Designation: F2986 – 23

# Standard Specification for Corrugated Polyethylene Pipe and Fittings for Mine Leachate, Heap Leach Aeration and Other Mining Applications[1]

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, leachate collection, heap leach aeration, and transmission pipe. It covers nominal sizes 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 SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to 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)

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 *ISO Standards:*[3]

ISO 9969 Thermoplastics pipes —Determination of ring stiffness

## 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

[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.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

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

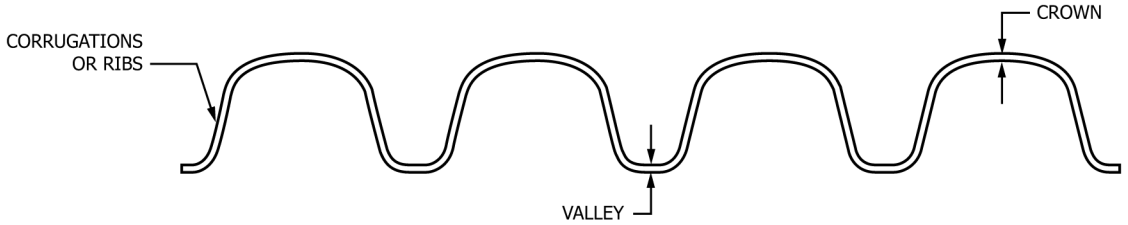


FIG. 1 Typical Single Wall Profile Cross-Section

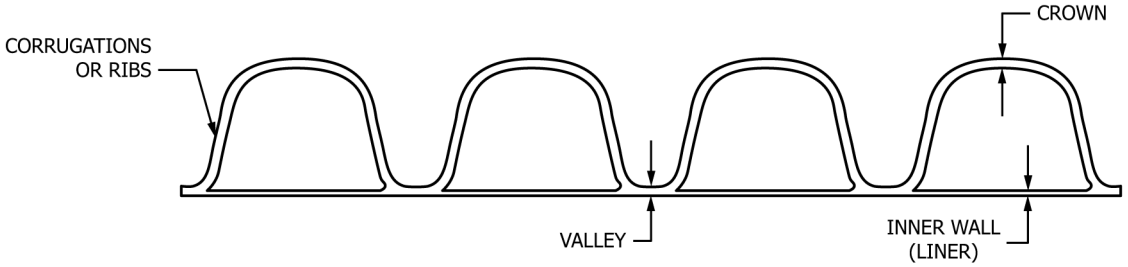


FIG. 2 Typical Double Wall Profile Cross-Section

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.

## 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 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 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 For slow crack-growth resistance, resins shall be evaluated using the notched constant ligament stress (NCLS) test according to the procedure described in 9.13. 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.

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 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:*

7.2.1 *NID*—The nominal size for the pipe and fittings shall be the NID value listed in Table 1 and Table 2, respectively, rounded to the closest whole number.

7.2.2 *Minimum Inside Diameter*—The manufacturer's stated minimum inside diameter for single profile wall and double profile wall shall be as shown in Table 1 and Table 2, 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 Crown, Valley and Liner, Wall Thicknesses*—The minimum wall thickness of the pipe crown 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*—Circular perforations or slots 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 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 the 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.

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:*

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 9.9, shall meet the requirements of 7.3 when tested in accordance with 9.10. Pipe that elongates more than 10 % shall be rejected.

7.5 *Brittleness*—Pipe and fitting specimens shall be tested in accordance with 9.12.

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

7.7 *Fitting Requirements:*

**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 serie | 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 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 | 0.216 | 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 | ... | ... | ... | ... |



**TABLE 3 Perforation Dimensions**

| NID | | Type of Perforation | | | | | | Minimum Inlet Area | |
|---|---|---|---|---|---|---|---|---|---|
| | | Circular | | Slots | | | | | |
| | | Maximum Diameter | | Maximum Width | | Maximum Length | | | |
| Metric Series | U.S. Customary Series | mm | in. | mm | in. | mm | in. | $cm^2/m$ | $in.^2/ft$ |
| 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 |



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

NOTE 6—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 7—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 9.11.

7.7.3 Fitting specimens shall not crack or split when tested in accordance with 9.12.