Designation: F3390 – 20

Standard Specification for 3 through 24 in. Lined Flexible Corrugated Polyethylene Pipe for Land Drainage Applications[1]

This standard is issued under the fixed designation F3390; 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 flexible annular, corrugated profile wall polyethylene pipe with an interior liner. It covers nominal sizes 3 in. (75 mm), 4 in. (100 mm), 5 in. (125 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).

1.2 The requirements of this specification are intended to provide non-pressure (gravity flow) lined flexible annular corrugated polyethylene pipe for subsurface and land drainage systems, such as agricultural or foundations, which do not operate under surcharge pressure heads.

NOTE 1—Pipe produced in accordance with this specification is to be installed in compliance with Practice F449. Lined flexible annular corrugated polyethylene provides axial flexibility allowing for subsurface installation using tile plows and allows the pipe to be coiled for storage and transport.

NOTE 2—Subsurface and land drainage systems pertain principally to agricultural applications for water table control.

NOTE 3—Lined flexible pipe provided in coiled lengths will experience distortion or folding in the interior pipe liner which may adversely affect flow characteristics, contact the pipe manufacturer for hydraulic design guidance for the coiled lined flexible pipe.

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

1.4 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.

1.5 *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.*

1.6 *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
D638 Test Method for Tensile Properties of Plastics
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
D1505 Test Method for Density of Plastics by the Density-Gradient Technique
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)
D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials
D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
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

[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.

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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.

F449 Practice for Subsurface Installation of Corrugated Polyethylene Pipe for Agricultural Drainage or Water Table Control
F477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
F667 Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings
F2136 Test Method for Notched, Constant Ligament-Stress (NCLS) Test to Determine Slow-Crack-Growth Resistance of HDPE Resins or HDPE Corrugated Pipe
F3181 Test Method for The Un-notched, Constant Ligament Stress Crack Test (UCLS) for HDPE Materials Containing Post- Consumer Recycled HDPE
F3308 Practice for Sampling and Testing Frequency for Recycled Materials in Polyethylene (PE) Pipe for Non-Pressure Applications
G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

2.2 *AASHTO Standard:*[3]
AASHTO LRFD Bridge Design Specifications

2.3 *Federal Standard:*[4]
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

2.4 *Military Standard:*[4]
MIL-STD-129 Marking for Shipment and Storage

2.5 *NCHRP (National Cooperative Highway Research Program) Report:*[5]
NCHRP Report 631 Updated Test and Design Methods for Thermoplastic Drainage Pipe
NCHRP Report 870 Performance of Corrugated Pipe Manufactured with Recycled Content

2.6 *ISO Standard:*[6]
ISO 15270 Guidelines for the Recovery and Recycling of Plastic Waste

2.7 *USDA Standard:*[4]
Reference, Engineering Standard 606

3. Terminology

3.1 *Definitions*—Definitions used in this specification are in accordance with Terminology F412 unless otherwise noted.

3.2 *Definitions:*

3.2.1 *boot*—the protecting apparatus linked to the rear of the installation machine in a manner which allows placement of the pipe on the trench bottom, protection of work person, and placement of envelope or filter material or both.

3.2.2 *coiled pipe*—Pipe which has been produced and wrapped around a central radius for storage and transportation for a greater length of pipe in a compact footprint versus sticks.

3.2.2.1 *Discussion*—The length of pipe in a coil varies by diameter and manufacturer, and coils can contain several hundred feet of pipe.

3.2.3 *coextruded pipe*—pipe consisting of two or more layers of compatible material bonded together in processing by any combination of temperature, pressure, grafting or adhesion.

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

3.2.5 *lined flexible corrugated pipe, n*—a pipe comprised of exterior hollow corrugations with an interior flexible liner.

3.2.5.1 *Discussion*—The interior liner does not perform as a structural component of the pipe and is a membrane solely intended to aid in the hydraulic flow of water through the pipe. See Fig. 1.

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

4. Ordering Information

4.1 Orders for the 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.

[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 DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.
[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.

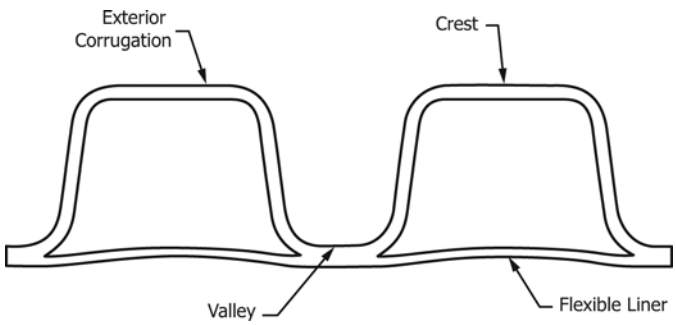

FIG. 1 Typical Lined Flexible Corrugated Polyethylene Pipe, as manufactured

5. Materials and Manufacture

5.1 *Pipe*—The coextruded pipe shall be made of polyethylene compounds meeting the following requirements for the exterior pipe corrugations and interior pipe liner.

5.1.1 *Pipe Exterior*—Polyethylene compounds used for the manufacture of the exterior corrugated wall of the pipe shall be made of virgin PE plastic compounds or PE compounds containing post-consumer or industrial recycled PE materials as defined in Guide ISO 15720. PE compounds shall meet the material requirements of the following cell classifications as and described in Specification D3350:

5.1.1.1 *Pipe Diameter 3 through 10 in.*—Cell Class 424400C or 424400E,

5.1.1.2 *Pipe Diameter 12 through 24 in.*—Cell Class 435400C or 435400E.

5.1.1.3 Compounds that have higher cell classification in one or more properties shall be permitted provided the density does not exceed 0.955 g/cm^3, and all other product requirements are met. When carbon black is used, the carbon black content shall be equal or greater than 2 % but not exceed 4 % when tested in accordance with Test Method D4218. Colored polyethylene compounds shall be protected from Ultraviolet (UV) degradation with UV stabilizers.

5.1.1.4 For slow crack-growth resistance, pipe exterior shall be evaluated using the notched constant ligament stress (NCLS) test according to the procedure described in 7.9. 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. The pipe liner and exterior material samples shall be collected separately to prevent comingling.

5.1.1.5 For PE compounds comprising recycled content, crack initiation shall also be evaluated using the un-notched constant ligament stress (UCLS) test according to the procedure described in 7.10. The average failure time of the five specimens shall exceed 22 h with no single test specimen's failure time less than 12 h. Maximum level of polypropylene present by volume shall not be greater than 5 % 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.

5.1.1.6 For PE compounds comprising recycled content shall be tested for Oxidative-Induction time in accordance with Test Method D3895. Samples shall have a minimum Oxidative-Induction time of 20 min and a break strain of 150 % when tested in accordance with Test Method D638.

5.1.1.7 For PE compounds comprising recycled content all sample and testing frequency shall be in accordance with Practice F3308.

5.1.2 *Interior Liner*—Virgin Polyethylene compounds used for the manufacture of the interior pipe liner shall meet the material requirements in Table 1. The liner shall be colored or black. When carbon black is used, the carbon black content shall be equal or greater than 2 % but not exceed 4 % when tested in accordance with Test Method D4218. Colored polyethylene compounds shall be protected from Ultraviolet (UV) degradation with UV stabilizers.

5.1.2.1 For slow crack-growth resistance, pipe liner resins shall be evaluated using the notched constant ligament stress (NCLS) test according to the procedure described in 7.9. 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. The pipe liner and exterior material samples shall be collected separately to prevent comingling.

NOTE 4—Pipe users should consult with the pipe manufacturer about the outdoor exposure life of the product under consideration. Evaluation of UV stabilizer in Code E color PE compound using Practice D2565, Practice G154, or Practice G155 may be useful for this purpose. Exposure to sunlight during normal construction periods is not harmful. It is good practice to store pipe and fittings under suitable cover prior to installation.

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

6. General Requirements

6.1 *Workmanship*—The pipe shall be uniform in color, opacity, and density. The inside and outside surfaces shall be semimatte or glossy in appearance and free of chalking, sticky, or tacky material. 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. Holes deliberately placed in perforated pipe are acceptable.

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

6.2 *Dimensions and Tolerance:*

6.2.1 *Nominal Size*—The nominal size for the pipe shall be the inside diameter shown in Table 2.

6.2.2 *Inside Diameter*—The average inside diameter for pipe shall not vary more than -1 % and +5.5 % from the *Pipe Inside Diameter* shown in Table 2, when measured in accordance with 7.5.1.

NOTE 5—The outside diameters and the corrugation pitch of the products manufactured to this specification are not specified; therefore, compatibility between pipe from different manufacturers or the same

TABLE 1 Interior Liner Virgin Material Compound Properties

Property	ASTM Test Method	Units (SI Units)	Minimum Value	Maximum Value
Melt Flow Rate	D1238	g/10 min	0.10 at 190 °C	...
Density	D792, D1505	lb/in.^{3} (g/cm^3)	0.0318 (0.880)	0.0338 (0.935)
Tensile Strength at Yield	D638	psi (N/mm^2)	1500 (10)	4000 (28)
Elongation at Yield	D638	%	10	...
Flexural Modulus (1% secant)	D790, Procedure B	psi (N/mm^2)	35 000 (241)	90 000 (621)
Notched Constant Ligament Stress	F2136	hour	12h[A]	...

[A]The average of five samples shall not be less than 12h with no single test specimen's failure less than 9h.

TABLE 2 Pipe Stiffness and Pipe Dimensions

Pipe Inside Diameter		Minimum Inside Diameter		Minimum Pipe Stiffness at 5% Deflection		Minimum Inner Liner Thickness	
in.	mm	in.	mm	lb/in./in.	kPa	in.	mm
3	75	2.97	75	50	345	0.020	0.5
4	100	3.96	101	50	345	0.020	0.5
5	125	4.95	126	50	345	0.020	0.5
6	150	5.94	151	50	345	0.020	0.5
8	200	7.92	201	50	345	0.024	0.6
10	250	9.9	251	50	345	0.024	0.6
12	300	11.88	302	50	345	0.030	0.8
15	375	14.85	377	42	290	0.035	0.9
18	450	17.82	453	40	275	0.040	1.0
24	600	23.76	604	34	235	0.048	1.2

manufacturer should be verified.

6.2.3 *Minimum Inside Diameter*—The minimum inside diameter shall be as shown in Table 2 when measured in accordance with 7.5.2.

6.2.4 *Length*—The pipe may be sold in any length agreeable to the user. Length shall not be less than 99 % of the stated quantity when measured in accordance with 7.5.3.

6.2.5 *Minimum Inner Liner Thickness*—The minimum inner-liner thickness of the pipe shall meet the requirements given in Table 2 when measured in accordance with 7.5.4.

NOTE 6—The inner pipe liner is a membrane solely intended to aid in the hydraulic flow of water as an improvement over single wall corrugated pipe. Pipe that has been coiled will not provide the same hydraulic performance as dual wall corrugated plastic pipe.

6.2.6 *Perforations*—When perforations are necessary, they shall be cleanly cut, placed in the valley of the corrugation rib and uniformly spaced along the length and circumference of the pipe in size, shape, and pattern suited to the needs of the user. The inlet area of the perforations shall be a minimum of 1 $in.^2$ /ft (21 cm^2 /m) of pipe, unless otherwise specified by the user. All measurements shall be made in accordance with 7.5.5.

6.3 *Pipe Stiffness*—Minimum pipe stiffness at 5 % deflection shall meet the requirements given in Table 2 when tested in accordance with 7.6.

NOTE 7—The 5 % deflection criterion, selected for testing convenience, is not a limitation with respect to in-use deflection. The engineer is responsible for establishing the acceptable deflection limit.

6.4 *Pipe Flattening*—There shall be no evidence of splitting, cracking, braking, separation of corrugation seams, separation of the valley and liner, or combinations thereof, on any specimen 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. The fittings shall not reduce or impair the overall integrity or function of the pipeline.

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. Joints shall meet the requirements of a soil-tight joint unless otherwise specified by the owner / designer.

6.6.3 Soil-tight joints are specified as a function of opening size, channel length, and backfill particle size. If the size of the opening exceeds 0.12 in. (3 mm), the length of the channel shall be at least four times the size of the opening. A backfill material containing a high percentage of find-graded soils requires investigation for the specific type of joint to be used to guard against soil infiltration. When gaskets are used, they shall meet the requirements of Specification F477.

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 73 ± 4 °F (23 ± 2 °C) at 50 % relative humidity for not less than 24 hours prior to testing. Conduct tests under the same conditions of temperature.

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

7.2 *Test Conditions*—Conduct tests in a laboratory atmosphere of 73 ± 4 °F (23 ± 2 °C) 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 shall be as agreed upon by the owner and the seller. Samples of pipe sufficient to determine conformance with this specification shall be taken at random from stock by the testing agency. Samples shall be representative of the product type under consideration.

7.4 *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 fails, the pipe or fitting does not comply with this specification.

7.5 *Dimensions:*

7.5.1 *Inside Diameter*—Pipe shall be measured prior to coiling and shall be laid flat and straight. Measure the inside diameter with a vernier caliper accurate to within ± 0.001 in. (0.02 mm) or circumferential wrap tape with ± 0.001 in. (0.02 mm) graduations. When a Vernier caliper is used, take a series