitting produced meet all the requirements of this specification. The use of these rework materials shall be governed by the requirements of 4.3 and PPI TN-30/2006 In pipe, rework materials shall be limited to a maximum of 30 % by weight. NOTE 1—The requirements for rework materials herein are	4.1 Only change is to reference 4.4 for the PE material classification codes 4.2 and Note 1 Based on a extensive project by NYSEARCH (with AGA PMC and PPI participation), the use of rework in gas pipes was limited to a maximum of 30%. This 30% limitation represents a “strengthening” of the gas pipe standard. The project was initiated in response to a PHMSA request and was fully supported by such.

’99 Edition	‘09a Edition	Comments
this standard is to reflect the current state of the art in gas distribution plastic piping.	intended to incorporate prudent specifications to ensure that the potential for contamination in gas piping products, that meet this specification, is reduced to the extent possible. It is imperative to emphasize that rework materials have not been identified as the cause of any field failures. The requirements for rework materials were developed by the consensus of interested parties including product manufacturers, gas utility companies, and regulatory agencies.	
	4.3 *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.	4.3 This section is new and was needed to reflect the modifications to the allowable rework and to provide complete documentation of the piping system raw materials.
	4.4 *Classification*—Polyethylene materials suitable for use in the manufacture of pipe and fittings under this specification shall be classified in accordance with Specification D3350, and as shown in Table 1. PE 2606 and PE 2708 are medium density PE (MDPE) materials. PE 3608, PE 3710, PE 4608 and PE 4710 are high density PE (HDPE) materials. Example : for a polyethylene material having an HDB of 1250 psi (8.6 MPa), Cell Class 3, the base resin density must have a cell classification of 2 ; the melt index classification must be 3 or 5; and so forth. NOTE 2—References and material descriptions for PE2306, PE2406, PE3306, PE3406 and PE3408 have been removed from D2513. Elimination of these materials does not affect the pipelines that are in service. They can still be used for gas distribution. The main reason for removing these materials from this standard is to reflect the current state of the art in PE gas distribution piping.	4.4 New material designation codes were added to this section. These modifications reflect the changes to ASTM D3350, PPI TR-3 and PPI TR-4 for higher performance PE grades such as PE2708 and PE4710. Stringent requirements must be met by the PE material to qualify as a higher performance grade. Numerous presentations were made at PPI, AGA PMC and various Plastic Pipe Conferences on the requirements to qualify as a higher performance grade. Note 2 was updated from the previous edition as Note 1.
	4.5 *Slow Crack Growth Resistance*—Use Test Method F1473 on compression molded plaques at a stress of 2.4 MPa based on the unnotched area and a test temperature of 80°C. Notch depth shall be in accordance with Table 1 in Test Method F1473. Materials shall meet the Slow Crack Growth Resistance requirements in Table 1.	4.5 This section was previously in the PE Annex in A1.3.5.
	4.6 *Additive Classes*—Polyethylene material compounds shall meet Specification D3350 code C or E. Code C material compounds shall have 2 to 3 percent carbon black. Code E	4.6 A version of this section was previously in the PE Annex in A1.3.6. However, modifications were made to delete Code B (with antioxidants & UV stabilizer)

'99 Edition	'09a Edition	Comments
	material compounds shall be colored with UV stabilizer. 4.7 *Thermal Stability*—The PE material shall contain sufficient antioxidant so that the minimum induction temperature shall be 428°F (220°C) when tested in accordance with Specification D3350. The sample shall be representative of the cross section of the pipe or fittings. 4.8 *Hydrostatic Design Basis (HDB) Substantiation*—The HDB for PE materials at 73°F (23°C) shall be substantiated by showing that the extrapolation of the stress regression curve is linear to the 438 000-h intercept (long-term hydrostatic strength at 50 years in accordance with Test Method D2837). This will be done in accordance with Test Method D2837 using one of the two following procedures: 4.8.1 Use the twelve data points from Conditions I and II obtained in 5.6.1 (Procedure I) of Test Method D2837 along with the 438 000-h intercept to solve for the three-coefficient rate process extrapolation equation. Then using this new model, calculate the mean estimated failure time for Condition III. When the log average time for six specimens tested at Condition III has reached this time, linear extrapolation of the 73°F (23°C) stress regression curve to 438 000 h is substantiated. 4.8.2 When 5.6.2 (Procedure II) of Test Method D2837 is used to validate the 73°F (23°C) HDB, linear extrapolation of the stress regression curve to 438 000 h is substantiated when the log average failure time of the test specimens at 176°F (80°C) surpasses 6000 h.	materials. More details on Code C and Code E materials are now provided. Also, references to ASTM D1248 which is now obsolete for PE was removed. 4.7 and 4.8 These sections were previously in the PE Annex in A1.5.6 and A1.3.3, respectively. No modifications were made to the verbiage.
	NOTE 3—The long-term hydrostatic strength at 50 years in accordance with Test Method D2837 is not to be used for any pressure rating calculations. The MAOP is still calculated using the HDB obtained from Test Method D2837 long-term hydrostatic strength at 100 000 h.	Note 3 was previously Note A1.2 in the PE Annex. No changes were made.
	4.9 *Resistance to Rapid Crack Propagation (RCP) for Material* —The PE 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 the procedures set forth in ISO 13477 (S4 Test) or ISO 13478 (Full Scale Test (FST)). 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	4.9 and Notes 4 & 5 This section and notes are new and represent the efforts of numerous AGA and PPI projects to provide RCP data on pipes by PE material and pipe size. Numerous presentations have been made at industry meetings and a white paper was issued by AGA PMC on this topic.

’99 Edition	‘09a Edition	Comments
	with the wall thickness of the pipe tested and all thinner wall pipes. In case of conflict, the RCP results of ISO 13478 shall apply. Note 4—While S4 or FST testing of any combination of outside diameter and SDR is permitted in fulfillment of the requirement for testing PE material resistance to RCP, S4 testing of SDR 9 or SDR 11 PE pipe specimens is currently the most common industry practice. Note 5—Caution should be exercised in applying the RCP test results obtained on one SDR or DR of pipe across a series of pipe SDR’s or DR’s produced from the same PE material classification (formulation). Industrial research to clarify the relationships between FST and S4 testing is ongoing at this time, particularly as it relates to the applicability of RCP test results obtained on one SDR or DR of pipe to other SDR’s or DR’s of pipe produced from the same PE material classification (formulation). Consult the resin manufacturer regarding the applicability of RCP test results across diameters or SDR’s, or both. Additional information regarding the use of RCP data is presented in ISO 4437.	
	4.10 *Outdoor Storage Stability*—PE materials shall be Code C or E as defined in Specification D3350. Code C material 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. Code E material shall be stabilized and protected against deterioration from unprotected UV exposure for not less than 3 years. Note 6—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.	4.10 and Note 6 Outdoor storage stability was previously in the PE Annex in Section A1.5.7. The information provided and requirements for 4.10 have been significantly revised. These revisions represent the improvements made in the UV stability technology, the improvements in PE materials (especially the higher performance PE grades), more details on carbon black, and a clarification in the unprotected UV exposure timeframes. Note 6 contain clarifying information.
	4.11 *Qualification for LPG Service*—Materials that qualify for natural gas service and that carry a recommended HDB for	4.11 This section was previously in the PE Annex in A1.3.4. No changes were made

’99 Edition	‘09a Edition	Comments
	140°F in accordance with 5.7, also qualify for LPG service without the need for further testing. NOTE 7—The terms LPG and LPG gas are synonymous and only apply to a particular kind of fuel gas. For compositions and properties of LPG gases see NFPA 58, Appendix B.	to 4.11. Note 7 was previously Note A1.3.
5. Requirements 5.1 *General*—See the annexes for specific product requirements in addition to the following. 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 1 or Table 2 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 1 or Table 2. 5.3.1.3 *Wall Thickness*—The wall thickness shall be as specified in Table 2 or Table 3 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 2 or Table 3. 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. Requirements** 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 2 or Table 3 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 2 or Table 3. 5.3.1.3 *Wall Thickness*—The wall thickness shall be as specified in Table 3 or Table 4 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 3 or Table 4. 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	5.1 First sentence deleted - *D2513 revised to cover only PE pipe and fittings. Former PE annex material moved to body of standard.* 5.3.1.1 No change except table number references updated-*D2513 revised to cover PE pipe and fittings. Former PE annex material moved to the body of the standard. New Table 1 for PE materials added to Section 4.* 5.3.1.2 No change except table number references updated-*D2513 revised to cover PE pipe and fittings. Former PE annex material moved to the body of the standard. New Table 1 for PE materials added to Section 4.* 5.3.1.3 No change except table number references updated-*D2513 revised to cover PE pipe and fittings. Former PE annex material moved to the body of the standard. New Table 1 for PE materials added to Section 4.*

’99 Edition	‘09a Edition	Comments
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.	(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. For further information, see **(1)**.[3]	NOTE 8—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. For further information, see **(1)**[4].	Note number 2 updated to 8 - *D2513 revised to cover PE pipe and fittings. Former PE annex material moved to the body of the standard. New Table 1 for PE materials added to Section 4.*
(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.	*(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.	NOTE 9—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.	Note number 3 updated to 9 - *D2513 revised to cover PE pipe and fittings. Former PE annex material moved to the body of the standard. New Table 1 for PE materials added to Section 4.*
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).	5.3.1.6 *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 1, Table 2, or Table 3 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.	5.3.1.7 When sizes other than those listed in Table 2, Table 3 or 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.	No change except table numbers updated from 1,2,3 to 2,3,5 - *D2513 revised to cover PE pipe and fittings. Former PE annex material moved to the body of the standard. New Table 1 for PE materials added to Section 4.*
5.3.2 *Fittings*—Fittings shall meet the requirements given in the applicable Annex.	5.4 *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. For pipe sizes above 4-in. nominal diameter, the testing lab 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 6.8 shall be 2520 psi (17.4 MPa).	
5.4 *Chemical Resistance*—The pipe and fittings shall not increase in weight more than 0.5 % (1.0 % for toluene in methanol). Where the test specimen is a pipe ring, the material shall not change more than ±12 % in apparent tensile yield strength when measured in accordance with 6.9. Where the test specimen is a plaque, the material shall not change more than ±12 % in tensile strength at yield when measured in accordance with Test Method D 638. See Annex A5 for specific requirements for polyamide pipe.	5.5 *Short Term Pressurization for Sizes Above 12 in.*—Pipe and molded or fabricated fittings shall not fail when tested in	5.4 Section number updated and last sentence deleted – *D2513 revised to cover PE pipe and fittings. Former PA gas pipe and fitting annex material is now in ASTM F 2785 “Standard Specification for Polyamide 12 Gas Pressure Pipe, Tubing & Fittings”.* Section A1.5.9 relocated as Section 5.4

---

[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[4] The boldface numbers in parentheses refer to a list of references at the end of this standard.

'99 Edition	'09a Edition	Comments
NOTE 4—This pipe test is only an indication of what will happen as a result of short term exposure to these chemicals. For longterm results, additional testing is required. 5.5 *Sustained Pressure*—The pipe, fittings, or systems shall not fail as defined in Test Method D 1598, when tested in accordance with 6.6. 5.6 *Elevated Temperature Service*—Plastic 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 D 2837. The 100 000-h intercept (long-term strength) shall be categorized in accordance with Table 4 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. 5.7 *Minimum Hydrostatic Burst Pressure*—The burst requirements for plastic pipe shall be as given in the appropriate annexes. 5.8 *Apparent Tensile Strength At Yield*— The minimum apparent tensile strengths at yield for plastic pipe are given in the annexes when determined in accordance with 6.8. 5.9 *Joints*: 5.9.1 *Solvent Cemented*—Joints of solvent cementable pipe and fittings shall be made in accordance with the user's written procedure. 5.9.2 *Heat Fusion*: 5.9.2.1 Heat fusion joints of thermoplastic pipe and fittings shall be made in accordance with Practice D 2657 and the user's written procedure. 5.9.2.2 PE 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	accordance with Test Method D1599 with the hoop stress of 2500 psi for MDPE materials or 2900 psi for HDPE density materials. Hoop stress calculation shall be based on the DR of the fitting at the point of fusion. (**Warning**—Pressurization of pipe specimens above 12 in. nominal diameter being tested in accordance with 5.5 should not commence until it is certain that all entrapped air has been bled from the water-filled specimens.) NOTE 10—The requirements in 5.3.1.1 and 5.3.1.3 are for laboratory proof testing only and should not be interpreted as applicable to on-site testing for acceptance of installed systems larger than 12 in. See appropriate installation standards or manufacturer's recommendations for field test procedures. 5.6 *Chemical Resistance*—The pipe and fittings shall not increase in weight more than 0.5 % (1.0 % for toluene in methanol). Where the test specimen is a pipe ring, the material shall not change more than ±12 % in apparent tensile yield strength when measured in accordance with 6.9. Where the test specimen is a plaque, the material shall not change more than ±12 % in tensile strength at yield when measured in accordance with Test Method D638. NOTE 11—This pipe test is only an indication of what will happen as a result of short term exposure to these chemicals. For long term results, additional testing is required. 5.7 *Melt Index*—Melt index is the flow rate of PE material when measured in accordance with Test Method D1238, condition 190/2.16 (formerly Condition E). Materials that record zero flow under condition 190/2.16 shall be measured in accordance with condition 190/21.6 (formerly condition F). The melt index of pipe/fitting shall meet the designated category in Table 5. The sample shall be representative of the cross section of the pipe or fitting and diced to an appropriate size by a method not producing heat. 5.8 *Sustained Pressure 73°F (23°C)*—The pipe or system shall not fail in less than 1000 h when tested in accordance with Test Method D1598. For MDPE material, the stress shall be 1320 psi, for HDPE materials, the stress shall be 1600 psi.. 5.9 *Elevated Temperature Service*—piping materials intended for use at temperatures above 100°F (38°C) shall have the PPI hydrostatic design basis (HDB) determined at the	(no change in requirements) No change except Note 4 number changed to Note 11 - *D2513 revised to cover only PE pipe and fittings. Former PE annex material moved to the body of the standard.* Note A1.4 relocated as Note 10. 5.5 Section number updated to 5.8. 1,000 hour test incorporated from '99 edition, section 6.6.2. Test stress incorporated from '99 edition Section 6.6.1.2 - *D2513 revised to cover only PE pipe and fittings.* 5.6 No change except renumbered as 5.9 - *D2513 revised to cover only PE pipe and fittings.* Note 5, no change except renumbered as Note 12 - *D2513 revised to cover only PE pipe and fittings. Former PE annex material moved to body of the standard.* Note 6, no change except renumbered as Note 13 - *D2513 revised to cover only PE pipe and fittings. Former PE annex material moved to body of the standard* Melt Index-Section A1.5.4 relocated without change to 5.7 - *D2513 revised to cover only PE pipe and fittings. Former PE annex material moved to body of the standard.* Section 5.7 and 5.8 deleted. Section A1.5.2 relocated as 5.4 - *D2513 revised to cover only PE pipe and fittings. Former PE annex material moved to body of the standard.*

’99 Edition	‘09a Edition	Comments
not adversely affected. The minimum requirement to demonstrate long term performance shall be the validation procedure for PE in Test Method D 2837. The Hydrostatic Design Basis (HDB) of the PE material shall be validated using specimens containing butt fusion joints resulting from different SDRs or DRs. Pipe/pipe joints of the given PE material that pass shall validate pipe/pipe, pipe/fitting, or fitting/fitting joints of the same SDR ratio for that PE material. 5.9.3 *Mechanical*—Mechanical fittings shall be installed in accordance with the user's written procedures and the fitting manufacturer's installation instructions. The joint shall be tested in accordance with the specific design category as outlined in 6.10. 5.10 *Plastic Valves*—All plastic gas valves shall meet the requirements of ANSI Standard B 16.40.	specific temperature in accordance with Test Method D2837. The 100 000-h intercept (long-term strength) shall be categorized in accordance with Table 5 and be listed as the “hydrostatic design basis of XXX psi at XXX °F (C°) for (compound name).” NOTE 12—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 13—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.	
	5.10 *HDB Validation for PE Pipe*—The 73°F (23°C) Hydrostatic Design Basis (HDB) of PE pipe shall be validated by the pipe producer using the PE validation procedure as outlined in Test Method D2837. For MDPE materials, the HDB of 1250 psi shall be validated; for HDPE materials, the HDB of 1600 psi shall be validated.	Section A15.10 was relocated to 5.10. PE2406 changed to MDPE and PE3408 changed to HDPE, otherwise unchanged. *D2513 revised to cover only PE pipe and fittings. Former PE annex material moved to body of the standard*.
	5.11 *Resistance to Rapid Crack Propagation (RCP) for Pipe*—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 for the PE compound. In these circumstances, additional testing for resistance to failure by RCP in accordance with the procedures set forth in ISO 13477 (S4 Test) or ISO 13478 (Full Scale Test (FST)) shall be conducted. In cases of conflict, the RCP results of ISO 13478 shall apply. 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.	5.11 is a new requirement, not part of ‘09a. – *Requires RCP resistance testing for PE piping*.
	NOTE 14—The requirements and testing for resistance to RCP specified in this specification 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.	New Note-*clarifies RCP resistance testing requirement for PE piping*
	5.12 *Inside Surface Ductility for Pipe*——The inside	5.12 New requirement.- *Requires pipe testing to assure ID surface has not been*

’99 Edition	‘09a Edition	Comments
	surface of pipe shall be ductile as shown by testing in accordance with 5.13.1, 5.13.1.1, and 5.13.1.2. Before testing, specimens shall be conditioned in accordance with Practice D618 for 40 h at 73.4 ± 3.6°F (23 ± 2°C) and 50 % relative humidity.	*oxidized during processing*
	NOTE 15—ID ductility testing may also be conducted for quality control purposes, however, there is no known data that identifies one test as inferior, equal, or superior to the others, therefore, results from one test should not be evaluated against the results from either of the other two tests.	Note 15 - New requirement.- *Requires pipe testing to assure ID surface has not been oxidized during processing*
	5.13 *Bend-back Test Method*: 5.13.1 From the pipe, squarely cut a ring of pipe with a minimum width of 1 1/4 (32 mm). The entire wall thickness may be tested, or material may be removed from the OD surface of the pipe, while maintaining an undisturbed ID surface, to produce a ring with 3/8-in. (9.5-mm) wall thickness. NOTE 16—The ring may be tested in its entirety, or may be cut into representative sectors to produce bend-back test specimens 5.13.1.1 In a well-lit area at 73.4 ± 3.6°F (23 ± 2°C) perform the following procedure within 5 min: *(a)* Bend the specimen inside-out (reverse-bend so that the pipe ID surface is on the outside surface of the bent specimen). *(b)* Using an apparatus such as a vise or other suitable bending equipment, close the legs of the specimen together. When the specimen legs are closed together, the top of the bend-back specimen shall protrude 1 to 11/4 in. (25 to 32 mm) or two wall thicknesses, whichever is greater, above the point of closure (jaws). *(c)* With the unaided (naked) eye, visually examine the protruding reverse-bent pipe ID surface for signs of brittle cracking or crazing. 5.13.1.2 Any indication of brittle cracking or crazing indicates failure. 5.13.2 *Elongation-at-Break Test Method* : 5.13.2.1 *(1)* Five Test Method D638 Type IV specimens cut in the longitudinal direction from locations equally spaced around the circumference of the pipe shall be tested in	5.13 New requirements. *Requires pipe testing to assure ID surface has not been oxidized during processing*

’99 Edition	‘09a Edition	Comments
	accordance with Test Method D638 at a cross-head separation speed of 2 in. (50.8 mm) min, and at 73.4 ± 3.6°F (23 ± 2°C). If the specimen thickness must be reduced by machining, the pipe ID surface shall be left unaltered.	
	NOTE 17—If the specimen thickness is reduced, the machined side of the specimen must be smooth and the thickness of the specimen in the gage length must be uniform. Surface cuts or scratches and non-uniform thickness in the specimen gage length can detrimentally affect test results.	Note 17 – New requirement - *Requires pipe testing to assure ID surface has not been oxidized during processing*
	(2) The percent elongation at break for each test specimen shall exceed 400 %.	(2) New requirement - *Requires pipe testing to assure ID surface has not been oxidized during processing*
	5.13.3 *Thermal Stability Test Method*—Specimens of the pipe inside wall surface not more than 0.005 in. (0.13 mm) thick shall demonstrate a minimum induction temperature of 428°F (220°C) when tested in accordance with the Test Method for Thermal Stability in Specification D3350.	5.13.3 New requirement - *Requires pipe testing to assure ID surface has not been oxidized during processing*
	5.14 *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 1000-h sustained pressure category when pipe is tested as follows: 5.14.1 Prepare six randomly selected pipe specimens in accordance with Test Method D1598 except they shall be unfilled. 5.14.2 The squeeze-off shall be effected at the mid-point 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 re-round pipe by closing squeeze bars at a point 90° from the squeeze area. 5.14.3 Immediately upon removal of the squeeze-off tool, fill the specimens with ambient temperature water, that is, 67 ± 10°F (19.4 ± 5.6°C), condition, and test in accordance with 6.6.	5.14 A1.5.5 moved to 5.14 without change-*D2513 now covers only PE. Former PE annex moved to the body of the standard*.
	5.15 *Joints*: 5.15.1 *Heat Fusion*:	5.9 changed to 5.15. *D2513 now covers only PE.*
	5.15.1.1 Heat fusion joints of thermoplastic pipe and fittings shall be made in accordance with Practice F2620 and the user's written procedure.	5.9.1.- PVC requirements removed. D2657 replaced with F2620. *D2513 now covers only PE.*
	5.15.1.2 PE butt fusion joining shall be between components	5.9.2 Renumbered as 5.15.1 - *D2513 now*

’99 Edition	‘09a Edition	Comments
	(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 validation procedure for PE in Test Method D2837. The Hydrostatic Design Basis (HDB) of the PE material shall be validated using specimens containing butt fusion joints resulting from different SDRs or DRs. Pipe/pipe joints of the given PE material that pass shall validate pipe/pipe, pipe/fitting, or fitting/fitting joints of the same SDR ratio for that PE material. 5.15.2 *Mechanical*—Mechanical fittings shall be installed in accordance with the user's written procedures and the fitting manufacturer's installation instructions. The joint shall be tested in accordance with the specific design category as outlined in 6.10. 5.15.3 *Electrofusion*—Electrofusion joints shall be made in accordance to user’s written procedures and the fitting manufacturer’s installation instructions 5.16 *Fittings*: 5.16.1 Socket-type fusion fittings shall meet the requirements of Specification D2683. 5.16.2 Butt-type fusion fittings shall meet the requirements of Specification D3261. 5.16.3 Electrofusion fittings should meet the requirements of Specification F1055. 5.17 *PE Valves*—All PE gas valves shall meet the requirements of ANSI Standard B 16.40. 5.18 *Excess Flow Valves*—All excess flow valves shall meet the requirements of Specification F2138.	*covers only PE.* 5.15.1.2 Section numbers updated. *D2513 now covers only PE.* 5.9.3 renumbered as 5.15.2. - *D2513 now covers only PE.* 5.15.3 New requirement – *Provides requirements for electrofusion joints*. 5.3.2 changed to 5.16 and material in “applicable annex’s” added to body of standard - *D2513 now covers only PE. Former PE annex moved to the body of the standard* 5.16.1 New requirements – *needed requirements for socket fittings.* 5.16.2 New requirements – *needed requirements for butt fusion fittings* 5.16.3 New requirements – *needed requirements for electrofusion fittings.* 5.17 Section number changed and “plastic valves” changed to “PE valves”- *D2513 now covers only PE.* 5.18 New requirements – *needed requirements for excess flow valves*
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. 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. no change 6.1 no change

’99 Edition	‘09a Edition	Comments
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 D 1898).	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).	6.2 no change
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.	6.2.1 *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.	6.2.1 no change
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 D 618 for those tests where conditioning is required and in all cases of disagreement.	6.3 *Conditioning*—For those tests where conditioning is required or unless otherwise specified, condition the specimens prior to testing for a minimum of 1 in water or 4h in air at 73.4 ± 3.6°F (23 ± 2°C).	6.3 ’99 states 50±5% humanity for 40h per D 618 Procedure A. 09a states 1h in water or 4h in air. No mention of humanity and test method.
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.	6.4 *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.	6.4 no change
6.5 *Dimensions and Tolerances*:	6.5 *Dimensions and Tolerances*:	6.5 no change
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 *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 no change
6.5.1.1 *Diameter*—Measure the diameter of the pipe in accordance with Test Method D 2122. 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 D 2122 for definitions of nonroundable and roundable pipe.	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.	6.5.1.1 no change
(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.	*(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.	(I) No change
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	NOTE 18—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	Note – no change

’99 Edition	‘09a Edition	Comments
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.	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 D 2122.	6.5.1.2 *Wall Thickness*—Make a minimum of six measurements at each cross section in accordance with Test Method D2122.	6.5.1.2 No change
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: $E = [(A - B)/A] \times 100$ (1)	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: $E = [(A - B)/A] \times 100$ (1)	6.5.1.3 no change
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).	6.5.1.4 *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).	6.5.1.4 No change
6.5.2 *Fittings*—Measure the dimensions of fittings in accordance with Test Method D 2122.	6.5.2 *Fittings*—Measure the dimensions of fittings in accordance with Test Method D2122.	6.5.2 No change
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: $\% \quad \text{ovality} = \frac{\text{maximum OD} - \text{minimum OD}}{\text{minimum OD} + \text{maximum OD}} \times 200$ (2)	6.5.3 *Ovality*—Determine percent ovality in accordance with Test Method D2122.	6.5.3 99-version specifies apparatus, procedure and calculation. 09a-version references D 2122
6.6 *Sustained Pressure Test*: 6.6.1 Select six test specimens of pipe or fittings at random, condition at the standard laboratory test temperature and humidity, and pressure test in accordance with Test Method D 1598. 6.6.1.1 Test specimens shall be prepared so that the minimum length of pipe on each side of the fitting is equal to 5 times the	6.6 *Sustained Pressure Test*: 6.6.1 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. 6.6.1.1 Test specimens shall be prepared so that the minimum length of pipe on each side of the fitting 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. 6.6.1.2 Pressures used shall be calculated using the pipe's actual measured minimum wall thickness, outside diameter, and the applicable fiber stress, whichever is greater. 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 90 % of the hydrostatic design basis (HDB). NOTE 19—Air, methane, or nitrogen may be substituted for water as the test medium.	6.6 no change 6.6.1 no change 6.6.1.1 no change

’99 Edition	‘09a Edition	Comments
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. 6.6.1.2 Pressures used shall be as shown in the annexes or as calculated (using the pipe's actual measured minimum wall thickness, outside diameter, and the applicable fiber stress shown in the annexes), whichever is greater. 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. 6.6.2 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) as specified in 6.6.1. 6.6.3 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 D 1598. 6.7 *Minimum Hydrostatic Burst Pressure (Quick Burst)*—The test equipment, procedures, and failure definitions shall be as specified in Test Method D 1599 and the annexes. Pressures shall be as shown in the Annexes or as calculated (using the pipe's actual measured minimum wall thickness, outside diameter, and the applicable fiber stress), whichever is greater. 6.8 *Apparent Tensile Properties*—The procedure and test equipment shall be as specified in Test Method D 2290, Procedure B. The speed of testing shall be 0.5 in. (12.7 mm)/min. Cut “ring” specimens from pipe. They shall be 1/2 in. (12.7 mm) wide with a 1/4-in. (6.3-mm) wide reduced section. Test a minimum of five specimens. This method is applicable to all pipe of nominal 3/4-in. (19.0-mm) outside diameter and larger. 6.9 *Chemical Resistance*—Determine the resistance to the following chemicals in accordance with Test Method D 543. Where available, the test specimen shall be a ring 2 in. SDR 11 pipe cut to the ring dimensions specified in 6.8. For materials that are not readily available as 2 in. SDR 11 pipe, the test	6.6.2 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) as specified in 6.6.1. 6.6.3 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. 6.7 *Minimum Hydrostatic Burst Pressure (Quick Burst)*—The test equipment, procedures, and failure definitions shall be as specified in Test Method D1599. Pressures shall be calculated using the pipe's actual measured minimum wall thickness, outside diameter, and the applicable fiber stress, whichever is greater. 6.8 *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. Test a minimum of five specimens. This method is applicable to all pipe of nominal 3/4-in. (19.0-mm) outside diameter and larger. 6.9 *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 6.8. For materials that are not readily available as 2 in. SDR 11 pipe, the test specimen shall be a plaque of material 1/4by 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	6.6.1.2 99-version requires the test fiber stress shall be HDB or 80% of 100,000-h intercept of the material, whichever is greater. 09a-version is 90% of HDB. Note no change 6.6.2 no change 6.6.3 no change 6.7 no change 6.8 no change 6.9 – the caution statement is captured in Note 9 of 99-version. It is changed to a warning statement as part of 6.9 in 09a-version. The content is identical.

<table>
<tr><th>’99 Edition</th><th>‘09a Edition</th><th>Comments</th></tr>
<tr>
<td>specimen shall be a plaque of material 1/4by 2 by 4 in. (6.3 by 50.8 by 101.6 mm) with a 1 in. (25.4 mm) wide reduced section.
<table>
<tr><th>Chemicals</th><th>Concentration (% by volume)</th></tr>
<tr><td>Mineral oil (USP)</td><td>100</td></tr>
<tr><td>Tertiary-butyl mercaptan</td><td>5 in mineral oil</td></tr>
<tr><td>Antifreeze agents (at least one shall be used):</td><td></td></tr>
<tr><td>Methanol, or</td><td>100</td></tr>
<tr><td>Ethylene glycol</td><td>100</td></tr>
<tr><td>Toluene</td><td>15 in methanol</td></tr>
</table>
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 21/4 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 6.8 within 1/2 h after weighing. Examine the weight and apparent tensile strength of each specimen for conformance to the requirement in 5.4.
NOTE 9—**Caution**: 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.
6.10 *Categorization of Mechanical Joints*—The following test methods provide a uniform procedure for qualification or categorization of mechanical joints using short term pullout resistance tests and burst tests. The mechanical joint categories and test methods are as follows:
6.10.1 *Category 1*—A mechanical joint design that provides a seal plus a resistance to a force on the pipe end equal to or greater than that which will cause a permanent deformation of the pipe.
6.10.1.1 The apparatus and report shall be as specified in Test Method D 638. The test shall be conducted at ambient temperatures, that is, 67 ± 10°F (19.4 ± 5.6°C). The speed of the testing shall be 0.2 in. (5 mm)/min ± 25 %. Five specimens shall be prepared following the manufacturer's published installation instructions. Length of the specimens shall be such that the unreinforced distance between the grip of the apparatus and the end of the stiffener is at least five times the nominal outside</td>
<td>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 21/4 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 6.8 within 1/2 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.)
6.10 *Categorization of Mechanical Joints*—The following test methods provide a uniform procedure for qualification or categorization of mechanical joints using short term pullout resistance tests and burst tests. The mechanical joint categories and test methods are as follows:
6.10.1 *Category 1*—A mechanical joint design that provides a seal plus a resistance to a force on the pipe end equal to or greater than that which will cause a permanent deformation of the pipe.
6.10.1.1 The apparatus and report shall be as specified in Test Method D638. The test shall be conducted at ambient temperatures, that is, 67 ± 10°F (19.4 ± 5.6°C). The speed of the testing shall be 0.2 in. (5 mm)/min ±25 %. Five specimens shall be prepared following the manufacturer's published installation instructions. Length of the specimens shall be such that the unreinforced distance between the grip of the apparatus and the end of the stiffener is at least five times the nominal outside diameter of the pipe size being tested. Apply a load until permanent deformation (yield) occurs in the unreinforced area of the piping.
6.10.1.2 Results obtained from the above method pertain only to the specific outside diameter, wall thickness, and compound of the piping used in the test and specific fitting design tested.
NOTE 20—The ability to restrain pipe to its yield as specified above does not guarantee that a properly installed joint will prevent pullout under actual long-term field conditions. Joints that cannot pass this test would be expected to pullout under actual long term field conditions. To date, this test is the best available for disqualifying unsound joints.
6.10.2 *Category 2*—A mechanical joint design that</td>
<td>6.10 - no change
6.10.1 – no change
6.10.1.1 - no change</td>
</tr>
</table>

’99 Edition	‘09a Edition	Comments
diameter of the pipe size being tested. Apply a load until permanent deformation (yield) occurs in the unreinforced area of the piping. 6.10.1.2 Results obtained from the above method pertain only to the specific outside diameter, wall thickness, and compound of the piping used in the test and specific fitting design tested. NOTE 10—The ability to restrain pipe to its yield as specified above does not guarantee that a properly installed joint will prevent pullout under actual long-term field conditions. Joints that cannot pass this test would be expected to pullout under actual long term field conditions. To date, this test is the best available for disqualifying unsound joints. 6.10.2 *Category 2*—A mechanical joint design that provides a seal only (see X2.5.5). A mechanical joint designed for this category excludes any provisions in the design or installation of the joint to resist any axial pullout forces; therefore, tensile tests are not required. 6.10.2.1 The test assembly shall meet the burst test requirements of 5.7 when tested in accordance with Test Method D 1599 with end closures designed in accordance with Test Method D 1599. 6.10.3 *Category 3*—A mechanical joint design that provides a seal plus a pipe restraint rating equivalent to the anticipated thermal stresses occurring in a pipeline (see Appendix X2.4). This category has a manufacturer's rated pipe end restraint less than the value required to yield the pipe as outlined in 6.10.1 (Category 1). 6.10.3.1 The procedures and testing shall be the same as outlined in 6.10.1 (Category 1) except the test tensile values shall meet the rated values published by the mechanical fitting manufacturer.	provides a seal only (see Appendix X1.5.5). A mechanical joint designed for this category excludes any provisions in the design or installation of the joint to resist any axial pullout forces; therefore, tensile tests are not required. 6.10.2.1 The test assembly shall meet the burst test requirements of 5.6 when tested in accordance with Test Method D1599 with end closures designed in accordance with Test Method D1599. 6.10.3 *Category 3*—A mechanical joint design that provides a seal plus a pipe restraint rating equivalent to the anticipated thermal stresses occurring in a pipeline (see Appendix X1.4). This category has a manufacturer's rated pipe end restraint less than the value required to yield the pipe as outlined in 6.10.1 (Category 1). 6.10.3.1 The procedures and testing shall be the same as outlined in 6.10.1 (Category 1) except the test tensile values shall meet the rated values published by the mechanical fitting manufacturer.	6.10.1.2 – no change Note – no change 6.10.2 the reference is changed from X2.5.5 to Appendix X1.5.5. no other changes 6.10.2.1 - the reference of 5.7 is changed to 5.6. 6.10.3 – Appendix X2.4 is changed to Appendix X1.4 6.10.3.1 – No change.
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	**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)*	1. Permanent marking required. 2. No change in required marking components. - *D2513 revised to cover only PE pipe and fittings.*

’99 Edition	‘09a Edition	Comments
channels when elastomeric gasket compression fittings are used to make the joints. These marking shall consist of the word GAS, the designation ASTM D 2513, 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. See Annex A1 and Annex A2 for additional specific marking requirements. 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 4 (the first code letter to identify the temperature of pressure rating, the second code letter to identify HDB at highest rated temperature, and the third code letter to identify the melt index). 7.3 *Fittings*—Fittings shall be marked D 2513, as well as with the applicable fitting specification. All fittings shall be marked on the body or hub. The markings shall consist at least of the manufacturer's name or trademark, or both, the size, the symbol for the type of material, and the three-letter code from Table 4 (as described in Section 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. NOTE 11—Section 7.3 is applicable to fusion type fittings only. The marking requirements in Section 7.3 are not applicable to mechanical fittings.	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 D2513, 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, and date of manufacture. NOTE 21—Earlier editions of Specification D2513 included PE material designations PE2406 and PE3408. Changes to Specification D3350 led to changes in the PE material designation codes that resulted in the PE material designations PE2406 and PE3408 being superceded by newer material designations. Additionally, OPS 49 CFR Part 192 may not reference the most current version of D2513 and as a result may require marking with material designation codes that are no longer included in this Specification. For these reasons two material designations may be present. For example, PE4710 pipes were previously described as PE3408 pipes and may be marked PE3408/4710. Similarly PE2708 pipes were previously described as PE2406 pipes and may be marked PE2406/2708. 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 2 ft (0.61 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 22—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	No technical changes. Paragraph 9.1 now separated into subsections under 7.1 - *D2513 revised to cover only PE pipe and fittings.* 1. Markings repeat at 2 ft (0.61 m) interval. 2. Indented printing requirements added. 3. Contrasting color printline marking required. 4. Yellow color required for gas service. PVC requirements removed. See ASTM F2817-10 “Standard Specification for Poly Vinyl Chloride (PVC) Gas Pressure Pipe and Fittings for Maintenance and

’99 Edition	‘09a Edition	Comments
	temperatures greater than 73°F (23°C) shall be marked with additional code letters from Table 5 (the first code letter to identify the temperature of pressure rating, the second code letter to identify HDB at highest rated temperature, and the third code letter to identify the melt index).	Repair” Table X2.1 revised to Table 5 and relocated from Appendix to body of the standard. Added requirement to mark melt index code.
	NOTE 23—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, (6) Elevated temperature code from Table 5, (7) ASTM D2513, (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. Example: 2 in. IPS SDR 11 MANUFACTURER NAME GAS PE 2708 CEC ASTM D2513 LOT CODE INFO 02JAN98 coil #506.	Note 23 added to address marking component printing order.
	7.3 PE pipe shall be marked with the melt index category in accordance with Table 5 in addition to the marking requirements of 7.1. 7.4 *Fittings*—Fittings shall be marked D2513, as well as with the applicable fitting specification. All fittings shall be marked on the body or hub. The markings shall consist at least of the manufacturer's name or trademark, or both, the size, the symbol for the type of material, and the three-letter code from Table 5 (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. NOTE 24—7.4 is applicable to fusion type fittings only.	Added requirement to mark “ASTM D-2513” on fittings. Added 50 year records retention requirement. Note 22 exempts mechanical fittings from requirement to mark ‘D2513” on the fitting.

’99 Edition	‘09a Edition	Comments
	The marking requirements in 7.4 are not applicable to mechanical fittings.	
8. Quality Assurance 8.1 When the product is marked with this designation, D 2513, 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.	**8. Quality Assurance** 8.1 When the product is marked with this designation, D2513, 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.	No changes.
SUPPLEMENTARY REQUIREMENTSGOVERNMENT/MILITARYPROCUREMENT These requirements apply only to federal/military procurement, not domestic sales or transfers. . *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 S1—In U.S. federal contracts, the contractor is responsible for inspection. . *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	**SUPPLEMENTARY REQUIREMENTSGOVERNMENT/MILITARYPROCUREMENT** These requirements apply only to federal/military procurement, not domestic sales or transfers. . *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 S00001—In U.S. federal contracts, the contractor is responsible for inspection. . *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	S1 changed to S00001 – *new numbering system.* S2 changed to S00002 – *new numbering system*

’99 Edition	‘09a Edition	Comments
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 S2—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.	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 S00002—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.	
ANNEXES **(Mandatory Information)** **A1. SUPPLEMENTAL REQUIREMENTS FOR GAS PRESSURE PIPE AND FITTINGS PRODUCED FROM POLYETHYLENE (PE) MATERIAL**	**ANNEXES** **A1. IN-PLANT QUALITY CONTROL PROGRAM FOR PE PLASTIC PIPE AND FITTINGS UP TO AND INCLUDING 12 IN. NOMINAL DIAMETER**	Annex A1 on PE materials in ASTM D 2513-99 is now in the main body of ASTM D 2513-09a.
A1.1 Scope A1.1.1 This annex covers requirements for PE pipe and fittings. These requirements are in addition to those in the main body of this specification. NOTE A1.1—Because Table 1, which covers nominal pipe sizes up to 12 in. is in the body of this specification, and Table A1.1 is in Annex A1, the user should be aware of the larger tolerance allowed the larger pipe.	**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.	Annex A1 on PE materials in ASTM D 2513-99 is now in the main body of ASTM D 2513-09a.
A1.2 Referenced Documents A1.2.1 *ASTM Standards*: A1.2.1.1 *Test Methods for*: D 1238 Flow Rate of Thermoplastics by Extrusion Plastometers[3] A1.2.1.2 *Specification for*: D 1248 Polyethylene Plastics Molding and Extrusion Materials[3]	None	Annex A1 on PE materials in ASTM D 2513-99 is now in the main body of ASTM D 2513-09a.

’99 Edition	‘09a Edition	Comments
D 2683 Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing[2] D 3261 Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing[2] D 3350 Polyethylene Plastic Pipe and Fittings Materials[3] F 1055 Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing[3]		
A1.3 Materials A1.3.1 *Classification*—Polyethylene materials suitable for use in the manufacture of pipe and fittings under this specification shall be classified in accordance with Specification D 3350, and as shown in Table A1.2. *Example*: for a polyethylene material having an HDB of 1250 psi (8.6 MPa), Cell Class 3, the base resin density must have a cell classification of 2 or 3; the melt index classification must be 1, 2, 3, 4, 5, or 6; etc. A1.3.2 *Short and Long Term Properties*—Polyethylene pipe and fittings shall be made from PE materials which also satisfy the combinations of short- and long-term property requirements shown in Table A1.3. A1.3.3 *Hydrostatic Design Basis (HDB) Substantiation*—The HDB for PE materials at 73°F (23°C) shall be substantiated by showing that the extrapolation of the stress regression curve is linear to the 438 000-h intercept (long-term hydrostatic strength at 50 years in accordance with Test Method D 2837). This will be done in accordance with Test Method D 2837 using one of the two following procedures: A1.3.3.1 Use the twelve data points from Conditions I and II obtained in 5.6.1 (Procedure I) of Test Method D 2837 along with the 438 000-h intercept to solve for the three-coefficient rate process extrapolation equation. Then using this new model, calculate the mean estimated failure time for Condition III. When the log average time for six specimens tested at Condition III has reached this time, linear extrapolation of the 73°F (23°C) stress regression curve to 438 000 h is substantiated. A1.3.3.2 When 5.6.2 (Procedure II) of Test Method D 2837 is used to validate the 73°F (23°C) HDB, linear extrapolation of		Annex A1 on PE materials in ASTM D 2513-99 is now in the main body of ASTM D 2513-09a.

’99 Edition	‘09a Edition	Comments
the stress regression curve to 438 000 h is substantiated when the log average failure time of the test specimens at 176°F (80°C) surpasses 6 000 h. NOTE A1.2—The long-term hydrostatic strength at 50 years in accordance with Test Method D 2837 is not to be used for any pressure rating calculations. The MAOP is still calculated using the HDB obtained from Test Method D 2837 long-term hydrostatic strength at 100 000 h. A1.3.4 *Qualification for LPG Service*—Materials that qualify for natural gas service in accordance with A1.3.3 and that carry a recommended HDB for 140°F in accordance with 5.6, also qualify for LPG service without the need for further testing. NOTE A1.3—The terms LPG and LPG gas are synonymous and only apply to a particular kind of fuel gas. For compositions and properties of LPG gases see NFPA 58, Appendix B. A1.3.5 *Slow Crack Growth Resistance*—Test method is F 1473 on compression molded plaques. Stress is 2.4 MPa based on the unotched area. Temperature is 80°C. Notch depth in accordance with Table 1 in F 1473. The minimum of the average of the two tests shall be 100 h. Do at least four tests in case of a dispute. A1.3.6 *Additive Classes*—PE materials shall be either Class B, with antioxidant and UV stabilizer, or C as defined in Specification D 1248, or Class C or E as defined in Specification D 3350.		
A1.4 Fittings A1.4.1 PE fittings intended for use with the corresponding sized outside-diameter PE pipe shall meet the requirements of Specification D 2683 for socket-type fittings, Specification D 3261 for butt-type fittings, or Specification F 1055 for electrofusion-type fittings and the requirements of this specification.		Annex A1 on PE materials in ASTM D 2513-99 is now in the main body of ASTM D 2513-09a.

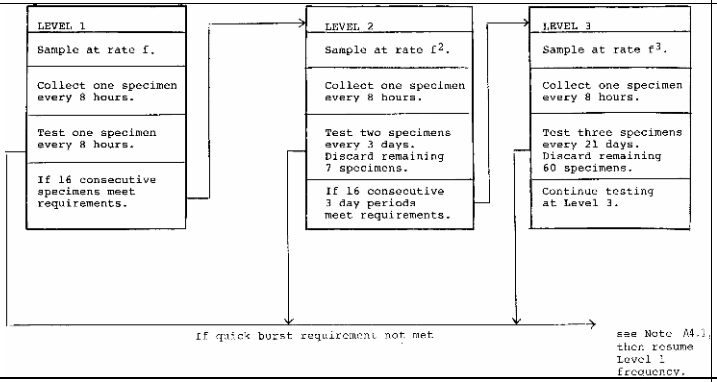
’99 Edition	‘09a Edition	Comments
A1.5 Requirements for Pipe and Fittings A1.5.1 *Conditioning*—For those tests where conditioning is required or unless otherwise specified, condition the specimens prior to testing for a minimum of 1 h in water or 4 h in air at 73.4 ± 3.6°F (23 ± 2°C) or in accordance with 6.3. The conditioning requirements of 6.3 shall be used in all cases of disagreement. A1.5.2 *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 D 1599. For pipe sizes above 4-in. nominal diameter, the testing lab shall be allowed to replace the quick burst test (Test Method D 1599) by the apparent ring tensile strength test (Test Method D 2290). The minimum apparent tensile strength at yield when determined in accordance with 6.8 shall be 2520 psi (17.4 MPa). A1.5.3 *Sustained Pressure 73°F (23°C)*—The pipe or system shall not fail in less than 1000 h when tested in accordance with Test Method D 1598. For PE 2406 material, the stress shall be 1320 psi, for PE 3408 materials, the stress shall be 1600 psi. A1.5.4 *Melt Index*—Melt index is the flow rate of PE material when measured in accordance with Test Method D 1238, condition 190/2.16 (formerly Condition E). Materials that record zero flow under condition 190/2.16 shall be measured in accordance with condition 190/21.6 (formerly condition F). The melt index of pipe/fitting shall meet the designated category in Table 4. The sample shall be representative of the cross section of the pipe or fitting and diced to an appropriate size by a method not producing heat. A1.5.5 *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 1000-h sustained pressure category when pipe is tested as follows: A1.5.5.1 Prepare six randomly selected pipe specimens in accordance with Test Method D 1598 except they shall be unfilled. A1.5.5.2 The squeeze-off shall be effected at the mid-point of the test specimen, 90° to the point of the measured minimum wall thickness. Close the squeeze bars to the gap stop in Specification F 1563 and hold in constraint for 4 h. Remove squeeze bars and	**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 21/2 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 6.6.1, 6.6.1.1 and 6.6.3 using either of the test conditions in Table A1.1 for PE, and in accordance with 6.6 for other materials. A1.2.2 *Product Quality Control* (Note A1.1) The tests in Table A1.2 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)	Annex A1 on PE materials in ASTM D 2513-99 is now in the main body of ASTM D 2513-09a.

’99 Edition	‘09a Edition	Comments
reround pipe by closing squeeze bars at a point 90° from the squeeze area. A1.5.5.3 Immediately upon removal of the squeeze-off tool, fill the specimens with ambient temperature water, that is, 67 ± 10°F (19.4 ± 5.6°C), condition, and test in accordance with 6.6. A1.5.6 *Thermal Stability*—The PE material shall contain sufficient antioxidant so that the minimum induction temperature shall be 428°F (220°C) when tested in accordance with Specification D 3350. The sample shall be representative of the cross section of the pipe or fittings. A1.5.7 *Outdoor Storage Stability*—PE pipe stored outdoors and unprotected for at least two years from date of manufacture shall meet all the requirements of this specification. PE pipe stored outdoors for over two years from date of manufacture is suitable for use if it meets the requirements of this specification. A1.5.8 *Dimensions and Tolerances*—The outside diameter shall meet the requirements in Table 1 and Table 2 in the main body for sizes through 12 in., or in Table A1.3 for larger sizes. The minimum wall thickness shall meet the requirements in Table 2 and Table 3 in the main body for sizes through 12 in., or in Table A1.4 for larger sizes. When sizes other than those listed in these tables are used, the tolerances of the next lower size shall be used. A1.5.9 *Short Term Pressurization for Sizes Above 12 in.*—Pipe and molded or fabricated fittings shall not fail when tested in accordance with Test Method D 1599 with the hoop stress of 2500 psi for Class 2 density materials or 2900 psi for Class 3 density materials. Hoop stress calculation shall be based on the DR of the fitting at the point of fusion. NOTE A1.4—The requirements in A 1.5.8 are for laboratory proof testing only and should not be interpreted as applicable to on-site testing for acceptance of installed systems larger than 12 in. See appropriate installation standards or manufacturer's recommendations for field test procedures. NOTE A1.5—**Safety Precaution**—Pressurization of pipe specimens above 12 in. nominal diameter being tested in accordance with A1.5.8 should not commence until it is certain that all entrapped air has been bled from the water-filled	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 . 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 A1.1). 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. **A1.3 Fittings Tests**[5] A1.3.1 The fittings tests listed in the following sub-paragraphs 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. Fittings that do not meet the requirements shall be rejected. A1.3.2 *Dimensions*: A1.3.2.1 *Socket Fittings:* (a) *Socket Entrance, Bottom and Minimum Internal Diameters*—Once an hour or one out of ten fittings, whichever is less frequent. (b) *Wall Thickness*—At the beginning of each production setup for each cavity. A1.3.2.2 *Butt Fusion Fittings:* (a) *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 *PE Fittings*—At the start of each production run,	

---

[5] Supporting data are available from ASTM Headquarters. Request RR:F17-1018.

<table>
<tr><th>’99 Edition</th><th>‘09a Edition</th><th>Comments</th></tr>
<tr>
<td>specimens.
A1.5.10 <i>HDB Validation for PE Pipe</i>—The 73°F (23°C) Hydrostatic Design Basis (HDB) of PE pipe shall be validated by the pipe producer using the PE validation procedure as outlined in Test Method D 2837. For PE 2406 materials, the HDB of 1250 psi shall be validated; for PE 3408 materials, the HDB of 1600 psi shall be validated.</td>
<td>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:
(a) The knit line strength for at least one fitting from each cavity shall be demonstrated by one of the following tests:
[1] 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.
[2] Apparent tensile strength tests of a ring cut from a fitting, with the load oriented normal to the knit line. See Note A1.5.
[3] Burst testing of the fitting. See Note A1.5.
(b) 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.
TABLE A1.1 PE Material and Extrusion Process Qualification Test Conditions [A]
<table>
<tr><th>Temperature</th><th>Stress</th><th>Time Requirement</th></tr>
<tr><td>176 ± 3.6°F (80 ± 2°C)</td><td>580 ± 10 psi
(4.0 ± 0.07 MPa)</td><td>1000 h</td></tr>
<tr><td>176 ± 3.6°F (80 ± 2°C)</td><td>670 ± 10 psi
(4.6 ± 0.07 MPa)</td><td>170 h</td></tr>
</table>
[A] Methane should not be substituted for water in this 176°F (80°C) test.
TABLE A1.2 Product Quality Control Tests</td>
<td></td>
</tr>
</table>

<table>
<tr><th>’99 Edition</th><th>‘09a Edition</th><th>Comments</th></tr>
<tr><td></td><td><table><tr><th>Property</th><th>Frequency</th></tr><tr><td>Diameter</td><td>once every hour or every coil, whichever is less frequent</td></tr><tr><td>Wall thickness</td><td>once every hour or every coil, whichever is less frequent</td></tr><tr><td>Ring tensile or burst pressure</td><td>Once every 8 h or once every coil, whichever is less frequent, or multilevel plan described in A3.2.3</td></tr></table></td><td></td></tr>
<tr><td></td><td>
</td><td></td></tr>
<tr><td>A1.6 Marking
A1.6.1 PE pipe shall be marked with the melt index category in accordance with Table 4 in addition to the marking requirements of 7.1.</td><td></td><td></td></tr>
<tr><td>TABLE A1.1 Outside Diameters and Tolerances, 14 in. and Larger Pipe<table><tr><th>Nominal Pipe Size</th><th colspan="2">Actual Outside Diameters, in. (mm)</th></tr><tr><th></th><th>Average</th><th>Tolerance</th></tr><tr><td>14</td><td>14.000 (355.6)</td><td>±0.063 (±1.60)</td></tr><tr><td>16</td><td>16.000 (406.4)</td><td>±0.072 (±1.83)</td></tr><tr><td>18</td><td>18.000 (457.2)</td><td>±0.081 (±2.06)</td></tr><tr><td>20</td><td>20.000 (508.0)</td><td>±0.090 (±2.29)</td></tr><tr><td>22</td><td>22.000 (558.8)</td><td>±0.099 (±2.51)</td></tr><tr><td>24</td><td>24.000 (609.6)</td><td>±0.108 (±2.74)</td></tr></table></td><td>A2. IN-PLANT QUALITY CONTROL PROGRAM FOR 14-IN. AND LARGER DIAMETER POLYETHYLENE PIPE
A2.1 Visual inspection of every length of pipe for workmanship defects shall be carried out at the manufacturer's plant. Measurements of outside diameter and wall thickness shall be made for each hour's production or each length of pipe, whichever is less frequent.
A2.2 Lengths of pipe that are shorter than standard shipping lengths are butt-fused to produce standard lengths. Such build-up lengths must otherwise meet all of the product requirements of this specification.
A2.3 Manufacturers of pipe shall conduct such other</td><td></td></tr>
</table>

<table>
<tr><th>’99 Edition</th><th>‘09a Edition</th><th>Comments</th></tr>
<tr><td></td><td>quality control tests as are appropriate to their manufacturing operations that will provide assurance that the product requirements of Section 5 will be met in place of the actual performance of the specified tests.

NOTE A2.1—The pressure tests required under product requirements are tests for performance. These tests are not adaptable to in-plant quality control. Quality control tests have not been standardized because the requirements for such tests vary substantially from one manufacturing plant to another.</td><td></td></tr>
<tr><td>TABLE A1.2 Specification D 3350 Cell Classifications of

Polyethylene Pipe and Fittings Materials
<table>
<tr><th><i>PE Material Designation Code:</i></th><th>PE 2406</th><th>PE 3408</th></tr>
<tr><td><i>Physical Properties:</i></td><td></td><td></td></tr>
<tr><td>Density</td><td>2</td><td>3</td></tr>
<tr><td>Melt index</td><td>1, 2, or 3</td><td>3, 4, or 5</td></tr>
<tr><td>Flexural modulus</td><td>3 or 4</td><td>4 or 5</td></tr>
<tr><td>Tensile strength</td><td>3 or 4</td><td>4 or 5</td></tr>
<tr><td>Slow crack growth resistance</td><td>6</td><td>6</td></tr>
<tr><td>PENT</td><td></td><td></td></tr>
<tr><td>Hydrostatic design basis</td><td>3</td><td>4</td></tr>
</table></td><td>APPENDIX

X1. DESIGN CONSIDERATIONS

X1.1 General

X1.1.1 The design of a PE 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 PE pipe. The design stress for PE pipe used for distribution of natural gas and petroleum fuels is regulated by the U.S. Department of Transportation as published in OPS 49 CFR Part 192 of the Code of Federal Regulations.

X1.2 Design Equations

X1.2.1 <i>Relationship Between Pipe Stress and Pressure</i>—The following expression is used to relate stress, pressure, pipe size, and wall thickness:

$P = 2S/(DR - 1)$
or
$2S/[(D_o/t) - 1]$ (X1.1)</td><td>Annex A1 on PE materials in ASTM D 2513-99 is now in the main body of ASTM D 2513-09a.</td></tr>
</table>

’99 Edition	‘09a Edition	Comments
	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). X1.2.2 The following expression can be used to determine the burst pressure or sustained pressures needed in testing: $P_b = 2S_y/(DR - 1) \quad (X1.2)$ where: P_b = burst pressure, psig (MPa), S_y = yield stress, psi (MPa), and DR = dimension ratio. $P_s = 2S_f/(DR - 1) \quad (X1.3)$ where: P_s = sustained pressure, psig (MPa), S_f = fiber stress psi (MPa), and DR = dimension ratio. X1.2.3 *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. $HDS = (HDB)(f) \quad (X1.4)$ NOTE X1.1—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	

<table>
<tr><th>’99 Edition</th><th>‘09a Edition</th><th>Comments</th></tr>
<tr>
<td></td>
<td>example, the design factor for gas pipelines under the jurisdiction of the Department of Transportation is 0.32.

NOTE X1.2—In some countries, the ISO MRS method is used to determine the maximum operating pressure (MOP) using the formula MOP= 2 MRS/(DR-1) C, which incorporates the pipe DR (dimension ratio), the MRS (minimum required strength) of the pipe material as determined by ISO 9080 and ISO 12162 and the design coefficient (C). Guidance on selection for the value of C is provided in the following references: ISO 4437, ISO 12162, and PPI TR-9.</td>
<td></td>
</tr>
<tr>
<td>TABLE A1.3 Short and Long Term Property Requirements
<table>
<tr><th>PE Material Designation Code</th><th>Short-Term in Accordance with D 3350</th><th>Long-Term in Accordance with D 2837 [A]</th></tr>
<tr><td>PE 2406</td><td>Grade PE 24</td><td>HDB of 1250 psi for 73°F</td></tr>
<tr><td>PE 3408</td><td>Grade PE 34</td><td>HDB of 1600 psi for 73°F</td></tr>
</table>
[A] The hydrostatic design basis (HDB) shall be established using water or natural gas as the pressurizing fluid.</td>
<td>X1.3 Design Stress and Internal Pressure for Natural Gas

X1.3.1 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 test medium should be natural gas or simulated natural gas except that water may be used where previous tests have shown that for the particular type of plastic, water and natural gas give essentially the same test results. The hydrostatic design basis of the PE presently included in the applicable ASTM specifications are as follows:</td>
<td>Annex A1 on PE materials in ASTM D 2513-99 is now in the main body of ASTM D 2513-09a.</td>
</tr>
<tr>
<td>TABLE A1.4 Minimum Wall Thickness and Tolerance, 14 in. and Larger Pipe, in.</td>
<td><table>
<tr><th>PE Pipe Material Designation</th><th>Hydrostatic Design Basis at 73°F (23°C), psi (MPa)</th></tr>
<tr><td>PE2606</td><td>1250 (8.6)</td></tr>
<tr><td>PE2780</td><td>1250 (8.6)</td></tr>
<tr><td>PE3608</td><td>1600 (11.0)</td></tr>
<tr><td>PE3710</td><td>1600 (11.0)</td></tr>
<tr><td>PE4608</td><td>1600 (11.0)</td></tr>
<tr><td>PE4710</td><td>1600 (11.0)</td></tr>
</table>
X1.3.2 The design stresses for natural gas at service temperatures above 73°F (23°C) should be based on hydrostatic</td>
<td>Annex A1 on PE materials in ASTM D 2513-99 is now in the main body of ASTM D 2513-09a.</td>
</tr>
</table>

’99 Edition

Nominal Pipe Size	SDR 32.5	SDR 26	SDR 21	SDR 17	DR 15.5	SDR 13.5	SDR 11	SDR 9	SDR 7.3
14	0.431 +0.052	0.538 +0.065	0.667 +0.080	0.824 +0.099	0.903 +0.108	1.037 +0.124	1.273 +0.153	1.556 +0.187	1.918 +0.230
16	0.492 +0.059	0.615 +0.074	0.762 +0.091	0.941 +0.113	1.032 +0.124	1.185 +0.142	1.455 +0.175	1.778 +0.213	. . .
18	0.554 +0.066	0.692 +0.083	0.857 +0.103	1.059 +0.127	1.161 +0.139	1.333 +0.160	1.636 +0.196	2.000 +0.240	. . .
20	0.615 +0.074	0.769 +0.092	0.952 +0.114	1.176 +0.141	1.290 +0.155	1.481 +0.178	1.818 +0.218	. . .	. . .
22	0.677 +0.081	0.846 +0.102	1.048 +0.126	1.294 +0.155	1.419 +0.170	1.630 +0.196	2.000 +0.240	. . .	. . .
24	0.738 +0.089	0.923 +0.111	1.143 +1.137	1.412 +0.169	1.548 +0.186	1.778 +0.213	2.182 +0.262	. . .	. . .

‘09a Edition

design basis of the pipe that are applicable for the particular use temperature.

X1.3.3 The design stress for PE pipe for fuel gases other than natural gas should be based on hydrostatic design basis categories that have been established with the intended gas as the pressurizing medium (see X1.7.2 for information on the effect of common LPG fuels on the long-term strength of PE pipes).

NOTE X1.3—Water may be used in lieu of a particular fuel gas where previous tests have shown that the results obtained with water are equivalent.

X1.3.4 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, OPS 49 CFR Part 192.

X1.3.5 For liquefied petroleum gas (LPG) applications, a maximum operating pressure of 30 psig (206 kPa) is recommended in NFPA 58 by the members of the National Liquefied Petroleum Gas Association. Liquefied petroleum gas has a higher condensation temperature than does natural gas; this maximum pressure is recommended to ensure that plastic pipe is not subjected to excessive exposure to LPG condensates. (See X1.7.1.)

X1.4 Thermal Stress

X1.4.1 Calculate the longitudinal stress (theoretical) induced in a pipe member between fixed points as follows:

$$S = E \times C \times \Delta t \qquad (X1.5)$$

where:

X1.4.1.1 The measured stress has been determined

Comments

’99 Edition	‘09a Edition	Comments
	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). to be less than that calculated. This difference is caused by the stress relaxation in viscoelastic materials. X1.4.2 Calculate the theoretical force sustained at the fixed points (typically joints) in a pipe member as follows: $F = S \times A \qquad (X1.6)$ where: F = force, lbf (N), S = stress, psi (MPa), and A = cross-sectional pipe wall area, in.^{2} (mm^2). X1.4.3 Calculate pipe contraction in unrestrained pipe caused by a reduction in temperature as follows: $\Delta L = k \times L \times C \times \Delta t \qquad (X1.7)$ 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.	
	X1.5 Installation Procedure X1.5.1 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 (as defined by Marston and Spangler **(2)**) 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	

’99 Edition	‘09a Edition	Comments
	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[6] are recommended. X1.5.2 Unrestrained PE pipe expands and contracts from thermal change significantly more than metallic pipe. This ratio may be of the magnitude of ten to one. Typical coefficients of thermal expansion for unrestrained pipe for PE is 9.0 × 10^{-5} (in./in.)/°F 24.30 (mm/mm)°C. X1.5.2.1 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. X1.5.3 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 support and containment of the pipe through suitable bedding and backfilling procedures. Attention should be given to all joints, particularly to transition joints between PE and metal pipe. X1.5.4 It is desirable to have pipe joints that are as strong as the pipe itself in the longitudinal (axial) direction. Thermal fusion, and mechanical joints outlined in 6.10, Category 1 can provide such joint strength. The joint strength is a function of the assembly procedure, the design of the fitting, and the pipe material and dimensions (see X1.5.5). X1.5.5 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. X1.5.6 Plastic pipe joined with mechanical connectors that utilize a compression-type gasket must be reinforced by means of a tubular stiffener that extends at least under the section of	

---

[6] Available from American Gas Association (AGA) 400 North Capitol Street, NW Suite 450 Washington, DC 20001, http://www.aga.org.

'99 Edition	'09a Edition	Comments
	pipe being compressed by the gasket and the gripping device (where used). The stiffener shall be nonsplit-type design to meet the performance requirements recommended by the manufacturer of the fitting in which it is used, and the joint shall meet the test requirements outlined in 6.10. X1.5.7 Kinks found in the pipe shall be cut out. Pipe with kinks shall not be placed in service.	
	X1.6 Repair Considerations **X1.6.1 Repairs may be made to PE pipe under appropriate circumstances. Selection and installation considerations for the use of full encirclement band clamps are available in ASTM Guide F1025. Additional information on repair of PE 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.[7]**	
	X1.7 Environmental Effects X1.7.1 *Natural Gas*—The natural gas of commerce consists of methane as the principal constituent with minor amounts of other gases, which can include other hydrocarbons (for example, ethane, propane, butane, pentane), inert gases (for example, nitrogen, carbon dioxide), and odorants. The long term effect of natural gas (methane, but with minor amounts of other gases) at 73°F (23°C) has been shown (**3,4**) to be essentially equivalent to that of water at 73°F (23°C) for PE pipe. X1.7.2 *Other Fuel Gases*— In accordance with this specification, PE materials must have not less than a 1250 psi HDB for 73.4°F, for methane. It has been shown (**5, 6,** and **7**) that aliphatic gaseous fuels of higher molecular weights than methane (natural gas) somewhat reduce the long-term strength of PE pipe materials compared to when using methane or water as the pressurizing medium. The reduction in PE's long-	

---

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

'99 Edition	'09a Edition	Comments
	term strength caused by gaseous propane, propylene and butane is modest, well under 20 %. On this basis one report (**5**) considers an HDB of 1000 psi, for 73.4°F, as a reasonable and conservative design basis for PE piping materials intended for LPG fuel gas service. X1.7.2.1 However, it has also been shown by the above referenced studies that propane, propylene and butane, when in the liquid phase, can cause a greater reduction in long-term strength, up to 40 %. Accordingly, the use of PE piping to convey LPG gaseous fuels should recognize this effect and the design and operation of such piping should consider the possibility for the occurrence of condensates. Extensive experience has shown that the NFPA maximum recommended operating pressure of 30 psig for LPG systems (see X1.3.4) both minimizes the possible occurrence of condensates and gives adequate consideration of the effect of LPG fuels on the long-term strength of PE piping. X1.7.2.2 It has been reported **(8,9)** and **(10)**, that during the heat fusion joining of PE piping that has been in service conveying fuel gases that consist of, or that include heavier hydrocarbons, the PE surfaces being heated in preparation for fusion sometimes exhibit a *bubbly* appearance. This bubbling is the result of the rapid expansion (by heat) and passage of absorbed heavier hydrocarbon gases through the molten material. Heat fusion (butt, socket, saddle, or electrofusion) joint strength may be reduced by the presence of the heavier hydrocarbons. Pimputkar et al **(8)** conclude that for a system operating at 50psi and conveying a mixture of as high as 16 volume percent in methane the propane concentration in PE will be under 0.2 percent, sufficient to sometimes show some bubbling, but not high enough to effect any significant degradation in fusion strength. However, if the concentration of propane in PE exceeds 0.2 percent, there is the risk of a rapid and large drop in fusion strength. Field tests to verify the level of contamination and subsequent degradation of joint strength are not currently available. Therefore, in the case of PE pipe that has previously been installed in these types of services, one should use mechanical fittings to join or repair the pipe. NOTE X1.4—PPI Technical Report TR 22–88 (**5**) lists maximum operating pressures for various minimum operating temperatures at which condensates will not form in LPG	

'99 Edition	'09a Edition	Comments
	systems in which the primary fuels are propane and butane.	
	BIBLIOGRAPHY (1) D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[2] (2) D1603 Test Method for Carbon Black Content in Olefin Plastics[2] (3) D4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle Furnace Technique[2] (4) D4883 Test method for density of Polyethylene by the Ultrasound Technique[2] (5) ISO 11922–1 Thermoplastics pipes for the conveyance of fluids–Dimensions and tolerances —Part 1: Metric series[5] (6) PPI TR-4 Hydrostatic Design Bases and Maximum Recommended Hydrostatic Design Stresses for Thermoplastic Piping Materials[6] National Fire Protection Association: NFPA 54,Storage and Handling Liquefied Petroleum Gases[7]	
A2. SUPPLEMENTAL REQUIREMENTS FOR GAS PRESSURE PIPE AND FITTINGS PRODUCED FROM POLY (VINYL CHLORIDE) (PVC) COMPOUNDS		Annex A2 on PVC materials in ASTM D2513-99 is now a new stand-alone ASTM standard for PVC gas pipe – ASTM F2817. It is no longer part of ASTM D2513-09a
A2.1 Scope **A2.1.1 This annex covers requirements for PVC pipe and fittings. These requirements are in addition to those in the main body of this specification.**		Annex A2 on PVC materials in ASTM D2513-99 is now a new stand-alone ASTM standard for PVC gas pipe – ASTM F2817. It is no longer part of ASTM D2513-09a
A2.2 Referenced Documents A2.2.1 *ASTM Standards*: A2.2.1.1 *Specifications for*: D 1784 Rigid Poly (Vinyl Chloride) (PVC) Compounds and		Annex A2 on PVC materials in ASTM D2513-99 is now a new stand-alone ASTM standard for PVC gas pipe – ASTM F2817. It is no longer part of ASTM D2513-09a

’99 Edition	‘09a Edition	Comments
Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds[2] D 2241 Poly (Vinyl Chloride) (PVC) Pressure-Related Pipe (SDR-PR)[2] D 2466 Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40[2] D 2467 Socket Type Poly (Vinyl Chloride) (PVC) Plastic Fittings, Schedule 80[2] D 2564 Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems[2] D 2672 Joints for IPS PVC Pipe Using Solvent Cement[2] D 2740 Poly (Vinyl Chloride) (PVC) Plastic Tubing[2] A2.2.1.2 *Test Methods and Practices*: D 2152 Degree of Fusion of Extruded Poly (Vinyl Chloride) (PVC) Pipe by Acetone Immersion[2] D 2412 Determination of External Loading Properties of Plastic Pipe by Parallel Plate Loading[2] D 2444 Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)[2] D 2855 Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings[2] F 402 Safe Handling and Solvent Cements Used for Joining Thermoplastic Pipe and Fittings[2]		
A2.3 Materials A2.3.1 PVC pipe and fittings shall be made from the following PVC plastics as defined in Specification D 1784. Type I, Grade 1, Class 12454B (PVC 11) Type II, Grade 1, Class 14333D (PVC 21) **A2.4 Requirements** A2.4.1 Requirements for plain end pipe are specified in Specification D 2241. Belled end pipe requirements are specified in Specification D 2672. Fitting requirements are specified in Specification D 2466 for schedule 40 and Specification D 2467 for schedule 80. These fittings are intended for use with corresponding sized outside diameter pipe made from the same compound. The following additional requirements shall also be		Annex A2 on PVC materials in ASTM D2513-99 is now a new stand-alone ASTM standard for PVC gas pipe – ASTM F2817. It is no longer part of ASTM D2513-09a

’99 Edition	‘09a Edition	Comments
met. A2.4.1.1 *Flattening*—There shall be no evidence of splitting, cracking, or breaking by the specimens subjected to this test and performed in accordance with Test Method D 2412. Flatten three specimens of the pipe, 2 in. (50.8 mm) long, between parallel plates in a suitable press until the distance between the plates is 40 % of the outside diameter of the pipe or the walls of pipe touch. The rate of loading shall be uniform and such that the compression is completed within 2 to 5 min. On removal of the load, examine the specimens for evidence of splitting, cracking, or breaking. A2.4.1.2 *Impact Resistance*—The impact resistance for PVC pipe shall fall within the range specified by the manufacturer's designated Impact Classification Cell (IC). Table A2.1 lists impact classification cell for SDR 17 and 21 pipe. The impact classification rating for PVC pipe shall be determined in accordance with Test Method D 2444 using a flat plate holder and 20-lb tup B for sizes 2 in. and less and 30-lb tup B for all larger sizes. The specimens shall be conditioned in a mixture of ice and water at 32 to 35°F (0 to 2°C) for 1 h (Note A2.1) and tested immediately on removal from this medium. **TABLE A2.1 Impact Requirements for PVC Pipe at 32 to 35°F (0** **to 2°C) for SDR 17 and 21 Pipe** (See Table A2.1) NOTE A2.1—Other conditioning media such as a refrigerated fluid bath of water and ethylene glycol at 32 to 35°F (0 to 2°C) for 1 h or a refrigerated air chamber at 32 to 35°F (0 to 2°C) for 4 h may be used if it can be demonstrated that equivalent results are obtained. However, in cases of disagreement, the ice water mixture shall be used. A2.4.1.3 *Impact Quality Assurance*—The impact quality assurance is a “GO/NO–GO” test. Five specimens shall be impacted in accordance with Test Method D 2444 using the tup and holder specified in A2.4.1.2 from a height determined by the lower value of the designated Impact Classification (IC) cell. All five specimens shall pass. If one specimen fails, a second set of five specimens shall be tested. None of the second set shall fail. If		

’99 Edition	‘09a Edition	Comments
nine out of the total ten specimens pass, the lot shall be considered to have met the requirements of this test. NOTE A2.2—This test is intended only for use as a quality control test, not for use as a simulated service test. A2.4.1.4 *Extrusion Quality*—PVC pipe shall not flake or disintegrate when tested in accordance with the Test Method D 2152. A2.4.1.5 *Outdoor Storage Stability*—PVC pipe when stored outdoors unprotected for six months from the date of extrusion shall meet all the requirements of this specification. PVC pipe stored outdoors for over six months from date of manufacture, is suitable for use if it meets the requirements of this specification. A2.4.1.6 *Solvent Cements for PVC Systems*—Solvent cements for PVC pipe and fittings shall meet the requirements of Specification D 2564. A2.4.1.7 *Marking*—Impact Classification Cell, as determined by the manufacturer, shall be printed on the pipe in addition to the marking requirements of 7.1. A2.4.1.8 *Minimum Hydrostatic Burst Strength/Apparent Tensile Strength*—The minimum burst pressure for PVC pipe shall be as given in Table A2.2 or as calculated (using the actural measured minimum wall, the actual measured average outside diameter, and the applicable fiber stress shown in Table A2.3) when determined in accordance with Test Method D 1599. For sizes above 4-in. nominal diameter, the testing laboratory shall be allowed to replace the quick burst (Test Method D 1599) by the apparent ring tensile strength test (Test Method D 2290). The minimum fiber stress shall be as given in Table A2.3. A2.4.1.9 *Sustained Pressure 73°F (23°C)*—The pipe or system shall not fail in less than 1000 h when tested in accordance with Test Method D 1598. The stress shall be as given in Table A2.3. **A2.5 Safety Requirements** **A2.5.1 Safety requirements for handling solvent cements shall be observed. Consult Practice F 402 and the solvent cement manufacturer for appropriate precautions**		

'99 Edition	'09a Edition	Comments
TABLE A2.1 Impact Requirements for PVC Pipe at 32 to 35°F (0 to 2°C) for SDR 17 and 21 Pipe		

<table>
<tr><th>'99 Edition</th><th>'09a Edition</th><th>Comments</th></tr>
<tr><td>
<table>
<tr><th>Impact Classification Cell</th><th colspan="3">ft·lbf (J)</th></tr>
<tr><th></th><th>IC-1</th><th>IC-2</th><th>IC-3</th></tr>
<tr><td>Nominal Pipe Size, in.</td><td></td><td></td><td></td></tr>
<tr><td>1</td><td>30 to 50
(41 to 68)</td><td>>50 to 65
(68 to 88)</td><td>>65 (88)</td></tr>
<tr><td>11/4</td><td>30 to 51
(41 to 68)</td><td>>50 to 65
(68 to 88)</td><td>>65 (88)</td></tr>
<tr><td>11/2</td><td>40 to 60
(54 to 81)</td><td>>60 to 75
(81 to 102)</td><td>>75 (102)</td></tr>
<tr><td>2</td><td>70 to 90
(95 to 122)</td><td>>90 to 100
(122 to 136)</td><td>>100 (122)</td></tr>
<tr><td>3</td><td>120 to 140
(163 to 190)</td><td>>140 to 180
(190 to 244)</td><td>>180 (244)</td></tr>
<tr><td>4</td><td>160 to 200
(217 to 271)</td><td>>200 to 240
(271 to 326)</td><td>>240 (326)</td></tr>
<tr><td>6</td><td>200 to 260
(271 to 353)</td><td>>260 to 300
(353 to 407)</td><td>>300 (407)</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>TABLE A2.2 Minimum Burst Pressure Test Requirements for
PVC Pipe at 73°F (23°C)</td><td></td><td>Annex A2 on PVC materials in ASTM D2513-99 is now a new stand-alone ASTM standard for PVC gas pipe – ASTM F2817. It is no longer part of ASTM D2513-09a</td></tr>
</table>

<table>
<tr><th>**'99 Edition**</th><th>'09a Edition</th><th>Comments</th></tr>
<tr><td>
<table>
<tr><th>Standard
Demension
Ratio</th><th>Minimum Burst Pressure, psi (MPa)</th><th></th></tr>
<tr><th></th><th>PVC 1120</th><th>PVC 2110
PVC 2116</th></tr>
<tr><td>11</td><td>1250 (8.6)</td><td>1000 (6.9)</td></tr>
<tr><td>13.5</td><td>1000 (6.9)</td><td>800 (5.5)</td></tr>
<tr><td>17</td><td>800 (5.5)</td><td>630 (4.3)</td></tr>
<tr><td>21</td><td>630 (4.3)</td><td>500 (3.4)</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>
TABLE A2.3 Minimum Fiber Stress, psi (MPa)
<table>
<tr><th></th><th>Minimum Hydrostatic Burst Strength and Apparent Tensile Tests</th><th>Sustained Pressure Test</th></tr>
<tr><td>PVC 1120</td><td>6400 (44.1)</td><td>4200 (29.0)</td></tr>
<tr><td>PVC 1220</td><td>6400 (44.1)</td><td>4200 (29.0)</td></tr>
<tr><td>PVC 2110</td><td>5000 (34.5)</td><td>2300 (15.9)</td></tr>
<tr><td>PVC 2116</td><td>5000 (34.5)</td><td>3650 (23.2)</td></tr>
</table>
</td><td></td><td>Annex A2 on PVC materials in ASTM D2513-99 is now a new stand-alone ASTM standard for PVC gas pipe – ASTM F2817. It is no longer part of ASTM D2513-09a</td></tr>
<tr><td>**A3. IN-PLANT QUALITY CONTROL PROGRAM FOR PLASTIC PIPE AND FITTINGS UP TO AND INCLUDING 12 IN. NOMINAL DIAMETER**</td><td></td><td>Annex A3 on a QC Program up to 12" is now in Annex A1.</td></tr>
<tr><td>**A3.1 Quality Control**
A3.1.1 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.
A3.1.2 *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,</td><td></td><td>Annex A3 on a QC Program up to 12" is now in Annex A1.</td></tr>
</table>

’99 Edition	‘09a Edition	Comments
those test methods in the applicable ASTM standard shall be used.		
A3.2 Pipe Tests A3.2.1 *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 21/2 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 6.6.1, 6.6.1.1 and 6.6.3 using either of the test conditions in Table A3.1 for PE, and in accordance with 6.6 for other materials. A3.2.2 *Product Quality Control* (Note A3.1)The tests in Table A3.2 shall be made per size per extrusion die at the denoted frequencies and the test results recorded and filed for inspection on request. NOTE A3.1—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. (See Table A3.1) (See Table A3.2) NOTE A3.2—For pipe sizes above 4 in. nominal diameter, the quick burst test (Test Method D 1599) may be replaced by the Apparent Ring Tensile Strength Test (Test Method D 2290) if agreed to between the purchaser and the manufacturer.		Annex A3 on a QC Program up to 12” is now in Annex A1.
A3.2.3 *Burst Pressure Multilevel Plan (see Fig. A3.1)*—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		Annex A3 on a QC Program up to 12” is now in Annex A1.

’99 Edition	‘09a Edition	Comments
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 A2.1). 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 A3.1). 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		
A3.3 Fittings Tests[8] A3.3.1 The fittings tests listed in the following sub-paragraphs shall be conducted at the frequencies indicated. NOTE A3.3—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. Fittings that do not meet the requirements shall be rejected.		Annex A3 on a QC Program up to 12” is now in Annex A1.

---

[8] Supporting data are available from ASTM Headquarters. Request RR: F17-1018.

’99 Edition	‘09a Edition	Comments
(See Fig A3.1 Quick Burst Multilevel Sampling Plan) A3.3.2 *Dimensions*: A3.3.2.1 *Socket Fittings:* (a) *Socket Entrance, Bottom and Minimum Internal Diameters*—Once an hour or one out of ten fittings, whichever is less frequent. (b) *Wall Thickness*—At the beginning of each production setup for each cavity. A3.3.2.2 *Butt Fusion Fittings:* (a) *Outside Diameter and Wall Thickness*—Once an hour or one out of ten fittings, whichever is less frequent. A3.3.3 *Other Tests:* A3.3.3.1 *PVC Fittings*—The burst pressure shall be measured on one fitting per 8-h production. A3.3.3.2 *PE and PB Fittings*—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: (a) The knit line strength for at least one fitting from each cavity shall be demonstrated by one of the following tests: [1] 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 A3.4. [2] Apparent tensile strength tests of a ring cut from a fitting, with the load oriented normal to the knit line. See Note A3.5. [3] Burst testing of the fitting. See Note A3.5. (b) The integrity of at least one part from each mold cavity shall be verified, using a method selected by the manufacturer as appropriate for his specific product and process. NOTE A3.4—Separation in the knit constitutes a failure. NOTE A3.5—In tests 2 and 3 the strength requirements shown in the annexes must be met.		
A4. IN-PLANT QUALITY CONTROL PROGRAM FOR 14-IN. AND LARGER DIAMETER POLYETHYLENE PIPE A4.1 Visual inspection of every length of pipe for		Annex A4 on a QC Program for 14” and larger pipe is now in Annex A2.

’99 Edition	‘09a Edition	Comments
workmanship defects shall be carried out at the manufacturer's plant. Measurements of outside diameter and wall thickness shall be made for each hour's production or each length of pipe, whichever is less frequent. A4.2 Lengths of pipe that are shorter than standard shipping lengths are butt-fused to produce standard lengths. Such build-up lengths must otherwise meet all of the product requirements of this specification. A4.3 Manufacturers of pipe shall conduct such other quality control tests as are appropriate to their manufacturing operations that will provide assurance that the product requirements of A1.5 will be met in place of the actual performance of the specified tests. NOTE A4.1—The pressure tests required under product requirements are tests for performance. These tests are not adaptable to in-plant quality control. Quality control tests have not been standardized because the requirements for such tests vary substantially from one manufacturing plant to another.		
A5. SUPPLEMENTAL REQUIREMENTS FOR GAS PRESSURE PIPE AND FITTINGS PRODUCED FROM POLYAMIDE MATERIAL		Annex A5 on polyamide materials in ASTM D2513-99 has been removed from ASTM D2513 and is now an open project in ASTM F17.60 to develop a new ASTM standard for PA-11 (Project 60-10-13 – WK28623)
A5.1 Scope A5.1.1 This annex covers requirements for PA pipe and heat fusion fittings. These requirements are in addition to those in the main body of this specification.		Annex A5 on polyamide materials in ASTM D2513-99 has been removed from ASTM D2513 and is now an open project in ASTM F17.60 to develop a new ASTM standard for PA-11 (Project 60-10-13 – WK28623)
A5.2 Referenced Documents A5.2.1 *ASTM Standards*: D 4066 Specification for Nylon Injection and Extrusion Materials (PA)[3]F 1563 Specification for Tools to Squeeze-Off Gas Pipe and Fittings[3]		Annex A5 on polyamide materials in ASTM D2513-99 has been removed from ASTM D2513 and is now an open project in ASTM F17.60 to develop a new ASTM standard for PA-11 (Project 60-10-13 – WK28623)

’99 Edition	‘09a Edition	Comments
A5.3 Materials A5.3.1 *Classification*—Polyamide materials suitable for use in the manufacturing of pipe and fittings under this specification shall be classified in accordance with Specification D 4066, as shown in Table A5.1. A5.3.2 *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 A5.2.		Annex A5 on polyamide materials in ASTM D2513-99 has been removed from ASTM D2513 and is now an open project in ASTM F17.60 to develop a new ASTM standard for PA-11 (Project 60-10-13 – WK28623)
A5.4 Requirements for Pipe and Fittings A5.4.1 *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. A5.4.2 *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 D 1599 at a 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 D 1599) by the apparent ring tensile strength test (Test method D 2290). The minimum apparent tensile strength at yield when determined in accordance with 6.8 shall be 3900 psi (27 MPa). A5.4.3 *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 D 1598. The stress shall be 2800 psi (19 MPa). A5.4.4 *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 1000-h sustained pressure category when pipe is tested as follows: A5.4.4.1 Prepare six randomly selected pipe specimens in accordance with Test Method D 1598, except they shall be unfilled. A5.4.4.2 The squeeze-off shall be effected at the midpoint of		Annex A5 on polyamide materials in ASTM D2513-99 has been removed from ASTM D2513 and is now an open project in ASTM F17.60 to develop a new ASTM standard for PA-11 (Project 60-10-13 – WK28623)

’99 Edition	‘09a Edition	Comments
the test specimen, 90° to the point of the measured minimum wall thickness. Close the squeeze bars to the gap stop in Specification F 1563 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. A5.4.4.3 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 6.6. A5.4.5 *Outdoor Storage Stability*—PA pipe stored outdoors and unprotected for at least two years from date of manufacture shall meet all the requirements of this specification. PA pipe stored outdoors for over two years from date of manufacture is suitable for use if it meets the requirements of this specification. A5.4.6 *Chemical Resistance*—The weight, yield strength, and inherent viscosity requirements for polyamide pipe when measured in accordance with 6.9 are in Table A5.3.		
A5.5 Marking A5.5.1 PA pipe shall be marked with the elevated temperature code letters EF CG in accordance with Table 4 in addition to the marking requirements of 7.1. E = maximum temperature of 180°F (82°C), F = 1250 psi HDB at 180°F (82°C), C = temperature of 140°F (60°C), and G = 1600 psi HDB at 140°F (60°C).		Annex A5 on polyamide materials in ASTM D2513-99 has been removed from ASTM D2513 and is now an open project in ASTM F17.60 to develop a new ASTM standard for PA-11 (Project 60-10-13 – WK28623)
TABLE A5.1 Specification D 4066 Classification **(See Table A5.1)** **TABLE A5.2 Short and Long Term Property Requirements** (See Table A5.2) **TABLE A5.3 Chemical Resistance**		Annex A5 on polyamide materials in ASTM D2513-99 has been removed from ASTM D2513 and is now an open project in ASTM F17.60 to develop a new ASTM standard for PA-11 (Project 60-10-13 – WK28623)

'99 Edition	'09a Edition	Comments
(See Table A5.3)		
APPENDIXES **(Nonmandatory Information)** **X1. NEW MATERIALS** X1.1 It is the intent of ASTM Committee F-17 on Plastic Piping Systems to consider for inclusion other kinds, types, and grades of thermoplastics in this specification, when evidence is presented to show that they are suitable for underground distribution of natural gas. Minimum requirements, in addition to all the pertinent parts of this specification are: (1) an ASTM material specification, (2) and ASTM product specification, (3) the material's long-term hydrostatic strength, determined in accordance with an appropriate test method such as Test Method D 2837, and (4) at least 3 years of service-related evidence to demonstrate that the material has performed satisfactorily as underground gas pressure piping. X1.2 Each candidate material is considered individually with respect to its own properties, the intended application, and other pertinent usage experience. Experience with a related approved material may be applicable to a new material provided the germane correlations can be demonstrated. X1.3 An example of appropriate evidence to meet service related requirements, but not necessarily the only way, would be a minimum of 3 years evaluation of representative piping systems in gas service under representative conditions without significant change in physical or mechanical properties. Such systems should aggregate at least 1000 ft (305 m) of piping to provide an ample basis for statistical evaluation. Piping systems should contain representative pipe sizes and companion pipe fittings such as elbows, tees, couplings, and caps. Recommendations for making individual service connections on both pressured and unpressured systems is also desirable information. If special backfill materials or techniques are necessary for satisfactory performance, they should be so stated and described; otherwise generally accepted industry practices are assumed to be adequate. Publications of the American Gas Association and the Plastic		Appendix X1 on new materials in ASTM D2513-99 has been removed from ASTM D2513 and is now an open project in ASTM F17.60 to develop a new ASTM standard practice for introduction of new materials (Project 60-08-03 – WK19571)

’99 Edition	‘09a Edition	Comments
Pipe Institute contain information which may be useful in assessing the suitability or relevancy of candidate materials.		
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 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 F-17 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.	**X1.1 General** X1.1.1 The design of a PE 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 PE pipe. The design stress for PE pipe used for distribution of natural gas and petroleum fuels is regulated by the U.S. Department of Transportation as published in OPS 49 CFR Part 192 of the Code of Federal Regulations.	Appendix X2 on design considerations in ASTM D2513-99 is now Appendix X1 in ASTM D2513-09a
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: $P = 2S/(DR - 1) \text{ or } 2S/[(D_o/t) - 1]$ where:	X1.2.1 *Relationship Between Pipe Stress and Pressure*—The following expression is used to relate stress, pressure, pipe size, and wall thickness: $P = 2S/(DR - 1) \text{ or } 2S/[(D_o/t) - 1]$ 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).	Appendix X2 on design considerations in ASTM D2513-99 is now Appendix X1 in ASTM D2513-09a

’99 Edition	‘09a Edition	Comments
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: $P_b = 2S_y/(DR - 1)$ (X2.2) where: P_b = burst pressure, psig (MPa), S_y = yield stress, psi (MPa), and DR = dimension ratio.	X1.2.2 The following expression can be used to determine the burst pressure or sustained pressures needed in testing: $P_b = 2S_y/(DR-1)$ (X1.2) where: P_b = burst pressure, psig (MPa), S_y = yield stress, psi (MPa), and DR = dimension ratio.	Appendix X2 on design considerations in ASTM D2513-99 is now Appendix X1 in ASTM D2513-09a
$P_s = 2S_f/(DR - 1)$ (X2.3) where: P_s = sustained pressure, psig (MPa), S_f = fiber stress psi (MPa), and DR = dimension ratio.	**$P_s = 2S_f/(DR-1)$ (X1.3)** where: P_s = sustained pressure, psig (MPa), S_f = fiber stress psi (MPa), and DR = dimension ratio.	Appendix X2 on design considerations in ASTM D2513-99 is now Appendix X1 in ASTM D2513-09a
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. $HDS = (HDB)(f)$ (X2.4) NOTE X2.1—The actual choice of design factor for a given installation must be reviewed by the design engineer taking into	X1.2.3 *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) (X1.4) NOTE X1.1—The actual choice of design factor for a given installation must be reviewed by the design engineer taking into	Appendix X2 on design considerations in ASTM D2513-99 is now Appendix X1 in ASTM D2513-09a

’99 Edition	‘09a Edition	Comments
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.	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. NOTE X1.2—In some countries, the ISO MRS method is used to determine the maximum operating pressure (MOP) using the formula MOP= 2 MRS/(DR-1) C, which incorporates the pipe DR (dimension ratio), the MRS (minimum required strength) of the pipe material as determined by ISO 9080 and ISO 12162 and the design coefficient (C). Guidance on selection for the value of C is provided in the following references: ISO 4437, ISO 12162, and PPI TR-9.	
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 D 2837. The test medium should be natural gas or simulated natural gas except that water may be used where previous tests have shown that for the particular type of plastic, water and natural gas give essentially the same test results. The hydrostatic design basis of the plastics presently included in the applicable ASTM specifications are as follows: Plastic Pipe Material Designation / Hydrostatic Design Basis at 73°F (23°C), psi (MP PA 32312 2500 (17.2) PE 2406 1250 (8.6) PE 3~~4~~08 1600 (11.0) PVC 1120 4000 (27.6) PVC 2110 2000 (13.8) PVC 2116 3150 (24.8)	**X1.3 Design Stress and Internal Pressure for Natural Gas** X1.3.1 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 test medium should be natural gas or simulated natural gas except that water may be used where previous tests have shown that for the particular type of plastic, water and natural gas give essentially the same test results. The hydrostatic design basis of the PE presently included in the applicable ASTM specifications are as follows: PE Pipe Material Designation / Hydrostatic Desig Basis at 73°F (23°C), psi (M PE2606 1250 (8.6) PE2780 1250 (8.6) PE3608 1600 (11.0) PE3710 1600 (11.0) PE4608 1600 (11.0) PE4710 1600 (11.0)	Appendix X2 on design considerations in ASTM D2513-99 is now Appendix X1 in ASTM D2513-09a
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.	X1.3.2 **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 stress for PE pipe for fuel gases other than	X1.3.3 The design stress for PE pipe for fuel gases other than	

’99 Edition	‘09a Edition	Comments
natural gas should be based on hydrostatic design basis categories that have been established with the intended gas as the pressurizing medium (see X.2.7.2 for information on the effect of common LPG fuels on the long-term strength of PE pipes).	natural gas should be based on hydrostatic design basis categories that have been established with the intended gas as the pressurizing medium (see X1.7.2 for information on the effect of common LPG fuels on the long-term strength of PE pipes).	
NOTE X2.2—Water may be used in lieu of a particular fuel gas where previous tests have shown that the results obtained with water are equivalent.	NOTE X1.3—Water may be used in lieu of a particular fuel gas where previous tests have shown that the results obtained with water are equivalent.	
X2.3.4 Strengths for other plastic pipe materials will be added when these materials are included in the applicable ASTM specifications~~.~~ 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.	X1.3.4 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, OPS 49 CFR Part 192.	
X2.3.5 For liquefied petroleum gas (LPG) applications, a maximum operating pressure of 30 psig (206 kPa) is recommended in NFPA 58 by the members of the National Liquefied Petroleum Gas Association. Liquefied petroleum gas has a higher condensation temperature than does natural gas; this maximum pressure is recommended to ensure that plastic pipe is not subjected to excessive exposure to LPG condensates. (See X2.7.1.)	X1.3.5 For liquefied petroleum gas (LPG) applications, a maximum operating pressure of 30 psig (206 kPa) is recommended in NFPA 58 by the members of the National Liquefied Petroleum Gas Association. Liquefied petroleum gas has a higher condensation temperature than does natural gas; this maximum pressure is recommended to ensure that plastic pipe is not subjected to excessive exposure to LPG condensates. (See X1.7.1.)	
X2.4 Thermal Stress	**X1.4 Thermal Stress**	
X2.4.1 Calculate the longitudinal stress (theoretical) induced in a pipe member between fixed points as follows: $S = E \times C \times \Delta t \qquad (X2.5)$ where: S = stress, psi (MPa),	X1.4.1 Calculate the longitudinal stress (theoretical) induced in a pipe member between fixed points as follows: $S = E \times C \times \Delta t \qquad (X1.5)$ where: S = stress, psi (MPa),	

’99 Edition	‘09a Edition	Comments
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).	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.	X1.4.1.1 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: $F = S \times A$ (X2.6) where: F = force, lbf (N), S = stress, psi (MPa), and A = cross-sectional pipe wall area, in.^{2}	X1.4.2 Calculate the theoretical force sustained at the fixed points (typically joints) in a pipe member as follows: $F = S \times A$ (X1.6) where: F = force, lbf (N), S = stress, psi (MPa), and A = cross-sectional pipe wall area, in.^{2}	
X2.4.3 Calculate pipe contraction in unrestrained pipe caused by a reduction in temperature as follows: $\Delta L = k \times L \times C \times \Delta t$ (X2.7) where: ΔL = change in length, k = 1000 for ΔL (mm), L (m), C (°C^{-1}) k = 12 for ΔL (in.), L (ft), C (°F^{-1}), Δt (L = original length, C = coefficient of linear expansion, and Δt = temperature change.	X1.4.3 Calculate pipe contraction in unrestrained pipe caused by a reduction in temperature as follows: $\Delta L = k \times L \times C \times \Delta t$ (X1.7) where: ΔL = change in length, k = 1000 for ΔL (mm), L (m), C (°C k = 12 for ΔL (in.), L (ft), C (°F^{-1}), Δ L = original length, C = coefficient of linear expansion, a Δt = temperature change.	
X2.5 Installation Procedure	**X1.5 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 (as defined by Marston and Spangler **(2)**) to support	X1.5.1 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 (as defined by Marston and Spangler **(2)**)	

’99 Edition	‘09a Edition	Comments
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 ~~B~~ 2774, ANSI B31.8, and the AGA Plastic Pipe Manual for Gas Service are recommended.	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[9] 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. Typical coefficients of thermal expansion for unrestrained pipe are as follows (see Note X2.3): PE 9.0×10^{-5} (in./in.)/°F 24.30 (mm/mm)/°C PVC 3.5×10^{-5} (in./in.)/°F 11.45 (mm/mm)/°C 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.	X1.5.2 Unrestrained PE pipe expands and contracts from thermal change significantly more than metallic pipe. This ratio may be of the magnitude of ten to one. Typical coefficients of thermal expansion for unrestrained pipe for PE is 9.0×10^{-5} (in./in.)/°F 24.30 (mm/mm)°C.	
NOTE X2.3—Coefficient of thermal expansion for the specific pipe being considered should be used, if available.		
	X1.5.2.1 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 support and containment of the pipe through suitable bedding and backfilling procedures. Attention should be given to all joints, particularly to	X1.5.3 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 support and containment of the pipe through suitable bedding and backfilling procedures. Attention should be given to all joints,	

---

[9] Available from American Gas Association (AGA) 400 North Capitol Street, NW Suite 450 Washington, DC 20001, http://www.aga.org.

’99 Edition	‘09a Edition	Comments
transition joints between ~~plastic~~ and metal pipe.	particularly to transition joints between PE 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. Thermal fusion, solvent cement joints~~,~~ and mechanical joints outlined in 6.10, Category 1 can provide such joint strength. The joint strength is a function of the assembly procedure, the design of the fitting, and the pipe material and dimensions (see X2.5.5).	X1.5.4 It is desirable to have pipe joints that are as strong as the pipe itself in the longitudinal (axial) direction. Thermal fusion, and mechanical joints outlined in 6.10, Category 1 can provide such joint strength. The joint strength is a function of the assembly procedure, the design of the fitting, and the pipe material and dimensions (see X1.5.5).	
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.	X1.5.5 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 Plastic pipe joined with mechanical connectors that utilize a compression-type gasket must be reinforced by means of a tubular stiffener that extends at least under the section of pipe being compressed by the gasket and the gripping device (where used). The stiffener shall be nonsplit-type design to meet the performance requirements recommended by the manufacturer of the fitting in which it is used, and the joint shall meet the test requirements outlined in 6.10.	X1.5.6 Plastic pipe joined with mechanical connectors that utilize a compression-type gasket must be reinforced by means of a tubular stiffener that extends at least under the section of pipe being compressed by the gasket and the gripping device (where used). The stiffener shall be nonsplit-type design to meet the performance requirements recommended by the manufacturer of the fitting in which it is used, and the joint shall meet the test requirements outlined in 6.10.	
X2.5.7 Kinks found in the pipe shall be cut out. Pipe with kinks shall not be placed in service.	X1.5.7 Kinks found in the pipe shall be cut out. Pipe with kinks shall not be placed in service.	
X2.6 Repair Considerations	**X1.6 Repair Considerations**	
X2.6.1 Repairs may be made to plastic pipe under appropriate circumstances. Selection and installation considerations for the use of full encirclement band clamps are available in ASTM Guide F 1025. Additional information on repair of plastic pipe may be found in manufacturers' literature, the ~~A. G. A.~~ Plastic Pipe Manual for Gas Service, ANSI B31.8 Gas Transmission and Distribution Piping Systems, and in the ASME Guide for Gas Transmission and Distribution Piping Systems.	X1.6.1 Repairs may be made to PE pipe under appropriate circumstances. Selection and installation considerations for the use of full encirclement band clamps are available in ASTM Guide F1025. Additional information on repair of PE 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.[10] [1]Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.	
X2.7 Environmental Effects	**X1.7 Environmental Effects**	
X2.7.1 *Natural Gas*—The long term effect of natural gas	X1.7.1 *Natural Gas*—The natural gas of commerce consists of	

’99 Edition	‘09a Edition	Comments
(methane, but with minor amounts of other gases) at 73°F (23°C) has been shown (**3,4**) to be essentially equivalent to that of water at 73°F (23°C) for three kinds of plastic pipe (PVC, PB, and PE). However, the effects of other liquid environments such as antifreeze agents, odorants, and hydrocarbons are known to be deleterious to some plastics, particularly when under service conditions, and therefore, should not be permitted in the gas system unless the plastic pipe has been fully evaluated under the service conditions.	methane as the principal constituent with minor amounts of other gases, which can include other hydrocarbons (for example, ethane, propane, butane, pentane), inert gases (for example, nitrogen, carbon dioxide), and odorants. The long term effect of natural gas (methane, but with minor amounts of other gases) at 73°F (23°C) has been shown (**3,4**) to be essentially equivalent to that of water at 73°F (23°C) for PE pipe.	
X2.7.2 *Other Fuel Gases*— In accordance with this specification, PE materials must have not less than a 1250 psi HDB for 73.4F, for methane. It has been shown (**5, 6,** and **7**) that aliphatic gaseous fuels of higher molecular weights than methane (natural gas) somewhat reduce the long-term strength of PE pipe materials compared to when using methane or water as the pressurizing medium. The reduction in PE's long-term strength caused by gaseous propane, propylene and butane is modest, well under 20 %. On this basis one report (**5**) considers an HDB of 1000 psi, for 73.4F, as a reasonable and conservative design basis for PE piping materials intended for LPG fuel gas service.	X1.7.2 *Other Fuel Gases*— In accordance with this specification, PE materials must have not less than a 1250 psi HDB for 73.4°F, for methane. It has been shown (**5, 6,** and **7**) that aliphatic gaseous fuels of higher molecular weights than methane (natural gas) somewhat reduce the long-term strength of PE pipe materials compared to when using methane or water as the pressurizing medium. The reduction in PE's long-term strength caused by gaseous propane, propylene and butane is modest, well under 20 %. On this basis one report (**5**) considers an HDB of 1000 psi, for 73.4°F, as a reasonable and conservative design basis for PE piping materials intended for LPG fuel gas service.	
X2.7.2.1 However, it has also been shown by the above referenced studies that propane, propylene and butane, when in the liquid phase, can cause a greater reduction in long-term strength, up to 40 %. Accordingly, the use of PE piping to convey LPG gaseous fuels should recognize this effect and the design and operation of such piping should consider the possibility for the occurence of condensates. Extensive experience has shown that the NFPA maximum recommended operating pressure of 30 psig for LPG systems (see X2.3.4) both minimizes the possible occurence of condensates and gives adequate consideration of the effect of LPG fuels on the long-term strength of PE piping.	X1.7.2.1 However, it has also been shown by the above referenced studies that propane, propylene and butane, when in the liquid phase, can cause a greater reduction in long-term strength, up to 40 %. Accordingly, the use of PE piping to convey LPG gaseous fuels should recognize this effect and the design and operation of such piping should consider the possibility for the occurrence of condensates. Extensive experience has shown that the NFPA maximum recommended operating pressure of 30 psig for LPG systems (see X1.3.4) both minimizes the possible occurrence of condensates and gives adequate consideration of the effect of LPG fuels on the long-term strength of PE piping.	
	X1.7.2.2 It has been reported **(8,9)** and **(10)**, that during the heat fusion joining of PE piping that has been in service conveying fuel gases that consist of, or that include heavier hydrocarbons, the PE surfaces being heated in preparation for fusion sometimes exhibit a *bubbly* appearance. This bubbling is the result of the rapid expansion (by heat) and passage of absorbed heavier hydrocarbon gases through the molten material. Heat fusion (butt, socket, saddle, or electrofusion)	

’99 Edition	‘09a Edition	Comments
	joint strength may be reduced by the presence of the heavier hydrocarbons. Pimputkar et al **(8)** conclude that for a system operating at 50psi and conveying a mixture of as high as 16 volume percent in methane the propane concentration in PE will be under 0.2 percent, sufficient to sometimes show some bubbling, but not high enough to effect any significant degradation in fusion strength. However, if the concentration of propane in PE exceeds 0.2 percent, there is the risk of a rapid and large drop in fusion strength. Field tests to verify the level of contamination and subsequent degradation of joint strength are not currently available. Therefore, in the case of PE pipe that has previously been installed in these types of services, one should use mechanical fittings to join or repair the pipe. [1] Available from American Gas Association (AGA) 400 North Capitol Street, NW Suite 450 Washington, DC 20001, http://www.aga.org. [1] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.	
NOTE X2.4—PPI Technical Report TR 22–88 (**5**) lists maximum operating pressures for various minimum operating temperatures at which condensates will not form in LPG systems in which the primary fuels are propane and butane.	NOTE X1.4—PPI Technical Report TR 22–88 (**5**) lists maximum operating pressures for various minimum operating temperatures at which condensates will not form in LPG systems in which the primary fuels are propane and butane.	
REFERENCES	**REFERENCE**	
(1) Allman, W.B., “Earthloading Design Considerations for Polyethylene Gas Distribution Systems,” *Proceedings of the Fifth Plastic Pipe Symposium*, November 13–15, 1974, Houston, TX, A.G.A., 1515 Wilson Blvd., Arlington, VA 22209, pp. 55–171.	Allman, W.B., “Earthloading Design Considerations for Polyethylene Gas Distribution Systems,” *Proceedings of the Fifth Plastic Pipe Symposium,* November 13–15, 1974, Houston, TX, A.G.A., 1515 Wilson Blvd., Arlington, VA 22209, pp. 55–171.	
(2) Spangler, M.G., “Secondary Stresses in Buried High Pressure Lines,” *Iowa State College Bulletin*, Engineering Report 23 of the Iowa Engineering Experiment Station, 1954, 1955.	Spangler, M.G., “Secondary Stresses in Buried High Pressure Lines,” *Iowa State College Bulletin*, Engineering Report 23 of the Iowa Engineering Experiment Station, 1954, 1955.	
(3) Kuhlman, H. W., Leninger, R. I., and Wolter, Fritz,	Kuhlman, H. W., Leninger, R. I., and Wolter, Fritz,	

’99 Edition	‘09a Edition	Comments
“Investigation of Engineering and Design Concepts for Plastics Pipe for Gas Distribution Application,” presented at ANSI B31.8 meeting in St. Charles, IL, October 19, 1965.	“Investigation of Engineering and Design Concepts for Plastics Pipe for Gas Distribution Application,” presented at ANSI B31.8 meeting in St. Charles, IL, October 19, 1965	
(4) Palermo, E. F., and Cassady, M. J., “Comparison of Long-Term Effect of Water and Methane on PE 2306 and PE 3406 Pipe Performance,” presented at the American Gas Association Plastic Material Committee Winter Workshop, February 23, 1982.	Palermo, E. F., and Cassady, M. J., “Comparison of Long-Term Effect of Water and Methane on PE 2306 and PE 3406 Pipe Performance,” presented at the American Gas Association Plastic Material Committee Winter Workshop, February 23, 1982.	
(5) “Polyethylene Plastic Piping Distrbution Systems for Components of Liquified Petroleum Gases,” *PPI Technical Report TR-22.*	“Polyethylene Plastic Piping Distribution Systems for Components of Liquefied Petroleum Gases,” *PPI Technical Report TR-22.*	
(6) Henrich, R.C., “Use of Polyethylene Pipe for Propane Distribution Systems,” Fifth Fuel Gas Pipe Symposium, Houston, TX, November, 1974.	Henrich, R.C., “Use of Polyethylene Pipe for Propane Distribution Systems,” Fifth Fuel Gas Pipe Symposium, Houston, TX, November, 1974.	
(7) Viebke, J., Tranker, T., Hedenquist, and Gedde, V.W., “Long-Term Behavior of MDPE Gas Pipes Exposed to Realistic Propane Environments,” Thirteenth Fuel Gas Pipe Symposium, San Antonio, TX, November, 1993.	Viebke, J., Tranker, T., Hedenquist, and Gedde, V.W., “Long-Term Behavior of MDPE Gas Pipes Exposed to Realistic Propane Environments,” Thirteenth Fuel Gas Pipe Symposium, San Antonio, TX, November, 1993 .	
(8)	Sudheer M. Pimputkar, Barbara Belew, Michael L. Mamoun, Joseph A. Stets, “Strength of Fusion Joints Made From Polyethylene Pipe Exposed to Heavy Hydrocarbons”, Fifteenth International Plastics Pipe Symposium, Lake Buena Vista, Florida, October 1997.	
(9)	S.M. Pimputkar, J.A. Stets, and M.L. Mamoun, “Examination of Field Failures”, Sixteenth International Plastics Pipe Symposium, New Orleans, Louisiana, November 1999.	
(10)	Gas Research Institute Topical Report GRI-96/0194, “Service	

’99 Edition	‘09a Edition	Comments
	Effects of Hydrocarbons on Fusion and Mechanical Performance of Polyethylene Gas Distribution Piping”, May 1997	