



Designation: **F2986–12 (Reapproved 2023) F2986 – 23**

Standard Specification for Corrugated Polyethylene Pipe and Fittings for Mine ~~Leachate~~ Leachate, Heap Leach Aeration and Other Mining 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~~ 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~~ drainage, leachate collection, heap leach aeration, 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. 50 mm (2 in.) to 250 mm (10 in.) in single-wall profile, and 75 mm (3 in.) to 1500 mm (60 in.) in double-wall profile.

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~~ SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to S~~inch-pound~~ 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

- D618 Practice for Conditioning Plastics for Testing
- D1600 Terminology for Abbreviated Terms Relating to Plastics
- D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
- D2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
- D2444 Practice for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)

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. Current edition approved July 1, 2023/Nov. 1, 2023. Published July 2023/December 2023. Originally approved in 2012. Last previous edition approved in 2017/2023 as F2986-12(2017)-F2986-12(2023). DOI: 10.1520/F2986-12R23.10.1520/F2986-23.

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.

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

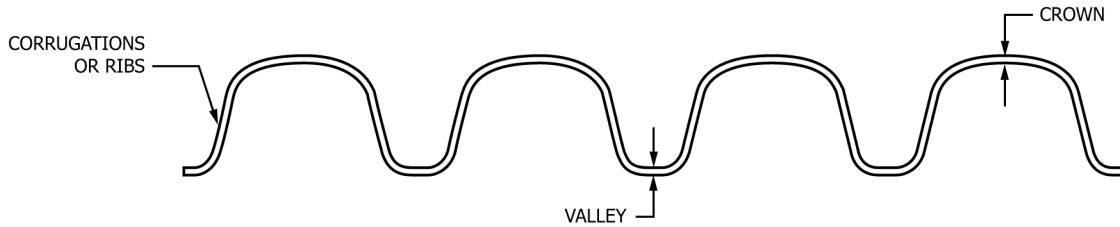


FIG. 1 Typical Single Wall Profile Cross-Section

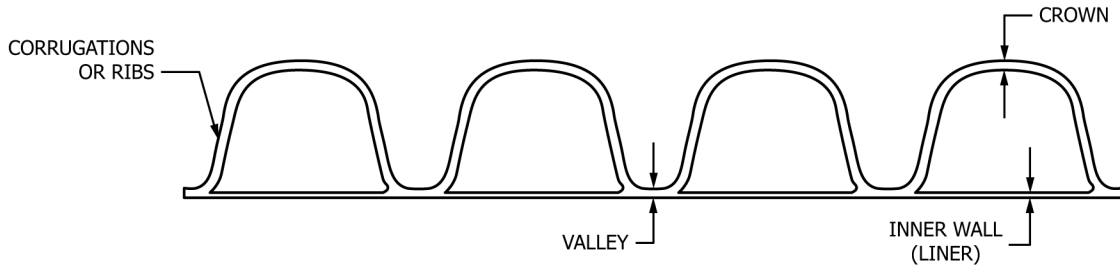


FIG. 2 Typical Double Wall Profile Cross-Section

[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/ISO Standards:*³

[Fed. Std. No. 123 ISO 9969 Marking for Shipment \(Civil Agencies\) Thermoplastics pipes —Determination of ring stiffness](#)

[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](#) [ASTM F2986-23](#)

<https://standards.iteh.ai/catalog/standards/astm/38ce1837-650b-4232-9035-73b7da210122/astm-f2986-23>

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 *NID, n*—numerical designation, which is approximately equal to the nominal inside diameter by which a pipe or fitting is defined.

3.2.4 *SN, n*—numerical designation of the ring stiffness of the pipe or fitting, determined according to ISO 9969, which is a convenient round number, indicating the minimum required ring stiffness of the pipe or stiffness of the fitting.

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

³ Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, <http://quicksearch.dla.mil> International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

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 or aeration 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~~-mineral or to aerate the pile to improve the chemical extraction of the desired metal by the leachate. Heap leaching is used to extract copper, gold, lead, nickel, silver, uranium, or zinc. The solution ~~may be~~ is 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.

6.2 The 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.

6.3 *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 **9-129.13**. 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**.

6.4 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**.

6.5 *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—Dimensions:*

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

7.2.2 *Minimum Inside Diameter*—The ~~actual~~ manufacturer’s stated minimum 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.~~ respectively, when measured in accordance with 9.3.

NOTE 1—The minimum inside diameter is the smallest diameter the pipe can be and is used for the hydraulic design of the pipe.

NOTE 2—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.

7.2.3 *Minimum Crest, Crown, Valley and Liner, Wall Thickness—Thicknesses*—The minimum wall thickness of the pipe ~~erest~~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*—Circular perforations or slots shall be cleanly cut, placed in the valley of the corrugation rib, and

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 1 Single Wall Pipe Dimension and Stiffness

NID		Minimum Inside Diameter		Minimum Crown Thickness		Minimum Pipe Stiffness at 5% Deflection		SN Class
Metric series	U.S. Customary series	mm	in.	mm	in.	kPa	psi	
50	2	49	1.92	0.50	0.0197	240	35	4
75	3	76	3.00	0.64	0.025	240	35	4
100	4	99	3.88	0.64	0.025	240	35	4
125	5	123	4.85	0.69	0.027	240	35	4
150	6	148	5.82	0.71	0.029	240	35	4
200	8	197	7.76	0.91	0.036	240	35	4
225	9	223	8.78	1.07	0.042	240	35	4
250	10	250	9.85	1.22	0.048	240	35	4

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			

TABLE 2 Double Wall Pipe Dimensions and Stiffness

NID		Minimum Inside Diameter		Minimum Valley Thickness		Minimum Liner Thickness		Minimum Standard Pipe Stiffness at 5 % Deflection		Minimum XS Pipe Stiffness at 5 % deflection		SN Class	
Metric series	U.S. Customary series	mm	in.	mm	in.	mm	in.	kPa	lbs/in./in.	kPa	lbs/in./in.	Standard	XS
50	2	48	1.90	0.64	0.025	0.05	0.020	345	50	485	70	6	9
75	3	75	3	0.64	0.025	0.05	0.020	345	50	485	70	6	10
100	4	95	3.74	0.64	0.025	0.05	0.020	345	50	485	70	6	10
125	5	125	5	0.69	0.027	0.05	0.020	345	50	450	65	6	8
150	6	145	5.71	0.71	0.028	0.05	0.020	345	50	450	65	6	8
200	8	195	7.68	0.91	0.036	0.6	0.024	345	50	415	60	6	8
225	9	229	5.82	1.07	0.042	0.6	0.024	345	50	415	60	6	8
250	10	245	9.65	1.22	0.048	0.6	0.024	345	50	415	60	6	8
300	12	295	11.61	1.80	0.071	0.9	0.035	345	50	380	55	6	7
375	15	369	14.54	2.21	0.087	1.0	0.040	290	42	310	45	5	6
400	16	392	15.43	2.49	0.098	1.1	0.045	283	41	303	44	5	6
450	18	443	17.45	3.05	0.120	1.3	0.051	275	40	297	43	5	6
500	20	490	19.92	3.05	0.120	1.4	0.055	265	39	280	41	5	6
525	21	517	20.36	3.05	0.120	1.5	0.060	260	38	276	40	5	6
600	24	588	23.15	3.05	0.120	1.5	0.060	235	34	262	38	5	6
675	27	665	26.18	3.3	0.130	1.5	0.060	195	28	...	...	...	...
750	30	739	29.08	3.4	0.132	1.5	0.060	195	28	...	...	...	...
800	32	785	30.91	3.8	0.150	1.6	0.063	180	26	...	...	...	...
900	36	886	34.90	4.6	0.182	1.7	0.067	150	22	...	...	...	...
1000	40	985	38.79	4.6	0.182	1.8	0.070	141	21	...	...	...	...
1050	42	1034	40.72	4.6	0.182	1.8	0.071	140	20	...	...	...	...
1200	48	1182	46.54	4.8	0.187	1.8	0.071	125	18	...	...	...	...
1350	54	1330	52.36	4.8	0.187	2.0	0.079	110	16	...	...	...	...
1500	60	1478	58.17	5.9	0.231	2.0	0.079	95	14	...	...	...	...

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 configurations 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. Perforations for aeration pipes shall be placed in the top 120° portion of the pipe.

NOTE 3—For heap leach aeration pipe systems, the perforation open area will vary throughout the pipe run to achieve even distribution of the air through the heap leach pile. Some non-perforated pipe is required as part of the air distribution manifold system.

7.2.6 Perforation covers—Perforations for aeration pipes must be protected from plugging with ore by a cover or hat as shown in Fig. 3. This cover must permit air to be discharged through the openings between the corrugation valleys and the cover (or “hat”). The covers are equal in thickness to the pipe couplings, are produced with resins compatible to the pipe, and welded at both longitudinal ends to the corrugation crests by extrusion welding. Perforation covers shall be clearly marked (color, large lettering, numbers) identifying the perforation pattern under it. Spacing of the perforations and covers are determined by the design engineer (typically 2 meters apart).

7.2.7 Crown Marking—The perforated pipe shall have clear marking, such as a stripe, colored spots, etc., identifying the pipe crown centered over the perforations.

TABLE 3 Perforation Dimensions

Minimum Inside Diameter		Type of Perforation			
		Circular		Minimum Inlet Area	
		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

TABLE 3 Perforation Dimensions

Metric Series	NID U.S. Customary Series	Type of Perforation						Minimum Inlet Area	
		Circular		Slots		Maximum Length		cm ² /m	in. ² /ft
		Maximum Diameter mm	in.	Maximum Width mm	in.	mm	in.		
150	6	4.75	0.19	3	0.12	25	1.00	20	1.0
200	8	6.25	0.26	3	0.12	30	1.20	20	1.0
225	9	6.25	0.26	3	0.12	30	1.20	20	1.0
250	10	8.00	0.32	3	0.12	30	1.20	20	1.0
300	12	10.00	0.38	3	0.12	70	2.75	30	1.5
375	15	10.00	0.38	3	0.12	70	2.75	30	1.5
400	16	10.00	0.38	3	0.12	70	2.75	30	1.5
450	18	10.00	0.38	3	0.12	70	2.75	30	1.5
500	20	10.00	0.38	3	0.12	70	2.75	40	2.0
525	21	10.00	0.38	3	0.12	70	2.75	40	2.0
600	24	10.00	0.38	3	0.12	70	2.75	40	2.0
675	27	10.00	0.38	3	0.12	70	2.75	40	2.0
750	30	10.00	0.38	3	0.12	70	2.75	40	2.0
800	32	10.00	0.38	3	0.12	70	2.75	40	2.0
900	36	10.00	0.38	3	0.12	70	2.75	40	2.0
1000	40	10.00	0.38	3	0.12	70	2.75	40	2.0
1050	42	10.00	0.38	3	0.12	70	2.75	40	2.0
1350	54	10.00	0.38	3	0.12	70	2.75	40	2.0
1500	60	10.00	0.38	3	0.12	70	2.75	40	2.0

<https://standards.iteh.ai/catalog/standards/astm/38ce1837-6506-4232-9035-73b7da210122/astm-f2986-23>

NOTE 4—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—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](#).

7.3.1 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 [7.3.2](#). Two pipe stiffness classes, standard and XS, are produced for 50 mm through 600 mm (2 in. through 24 in.) diameters in [Table 2](#).

7.3.2 Optionally, and in addition to the minimum pipe stiffness at 5 % deflection, where required, the minimum SN (Nominal Ring Stiffness) class shall meet the requirements given in [Table 1](#) when tested in accordance with [9.8](#).

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 [9.89.9](#), shall meet the requirements of [7.3](#) when tested in accordance with [9.99.10](#). Pipe that elongates more than 10 % shall be rejected.

7.5 *Brittleness*—Pipe and fitting specimens shall be tested in accordance with [9.H9.12](#).

7.6 *Bond*—The bond between layers of spirally laminated pipe shall be strong and uniform. There shall be no separation of layers