



Standard Specification for Corrugated Polyethylene Pipe and Fittings for Mine Leachate Applications¹

This standard is issued under the fixed designation F2986; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers requirements and test methods for materials, workmanship, dimensions, perforations, pipe stiffness, elongation, joint separation resistance, quality of extruded polyethylene, brittleness, testing, and marking of corrugated polyethylene (PE) pipe and fittings for mine drainage and leachate collection and transmission pipe. It covers nominal sizes 3 in. (75 mm), 4 in. (100 mm), 6 in. (150 mm), 8 in. (200 mm), 10 in. (250 mm) 12 in. (300 mm), 15 in. (375 mm), 18 in. (450 mm) and 24 in. (600 mm) diameter.

1.2 This specification covers single profile wall, annular extruded corrugated polyethylene pipe as depicted in Fig. 1, and double wall, annular extruded corrugated polyethylene pipe as depicted in Fig. 2.

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

1.4 *The following precautionary caveat pertains only to the test method portion, Section 9, of this specification: This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- D618 Practice for Conditioning Plastics for Testing
- D1600 Terminology for Abbreviated Terms Relating to Plastics
- D2122 Test Method for Determining Dimensions of Ther-

¹ This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.65 on Land Drainage.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

moplastic Pipe and Fittings

D2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

D2444 Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

F412 Terminology Relating to Plastic Piping Systems

F2136 Test Method for Notched, Constant Ligament-Stress (NCLS) Test to Determine Slow-Crack-Growth Resistance of HDPE Resins or HDPE Corrugated Pipe

2.2 *Federal Standards:*³

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)
Federal Emergency Management Agency (FEMA) Practices for Design, Construction, Problem Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair

2.3 *Military Standard:*³

MIL-STD-129 Marking for Shipment and Storage

3. Terminology

3.1 *Definitions*—Definitions used in this specification are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise specified. The abbreviation for polyethylene is PE.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *crease*—a deformation that cannot be removed like a dent: generally associated with wall buckling.

3.2.2 *leaching*—minerals are removed (leached) from ores that have been mined, crushed, and placed on impervious pads for removal (by chemical leaching) by percolation of the solution through the ore, and collection of that solution at the bottom of the heap leach pile.

3.2.3 *split*—any break or crack that extends through the wall.

³ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

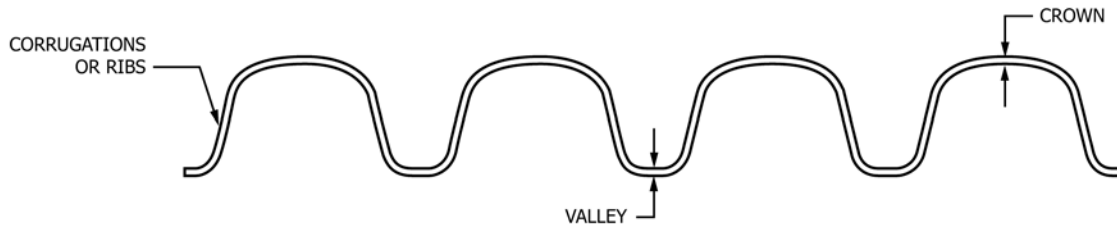


FIG. 1 Typical Single Wall Profile Cross-Section

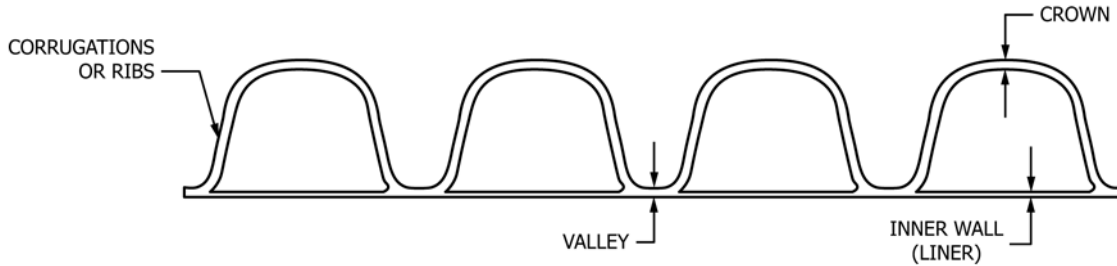


FIG. 2 Typical Double Wall Profile Cross-Section

4. Ordering Information

4.1 Orders for product made to this specification shall include the following information to adequately describe the desired product:

- 4.1.1 This ASTM designation and year of issue,
- 4.1.2 *Perforations*:
 - 4.1.2.1 With perforations,
 - 4.1.2.2 Without perforations,
- 4.1.3 Diameters,
- 4.1.4 Total footage of each pipe diameter involved,
- 4.1.5 Pipe laying length,
- 4.1.6 *Fitting type(s)*:
 - 4.1.6.1 Size and type of fittings, including mainline and branch diameters, and
 - 4.1.6.2 Number of fittings per diameter.

5. Significance and Use

5.1 Corrugated PE pipe and fittings in this standard are intended for deep underground applications under harsh chemical exposure from a corrosive effluent where they serve as leachate pipe under a mine heap or dump leaching process. Their major use is to collect or convey ore leachate to a facility for processing and extraction of the desired metal or mineral. Heap leaching is used to extract copper, gold, lead, nickel, silver, uranium, or zinc. The solution may be either acidic or alkaline, depending on the metal being extracted.

6. Materials

6.1 *Pipe and Fittings*—The pipe and fittings shall be made of virgin PE plastic compound meeting the requirements of Specification D3350 cell classification 435400C or 435400E, except that carbon black content shall be equal to or greater than 2.0 % but not exceed 3.0 %. Compounds that have a higher cell classification in one or more performance properties shall be permitted if all other product requirements are met. For slow crack-growth resistance, resins shall be evaluated using the notched constant ligament stress (NCLS) test according to

the procedure described in 9.12. Samples shall be taken from the extruded pipe supplied to the project. The average failure time of the five test specimens shall exceed 24 h with no single test specimen’s failure time less than 17 h. Samples taken from the extruded pipe supplied to the project shall have a minimum Oxidative-Induction-Time of 20 minutes when tested in accordance with Test Method D3895.

6.2 *Rework Material*—Clean rework material, generated from the manufacturer’s own production of this product, may be used by the manufacturer provided that the tubing and fittings produced meet all requirements of this specification.

7. General Requirements

7.1 *Workmanship*—The pipe and fittings shall be homogeneous throughout and be as uniform as commercially practical in color, opacity, and density. The pipe walls shall be free of cracks, holes, blisters, voids, foreign inclusions, or other defects that are visible to the naked eye and that may affect the wall integrity. The ends shall be cut cleanly and squarely. Holes intentionally placed in perforated pipe are acceptable.

7.1.1 Visible defects, cracks, creases, splits, obstruction to flow in perforations or in pipe, are not permissible.

7.2 *Dimensions and Tolerance*:

7.2.1 *Nominal Size*—The nominal size for the pipe and fittings for single profile wall and double profile wall shall be the minimum inside diameter as shown in Table 1 and Table 2, respectively, rounded to the closest whole number.

7.2.2 *Inside Diameter*—The actual inside diameter for single profile wall and double profile wall shall be the minimum inside diameter with a +4.5 % or – 0 % tolerance when measured in accordance with 9.3 and as shown in Table 1 and Table 2, respectively.

NOTE 1—The outside diameters and the corrugation pitch of products manufactured to this specification are not specified; therefore, compatibility between pipe and fittings from different manufacturers or the same manufacturer shall be verified.

TABLE 1 Single Wall Pipe Stiffness and Pipe Dimensions

Minimum Inside Diameter		Minimum Pipe Stiffness at 5 % Deflection		Minimum XS Pipe Stiffness at 5 % Deflection		Minimum Crest Thickness	
in.	mm	lbs/in/in	kPa	lbs/in/in	kPa	in.	mm
3	75	50	345	70	480	0.025	0.64
4	100	50	345	70	480	0.025	0.64
5	125	50	345	65	450	0.027	0.69
6	150	50	345	60	415	0.028	0.71
8	200	50	345			0.036	0.91
10	250	50	345			0.048	1.22
12	300	50	345			0.071	1.80
15	375	42	290			0.087	2.21
18	450	40	275			0.120	3.05
24	600	34	235			0.120	3.05

TABLE 2 Double Wall Pipe Stiffness and Pipe Dimensions

Minimum Inside Diameter		Minimum Pipe Stiffness at 5 % Deflection		Minimum Valley Thickness		Minimum Liner Thickness	
in.	mm	lbs/in/in	kPa	in.	mm	in.	mm
3	75	50	345	0.025	0.64	0.020	0.5
4	100	50	345	0.025	0.64	0.020	0.5
5	125	50	345	0.027	0.69	0.020	0.5
6	150	50	345	0.028	0.71	0.020	0.5
8	200	50	345	0.036	0.91	0.024	0.6
10	250	50	345	0.048	1.22	0.024	0.6
12	300	50	345	0.071	1.80	0.035	0.9
15	375	42	290	0.087	2.21	0.040	1.0
18	450	40	275	0.120	3.05	0.051	1.3
24	600	34	235	0.120	3.05	0.060	1.5

7.2.3 *Minimum Crest, Liner, Wall Thickness*—The minimum wall thickness of the pipe crest shall meet the requirements given in **Table 1** when measured in accordance with 9.4. The minimum wall thickness of the valley and liner shall meet the requirements given in **Table 2** when measured in accordance with 9.4.

7.2.4 *Length*—The pipe shall be supplied in any length agreeable to both the owner and the manufacturer. Length shall not be less than 99 % of stated quantity when measured in accordance with 9.5.

7.2.5 *Perforations*—Perforations shall be cleanly cut, placed in the valley of the corrugation rib, and uniformly spaced along the length and circumference of the pipe. Dimensions of the perforations and the minimum perforation inlet area shall be as listed in **Table 3**. Other perforation dimensions and configura-

tions shall be permitted, where required to meet the needs of the specifier. All measurements shall be made in accordance with 9.6. Pipe connected by bell and spigot joints shall not be perforated in the area of the bells and spigots.

NOTE 2—For perforated pipe applications, the size of the embedment zone and permeability of the embedment material provide the desired level of infiltration or inflow. The gradation and compaction of the embedment material shall be compatible with the perforation size to avoid embedment backfill migration into the pipe.

7.3 *Pipe Stiffness*—The pipe shall have a minimum pipe stiffness at 5 % deflection for single wall and double wall as shown in **Table 1** and **Table 2**, respectively, when tested in accordance with 9.7. Two pipe stiffness classes, standard and XS, are produced for 3 in.– 6 in. (75 mm through 150 mm) diameters in **Table 1**.

TABLE 3 Perforation Dimensions

Minimum Inside Diameter		Type of Perforation				
		Circular				
		Maximum Diameter		Minimum Inlet Area		
in.	mm	in.	mm	in ² /ft	cm ² /m	
3	75	0.187	4.75	1.0	20	
4	100	0.187	4.75	1.0	20	
5	125	0.187	4.75	1.0	20	
6	150	0.187	4.75	1.0	20	
8	200	0.256	6.25	1.0	20	
10	250	0.315	8.00	1.0	20	
12	300	0.375	10.0	1.5	30	
15	375	0.375	10.0	1.5	30	
18	450	0.375	10.0	1.5	30	
24	600	0.375	10.0	2.0	40	

7.4 *Elongation*—For single wall pipe only; continuously extruded pipe that elongates more than 5 %, but less than 10 %, when tested in accordance with 9.8, shall meet the requirements of 7.3 when tested in accordance with 9.9. Pipe that elongates more than 10 % shall be rejected.

7.5 *Brittleness*—Pipe and fitting specimens shall be tested in accordance with 9.11.

7.6 *Bond*—The bond between layers of spirally laminated pipe shall be strong and uniform. There shall be no separation of layers when the pipe is deflected 20 %, in accordance with Test Method D2412, nor shall it be possible to separate the layers with the point of a knife when the pipe is in the deflected condition.

NOTE 3—This test may be conducted as a continuation of pipe stiffness testing as specified in 9.7.

7.7 *Fitting Requirements:*

7.7.1 The fittings shall not reduce or impair the overall integrity or function of the pipe line.

NOTE 4—Common corrugated fittings include in-line joint fittings, such as tees, Y's, reducers, couplers, elbows, and end caps. These fittings are installed internally or externally by various methods, such as snap-on, V-insertion, screw-on, or wrap around.

NOTE 5—Some corrugated fittings will not fit all pipe. Only fittings supplied or recommended by the pipe manufacturer should be used.

7.7.2 Joints made with couplers, installed in accordance with the manufacturer's instructions, shall not separate when tested in accordance with 9.10.

7.7.3 Fitting specimens shall not crack or split when tested in accordance with 9.11.

8. Sampling and Retest

8.1 *Sampling*—Samples of pipe and fittings sufficient to determine conformance with this specification shall be taken at random from stock or from the project site by the testing agency. Samples shall be representative of the product type under consideration. A minimum of one sample shall be taken for every 1,000 meters of pipe length supplied on a project.

8.2 *Retest and Rejection*—If any test failure occurs, the pipe or fitting may be retested to establish conformity. The test shall be repeated on two additional samples from the same lot or shipment. If either of these two additional samples fail, the pipe or fitting does not comply with this specification.

9. Test Methods

9.1 *Conditioning Test Specimens*—Condition the specimen prior to test at $73.4 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and $50 \pm 5\%$ relative humidity for not less than 40 h prior to the test, in accordance with Procedure A in Practice D618 for those tests where conditioning is required, unless otherwise specified.

9.2 *Test Conditions*—Conduct tests in laboratory atmosphere of $73.4 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and $50 \pm 5\%$ relative humidity, unless otherwise specified.

9.3 *Inside Diameter*—Measure the inside diameter of three 1 ft. (300-mm) specimens, with any suitable device accurate to 0.8 mm [$\pm 1/32$ in.], at two positions, namely, the block seam and 90° from the block seams, and average the six measurements.

9.4 *Minimum Crest and Liner Wall Thickness*—Measure the thickness of the crest, valley and liner (when applicable) wall thickness in accordance with Test Method D2122. Each specimen shall be cut perpendicular to the seam line of the pipe directly through a corrugation allowing a plain view of the inner wall 360 degrees around the circumference in order to obtain a minimum of eight measurements in accordance with Test Method D2122. As an alternative to Test Method D2122 minimum liner thickness is allowed to be determined with the use of a calibrated ultrasonic thickness gauge.

NOTE 6—Test Method D2122 also permits the use of alternate measurement methods such as ultrasonic gauges.

9.5 *Length*—Measure pipe with any suitable device accurate to $\pm 1/32$ in. in 10 ft (1 mm in 3 m). Make all measurements on the pipe while it is resting on a relatively flat surface, in a straight line, with no external tensile or compressive forces exerted on the pipe.

9.6 *Perforations*—Measure dimensions of perforations on a straight specimen without external forces applied. Linear measurements shall be made with an instrument with calibration increments of 0.01 in. (0.25 mm).

9.7 *Pipe Stiffness*—Select a minimum of three pipe specimens and test for pipe stiffness $F/\Delta y$, as described in Test Method D2412, except for the following conditions: (1) The test specimens shall be at least as long as the outside diameter; the exact length shall be an integer multiple of corrugation pitch. (2) Locate the first specimen of all annular (tubularly) extruded pipe in the loading machine with the imaginary line between the two corrugation seams (end view) parallel to the loading plates. The specimen must lay flat on the plate within $1/8$ in. (3 mm) and may be straightened by hand bending at room temperature. Use the first location as a reference point for rotation of the other two specimens. Rotate the second specimen 45° and the third specimen 90° . Test each specimen in one position only. (3) The deflection indicator shall be readable and accurate to ± 0.001 in. (± 0.02 mm). (4) The parallel plates must exceed the samples in length. (5) If the pipe under test has self-coupling end sections, include a self-coupling assembly as one of the three test lengths.

9.8 *Elongation*—This test applies to single wall pipe only, and is not applicable to double wall pipe. Test a minimum of three specimens, each 60-in. (1.5-m) in length, for stretch resistance. Subject each test specimen to a longitudinal stretching force equal to 5 lb/in. (0.9 kg/cc) of nominal inside diameter to a maximum of 50 lb (22.7 kg), excluding the weight of the specimen. Hang the specimens in a vertical manner with the test force applied as a dead (hanging) weight to the bottom end of the pipe. The gage length for determining percent elongation shall be the middle 3-ft (1-m) portion of the unstretched specimen. Apply the test weight gently, and allow it to remain for 3 min; then quickly measure the gage length to the nearest 0.125 in. (3 mm) to determine elongation. Calculate elongation (E) as follows:

$$E(\%) = \frac{(E l o n g a t i o n) \times (100)}{g a g e \ l e n g t h} \quad (1)$$

Calculate the average of the three values.

9.9 *Pipe Stiffness While Elongated*—Test three 30-in. (750-mm) gage lengths cut from the centers of the 60-in. (1.5-m) specimens for pipe stiffness at 5 % deflection as described in Test Method D2412, except for the following conditions: (1) stretch the test specimen as shown in Fig. 3 to the same percent elongation as determined in 9.6 and test in this condition; (2) support the test specimen on a rigid base plate 12 in. (300 mm) in length; and (3) apply a load plate 12 in. (300 mm) in length to the center portion of the 30 inch (750-mm) specimen.

9.10 *Joint-Separation Test*—Repeat the elongation test specified in 9.6 on two specimens with a coupling in the center of the specimens. Separation shall be considered a failure. Gage length and stretch are omitted in this test.

9.11 *Brittleness*—Test pipe and fitting specimens in accordance with Test Method D2444, except six specimens shall be tested. Use Tup B weighing 5.5 lbs (2.5 kg); the height of the drop shall be 5 ft (1.5 m) Use a flat-plate specimen holder. Condition the specimens for 24 h at a temperature of 25 ± 3.6°F (3.9 ± 2°C) and conduct all tests within 60 s of removal from this atmosphere. The center of the falling tup shall strike on a corrugation crest for three specimens and between crests for three specimens. Five non-failures are acceptable. Fittings shall be assembled on appropriate size pipe for testing.

9.12 *Slow Crack Growth Resistance of PE plastic pipe*—Pipe test specimens shall be taken from extruded pipe and molded into test specimens. Test 5 pipe specimens using the same protocol for molded bars in Test Method F2136, except for the following modifications:

9.12.1 The applied stress for the NCLS test shall be 600 psi (4138 kPa).

9.13 *Oxidative-Induction-Time of Polyolefins*—Test samples shall be removed from the pipe and compression molded into sheet format prior to analysis. Specimens cut from the sheet shall have a weight of 5 to 10 mg. in accordance with Test Method D3895.

10. Installation

10.1 It is recommended that pipe and fittings shall be installed in only coarse graded gravel or crush ore may be used as backfill. Backfill or pipe envelope material shall have a maximum size of 40 mm and shall have less than 5 % passing number 100 sieve.

10.2 Defective sections may be removed and the line spliced in the field, where practicable.

11. Certification

11.1 Upon request of the user, the manufacturer shall provide certification that the product was produced and tested in accordance with this specification. This certification shall be furnished at the time of shipment.

12. Marking

12.1 Corrugated PE drainage pipe complying with this specification shall be marked with the designation number of this specification: ASTM F2986, and with the manufacturer’s identification symbol, regularly spaced at intervals not exceeding 10 ft (3 m).

12.1.1 *Dating*—Each unit of corrugated PE drainage pipe shall be marked with the day, month, and year. This date shall be permanently marked on the product.

12.2 Fittings for corrugated polyethylene pipe complying with this specification shall be marked with the designation number of this specification, ASTM F2986, and with the manufacturer’s identification symbol.

13. Report

13.1 The report shall include the following:

13.1.1 Date or dates of tests,

13.1.2 Complete identification of product tested, including size, nomenclature, manufacturer, previous history, if any, etc,

13.1.3 Description of manufacturer’s product marking,

13.1.4 Conditioning method,

13.1.5 Details of sampling,

13.1.6 Weight per foot of each test specimen and the average weight,

13.1.7 Individual average test results of manufacture,

13.1.8 Notation describing any retest due to previous test failure, and

13.1.9 Description of terms.

14. Quality Assurance

14.1 When the product is marked with this designation, ASTM F2986, 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. When specified in the purchase order or contract, a report of the test results shall be furnished.

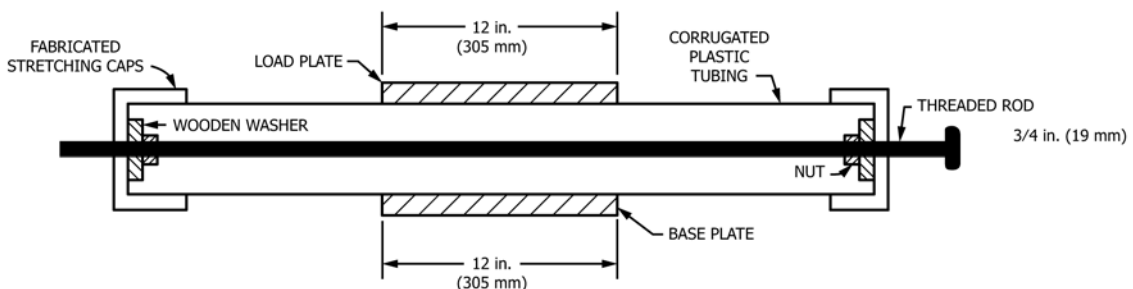


FIG. 3 Test Rig for Determining Stiffness While Elongated

15. Keywords

15.1 collectors; HDPE; perforated; underdrain

SUPPLEMENTARY REQUIREMENTS

FOR GOVERNMENT/MILITARY PROCUREMENT

These requirements apply *only* to Federal/Military procurement, not domestic sales or transfers.

S1. Responsibility for Inspection

S1.1 Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use their 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 S1.1—In U.S. Federal contracts, the contractor is responsible for inspection.

S2. Packaging and Marking for U.S. Government Procurement

S2.1 *Packaging*—Unless otherwise specified in the contract, the materials shall be packaged in accordance with the supplier's standard practice in a manner ensuring arrival at destina-

tion in satisfactory condition and which will be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification rules or National Motor Freight Classification rules.

S2.2 *Marking*—Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

NOTE S2.1—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 document.

APPENDIX

(Nonmandatory Information)

X1. FITTINGS

X1.1 The actual inside diameter of a fitting typically exceeds the outside diameter of the pipe to permit the connection to be external to the pipe.

X1.2 The fittings should not reduce or impair the overall integrity or function of the pipe.

X1.3 Common corrugated fittings include in-line joint fittings, such as couplings and reducers, and branch or complementary assembly fittings, such as tees. These fittings may be

installed by various methods, such as snap-on, screw-on, or wrap around, depending on the specific designs.

NOTE X1.1—Some corrugated fittings will not fit certain pipe. Only fittings supplied or recommended by the pipe manufacturer should be used.

X1.4 Fittings should not reduce the capacity of the pipe being joined. Reducer fittings should not reduce the cross-sectional area of the smaller size.

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