Designation: F2648/F2648M – 23

Standard Specification for 50 mm to 1500 mm [2 in. to 60 in.] Annular Corrugated Profile Wall Polyethylene (PE) Pipe and Fittings for Land Drainage Applications[1]

This standard is issued under the fixed designation F2648/F2648M; 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 annular corrugated profile wall polyethylene pipe and fittings with an interior liner. The inside diameters covered are 50 mm to 1500 mm [2 in. to 60 in.].

1.2 The requirements of this specification are intended to provide non-pressure (gravity flow) pipe and fittings for underground use for subsurface and land drainage systems, which do not operate under surcharge pressure heads.

NOTE 1—Pipe and fittings produced in accordance with this specification are be installed in compliance with Practice D2321 or Practice F449 based on diameter limitations within the respective standards.

NOTE 2—Subsurface and land drainage systems pertain principally to non-municipal or private facilities for water table control, storm drainage and agricultural drainage applications. The products supplied under this specification are not intended for any sanitary sewer or municipal storm sewer applications.

1.3 This specification covers pipe and fittings with an interior liner using an annular exterior corrugated profile (Fig. 1).

1.4 This specification permits the use of recycled materials for pipe in accordance with the requirements in Section 5.

1.5 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.6 *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.*

1.7 *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

D2321 Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

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

D4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique

D5630 Test Method for Ash Content in Plastics

D7399 Test Method for Determination of the Amount of Polypropylene in Polypropylene/Low Density Polyethylene Mixtures Using Infrared Spectrophotometry

F412 Terminology Relating to Plastic Piping Systems

F449 Practice for Subsurface Installation of Corrugated Polyethylene Pipe for Agricultural Drainage or Water Table Control

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

[1] This specification 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 May 1, 2023. Published May 2023. Originally approved in 2007. Last previous edition approved in 2022 as F2648/F2648M – 22. DOI: 10.1520/F2648_F2648M-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**

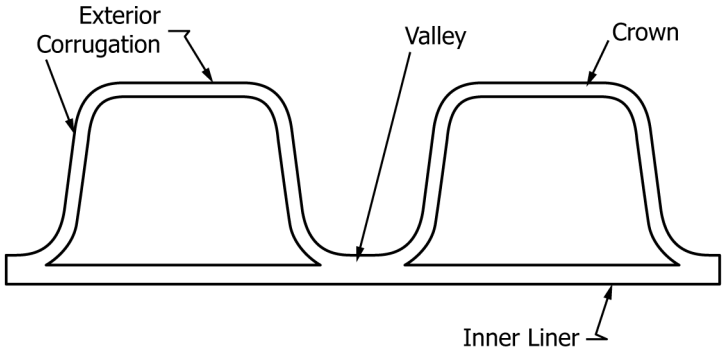

FIG. 1 Annular Corrugated Profile Wall Polyethylene Pipe with Interior Liner

TABLE 1 Pipe Dimensions and Stiffness[A]

NID		Minimum Inside Diameter		Minimum Liner Thickness		Minimum Pipe Stiffness at 5% Deflection		Minimum SN Class
Metric Series	US Customary Series	mm	in.	mm	in.	kPa	lb/in./in.	[SN]
50	2	48	1.90	0.5	0.020	345	50	8
75	3	75	2.97	0.5	0.020	345	50	8
100	4	95	3.74	0.5	0.020	345	50	8
150	6	145	5.71	0.5	0.020	345	50	6
200	8	195	7.68	0.6	0.024	345	50	6
225	9	220	8.66	0.6	0.024	345	50	6
250	10	245	9.65	0.6	0.024	345	50	6
300	12	295	11.61	0.9	0.035	345	50	6
375	15	369	14.54	1.0	0.040	290	42	6
400	16	392	15.43	1.1	0.045	283	41	4
450	18	443	17.45	1.3	0.051	275	40	4
500	20	490	19.29	1.4	0.055	265	39	4
525	21	517	20.36	1.5	0.060	260	38	4
600	24	588	23.15	1.5	0.060	235	34	4
675	27	665	26.18	1.5	0.060	205	30	4
750	30	739	29.08	1.5	0.060	195	28	4
800	32	785	30.91	1.6	0.063	180	26	4
900	36	886	34.90	1.7	0.067	150	22	4
1000	39	985	38.79	1.8	0.070	141	21	2
1050	42	1034	40.72	1.8	0.071	140	20	2
1200	48	1182	46.54	1.8	0.071	125	18	2
1350	54	1330	52.36	2.0	0.079	110	16	2
1500	60	1478	58.17	2.0	0.079	95	14	2

[A] Inside Diameters for metric (SI) sizes are in direct Imperial equivalent dimensions

2.2 *AASHTO (American Association of Highway and Transportation Officials) Standard:*[3]

(AASHTO) AASHTO LRFD Bridge Design Specifications

2.3 *CSA Standards:*[4]

B181.0 Definitions, general requirements, and methods of testing for thermoplastic nonpressure piping

2.4 *NCHRP (National Cooperative Highway Research Program) Report:*[5]

NCHRP Report 631 Updated Test and Design Methods for Thermoplastic Drainage Pipe

2.5 *ISO Standard:*[6]

ISO 15270 Guidelines for Recovery and Recycling of Plastic Waste

ISO 9969 Thermoplastics pipes —Determination of ring stiffness

3. Terminology

3.1 Definitions 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 *buckling, v*—Any reverse curvature or deformation in the pipe wall or profile element that reduces the load-carrying

[3] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

[4] Available from Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, http://www.csagroup.org.

[5] Transportation Research Board, The National Academies 500 Fifth Street, NW Washington, DC 20001. http://www.TRB.org.

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

capacity of the pipe. For testing evaluations in this standard, buckling is defined as the buckling deflection limit, the point where the pipe no longer sustains increasing or constant load with increasing deflection.

3.2.2 *inside diameter, n*—The manufacturer's stated pipe inside diameter (Table 1).

3.2.3 *graphitic material, n*—a non-oxidized, highly crystalline carbon nanosheet substance with predominant thickness of 6-10 atomic layers (See CSA B181.0 Clause 4.5).

3.2.4 *mold line, n*—A line formed on the product as a result of the mold blocks parting during manufacturing, also referred to as a parting line.

3.2.5 *profile wall, n*—A pipe wall construction that presents an interior liner in the waterway but includes exterior ribs, corrugations, or other shapes, which can be either solid or hollow, that help brace the pipe against diametrical deformation.

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

3.2.7 *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.

4. Ordering Information

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

4.1.1 This ASTM designation,

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 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,

4.1.7 Material designation,

4.1.7.1 Virgin resin, and

4.1.7.2 Recycled resin.

5. Materials and Manufacture

5.1 *Virgin Resin Products:*

5.1.1 *Pipe and Fittings*—The pipe and fittings shall be made of PE virgin plastic compound meeting the requirements of the following cell classifications as defined and described in Specification D3350:

5.1.1.1 Pipe Diameter < 300 mm [<12 in.]: Cell Class 424420C or 424420E (ESCR Test Condition B),

5.1.1.2 Pipe Diameter ≥ 300 mm [≥12 in.]: Cell Class 435420C or 435420E (ESCR Test Condition B).

5.1.1.3 Environmental crack resistance shall be determined in accordance with 7.9. When carbon black is used, the carbon black content shall be equal to or greater than 2.0 % but not exceed 4.0 % when tested in accordance with Test Method D4218. When graphitic material is used, the carbon content in the pipe shall be 1.0 % to 3.0 % when tested in accordance with Test Method D4218. When carbon black and graphitic material are used in combination, the carbon content in the pipe shall be 2.0 % to 4.0 % when tested in accordance with Test Method D4218.

5.1.1.4 In all cases, the density of the PE plastic without pigment shall not be less than 0.945 g/cm^3 nor greater than 0.955 g/cm^3. For pipe containing carbon black, or graphitic material, or both, determine the density, *Dp*, and calculate the resin density, *Dr*, as follows:

$$Dr = Dp - 0.0044C \quad (1)$$

where:

C = weight percent of carbon black, graphitic materials or both.

Compounds that have a higher cell classification in one or more properties shall be permitted provided all other product requirements are met.

5.1.2 *Rotationally Molded Fittings and Couplings*—Compounds used in the manufacture of rotationally molded fittings and couplings shall be made of virgin PE plastic compound meeting the requirements of cell classification 213320C or 213320E (ESCR Test Condition B) as defined in Specification D3350, except that the carbon black content shall be equal to or greater than 2.0 % but not exceed 4 % when tested in accordance with Test Method D4218. When graphitic material is used, the carbon content in the pipe shall be 1.0 % to 3.0 % when tested in accordance with Test Method D4218. When carbon black and graphitic material are used in combination, the carbon content in the pipe shall be 2 % to 4 % when tested in accordance with Test Method D4218.

5.1.2.1 For black compounds, containing carbon black, or graphitic material, or both, determine the density, *Dp*, and calculate the resin density, *Dr* per Eq 1. Compounds that have a higher cell classification in one or more properties shall be permitted provided all other product requirements are met.

5.1.3 *Injection and Blow Molded Fittings and Couplings*—Compounds used in the manufacture of injection molded fittings and couplings shall be made of virgin PE plastic compound meeting the requirements of cell classification 414420C or 414420E (ESCR Test Condition B) as defined in Specification D3350, except that the carbon black content shall be equal to or greater than 2.0 % but not exceed 4 % when tested in accordance with Test Method D4218. When graphitic material is used, the carbon content in the pipe shall be 1.0 % to 3.0 % when tested in accordance with Test Method D4218. When carbon black and graphitic material are used in combination, the carbon content in the pipe shall be 2 % to 4 % when tested in accordance with Test Method D4218.

5.1.3.1 For black compounds, containing carbon black, or graphitic material, or both, determine the density, *Dp*, and calculate the resin density, *Dr* per Eq 1. Compounds that have a higher cell classification in one or more properties shall be permitted provided all other product requirements are met.

5.1.4 *Rework Material*—Clean rework material generated from the manufacturer's own pipe and fittings production shall

be permitted to be used by the same manufacturer provided that the material meets the same or higher Specification D3350 cell classification as the material required for the intended part and pipe or fittings to be produced under this specification.

5.2 *Recycled Resin Products:*

5.2.1 *Recycled Resin Pipe*—The pipe containing any post-consumer or industrial recycled materials shall be made of PE plastic compound as defined in ISO 15720 meeting the requirements of the following cell classifications as defined and described in Specification D3350:

5.2.1.1 Pipe Diameter < 300 mm [≤12 in.]: Cell Class 424400C or 424400E,

5.2.1.2 Pipe Diameter ≥ 300 mm [≥12 in.]: Cell Class 435400C or 435400E.

5.2.1.3 When carbon black is used, the carbon black content shall be equal to or greater than 2 % but not exceed 4 % when tested in accordance with Test Method D4218. When graphitic material is used, the carbon content in the pipe shall be 1.0 % to 3.0 % when tested in accordance with Test Method D4218. When carbon black and graphitic material are used in combination, the carbon content in the pipe shall be 2 % to 4 % when tested in accordance with Test Method D4218.

5.2.1.4 For black compounds, containing carbon black, or graphitic material, or both, determine the density, *Dp*, and calculate the resin density, *Dr* per Eq 1. Compounds that have a higher cell classification in one or more properties shall be permitted provided all other product requirements are met. For slow crack growth resistance, extruded pipe shall be evaluated using the notched constant ligament stress (NCLS) test according to the procedure described in 7.10. The average failure time of the five test specimens shall exceed 12 h with no single test specimen's failure time less than 9 h. Maximum level of polypropylene present by volume shall not be greater than 5 percent when tested in accordance with the procedures in 7.11. Maximum ash content shall not be more than 2 % in accordance with the procedures in 7.12.

5.2.2 *Recycled Resin Fittings*—Fittings made from recycled resins are not permitted under this standard.

6. General Requirements

6.1 *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. There shall be no delamination or separation of the inner liner and the profile. The ends shall be cut squarely and cleanly. Holes intentionally placed in perforated pipe shall be permitted.

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

6.2 *Dimensions:*

6.2.1 *NID*—The nominal size for the pipe and fittings shall be the NID value listed in Table 1.

6.2.2 *Minimum Inside Diameter*—The manufacturer's stated minimum inside diameter shall be as shown in Table 1 when measured in accordance with 7.4.1.

NOTE 3—The minimum inside diameter is the smallest diameter the pipe can be and is used for the hydraulic design of the pipe.

NOTE 4—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.

6.2.3 *Length*—The pipe shall be supplied in any length agreeable to both the owner and manufacturer. Length shall not be less than 99 % of stated quantity when measured in accordance with 7.4.2.

6.2.4 *Minimum Inner Liner Thickness*—The minimum inner liner thickness of the pipe shall meet the requirements given in Table 1 when measured in accordance with 7.4.3.

6.2.5 *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 2. 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 7.4.4. Pipe connected by bell and spigot joints shall not be perforated in the area of the bells and spigots.

6.3 *Pipe Stiffness:*

6.3.1 Minimum pipe stiffness at 5 % deflection shall meet the requirements given in Table 1 when tested in accordance with 7.5.

NOTE 5—The 5 % deflection criterion, which was selected for testing convenience, is not a limitation with respect to in-use deflection. The engineer is responsible for establishing the acceptable in-use deflection limit.

6.3.2 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 7.6.

6.4 *Pipe Flattening*—There shall be no evidence of splitting, cracking, breaking, separation of seams, separation between the exterior corrugation and inner liner, or combinations thereof, when tested in accordance with 7.7.

6.5 *Pipe Impact Strength*—There shall be no evidence of splitting, cracking, breaking, separation of seams, separation of the outer and inner wall, or combinations thereof, when tested in accordance with 7.8.

6.6 *Fittings and Joining Systems:*

6.6.1 Only fittings supplied or recommended by the pipe manufacturer shall be used. Fittings shall be installed in accordance with the manufacturer's recommendations.

6.6.2 The joining system(s) shall be of a design that preserves alignment during construction and prevents separation at the joints. Bell and spigot, external snap or split couplers are examples of typical designs.

NOTE 6—The ability of a joint to resist soil infiltration (soil tightness) shall be considered. Soil tightness is a function of opening size, channel length, and backfill particle size. A backfill material containing a high percentage of Class III and Class IVA material as defined in Practice D2321 requires consulting with the manufacturer for the specific type of joint to be used to guard against soil infiltration. Alternatively, the joint

TABLE 2 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
50	2	4.75	0.19	3	0.12	25	1.0	20	1.0
75	3	4.75	0.19	3	0.12	25	1.0	20	1.0
100	4	4.75	0.19	3	0.12	25	1.0	20	1.0
150	6	4.75	0.19	3	0.12	25	1.0	20	1.0
200	8	6.25	0.25	3	0.12	30	1.2	20	1.0
225	9	6.25	0.25	3	0.12	30	1.2	20	1.0
250	10	8	0.3	3	0.12	30	1.2	20	1.0
300	12	10	0.4	3	0.12	70	2.75	30	1.5
375	15	10	0.4	3	0.12	70	2.75	30	1.5
400	16	10	0.4	3	0.12	75	2.75	30	1.5
450	18	10	0.4	3	0.12	75	2.75	30	1.5
500	20	10	0.4	3	0.12	75	2.75	40	2.0
525	21	10	0.4	3	0.12	75	2.75	40	2.0
600	24	10	0.4	3	0.12	75	2.75	40	2.0
675	27	10	0.4	3	0.12	75	2.75	40	2.0
750	30	10	0.4	3	0.12	75	2.75	40	2.0
800	32	10	0.4	3	0.12	75	2.75	40	2.0
900	36	10	0.4	3	0.12	75	2.75	40	2.0
1000	40	10	0.4	3	0.12	75	2.75	40	2.0
1050	42	10	0.4	3	0.12	75	2.75	40	2.0
1200	48	10	0.4	3	0.12	75	2.75	40	2.0
1350	54	10	0.4	3	0.12	75	2.75	40	2.0
1500	60	10	0.4	3	0.12	75	2.75	40	2.0

shall be wrapped with a geotextile designed to prevent migration of soils into the pipe.

7. Test Methods

7.1 *Conditioning:*

7.1.1 *Referee Testing*—When conditioning is required for referee tests, condition the specimens in accordance with Procedure A of Practice D618 at 23 °C ± 2° C [73 °F ± 4 °F] at 50 % relative humidity for not less than 24 hours prior to test. Conduct tests under the same conditions of temperature.

7.1.2 *Quality Control Testing*—Condition specimens prior to test at 23 °C ± 2° C [73 °F ± 4 °F] for a minimum of 4 h without regard to relative humidity or 1 h in water.

7.2 *Test Conditions*—Conduct tests other than those for routine quality control purposes in the Standard Laboratory Atmosphere of 23 °C ± 2° C [73 °F ± 4 °F] and 50 ± 5 % relative humidity in the referenced test method or in this specification.

7.3 *Sampling*—The selection of the sample or samples of the pipe and fittings shall be as agreed upon between the owner and the seller. In case of no prior agreement, any samples selected by the testing laboratory shall be permitted.

7.4 *Dimensions:*

7.4.1 *Inside Diameter*—Measure the inside diameter in accordance with Test Method D2122.

7.4.2 *Length*—Measure pipe length in accordance with Test Method D2122. Length shall be measured at ambient temperature.

7.4.3 *Minimum Inner Liner Thickness*—Measure the thickness of the inner liner 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 7—Test Method D2122 also permits the use of alternate measurement methods such as ultrasonic gauges.

7.4.4 *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 0.25 mm [0.01 in.].

7.5 *Pipe Stiffness*—Select three pipe specimens and test for pipe stiffness in accordance with Test Method D2412, except for the following conditions:

7.5.1 The test specimens shall be a minimum of the lesser of one diameter or 600 mm [24 in.] but not less than three full corrugations in length.

7.5.2 Each specimen shall be cut mid valley to mid valley while still meeting or exceeding the minimum length requirement.

7.5.3 Locate the first specimen in the loading machine in line with the mold line. The specimen must lie flat on the plate within 3 mm [0.125 in.]. Use the first location as a reference point for rotation and testing of the other specimen. Rotate the subsequent specimen 90 degrees, respectively, from the original orientation. Test each specimen in only one position.

7.5.4 Test cross head speed shall be 12.5 mm/min [0.5 in./min] for all diameter specimens, until deflection reaches 5 % of initial inside diameter.

7.6 *Nominal Ring Stiffness (SN)*—Nominal ring stiffness shall be determined in accordance with ISO 9969.

7.7 *Flattening*—Flatten the three test specimens from 7.5 between parallel plates until the pipe inside diameter is reduced