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.

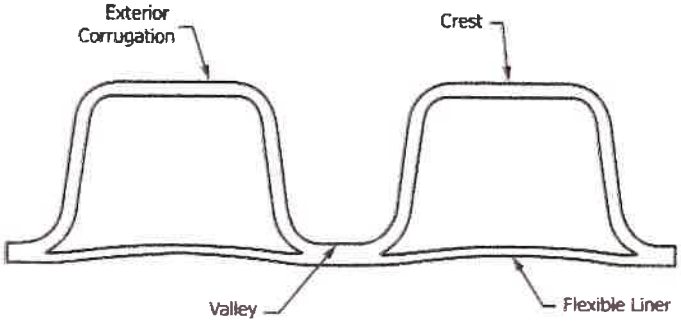

FIG. 1 Typical Lined Flexible Corrugated Polyethylene Pipe, as manufactured

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

of diameter measurements at closely spaced intervals to ensure the minimum and maximum diameters have been determined, make a minimum of six measurements.

7.5.2 *Minimum Inside Diameter*—Measure the minimum inside diameter at the location of the smallest inside diameter with the pipe laid flat and straight. A pipe that has been coiled shall be uncoiled and shall be laid generally flat and generally straight for no less than 24 h prior to measurement. The minimum inside diameter shall be measured with an apparatus with at least 0.001 in. (0.02 mm) graduations. In no case shall the inside diameter be less than the minimum inside diameter values listed in Table 2.

NOTE 8—Allowing the pipe to stabilize in an uncoiled state for 24 h is to permit relaxation of the liner from the temporary liner distortion caused from the pipe being coiled.

7.5.3 *Length*—Measure pipe laying length in accordance with Test Method D2122. These measurements may be taken at ambient temperature.

7.5.4 *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° around the circumference 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.

7.5.5 *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).

7.6 *Pipe Stiffness*—Select a minimum of two pipe specimens and test for pipe stiffness $F/\Delta y$, as described in Test Method D2412, except for the following conditions:

7.6.1 The test specimens shall be at least one diameter or 24 in. in length, which ever is less. However, the test specimen shall not be less than three full corrugations in length.

7.6.2 Each specimen shall be cut mid-valley to mid-valley while still meeting or exceeding the minimum length requirements.

7.6.3 Locate the first specimen in the loading machine with the imaginary line between the two corrugator seams (end view) parallel to the loading plates. The specimen must lay flat on the plate within 0.12 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 specimen. Separately, locate the second specimen 90 °C from the orientation of the first specimen and test. Test each specimen in one position only. The deflection indicator shall be readable and accurate to ± 0.001 in. (± 0.02 mm).

7.6.4 The test cross head speed shall be 0.5 in./min (12.5mm/min) for all diameter specimens until deflection reaches 5 % of initial inside diameter.

7.7 *Flattening*—Flatten the two test specimens from 7.5 between parallel plates until the pipe inside diameter is reduced by 40 %. The rate of loading shall be 0.5 in./min (12.5 mm/min). For pipe with inside diameters greater than 10 in., test speed may be increased to a maximum of 5 % of the inside diameter per minute, once deflection has reached 5 % of inside diameter. The specimen shall have no splitting, cracking, breaking, or separation of ribs, seams, or corrugations where observed under normal light with the unaided eye. Additionally, at or below 20 % deflection, the specimen shall be considered as failing this flattening test if, during the flattening test, the load does not increase continuously with increasing deflection.

7.8 *Impact Resistance*—Test pipe specimens in accordance with Test Method D2444 except six specimens shall be tested. Use Tup B weighing 5.5 lbs (2.5kg); 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 ± 4 °F (-4 ± 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.

7.9 *Slow-Crack-Growth Resistance of Resin Compounds*—Test basic resin compounds in accordance with the Test Method F2136, test except for the following modifications:

7.9.1 The applied stress for the NCLS test shall be 600 psi (4138 kPa). The test specimen is taken from the extruded pipe and is chopped and molded into a plaque. The pipe interior liner and exterior material shall be cut from pipe separately to prevent comingling of the interior liner and exterior material. Each sample shall be chopped and molded into separate plaques.

7.10 *Determination of Crack Initiation of Pipes Manufactured with Recycled Compounds*—

7.10.1 Crack initiation shall be tested in accordance with the un-notched, constant ligament stress (UCLS) crack test per F3181 at a condition of 650 psi (4482 kPa) stress and 176 °F (80 °C).

7.10.2 The average failure time of five specimens shall be greater than or equal to 22 h, and no specimen shall fail in less than 12 h. [7]

7.10.3 An example calculation providing the basis for these average and minimum UCLS failure times is provided in Appendix X4.

7.11 *Determination of Percent Polypropylene for Recycled Resin Compounds*—Test samples of the recycled resin compound in accordance with Test Method D7399.

7.12 *Determination of Ash Content in Recycle Materials*—Test a two-gram sample at 1472 °F (800 °C) in accordance with Test Method D5630.

8. Inspection

8.1 *General*—Owner inspection of the product during manufacture shall be as agreed upon between the owner and manufacturer as part of the purchase contract. Unless otherwise

[7] Kurdziel, J. and Pluimer, M. "Engineering and Testing Requirements for Infrastructure Pipeline Applications Utilizing HDPE Recycled Materials" Proceedings of the nineteenth Plastic Pipes Conference, September 24-26, 2018, Las Vegas, Nevada.

specified in the contract or purchase agreement, the manufacturer is responsible for the performance of all inspection and test requirements specified herein.

8.2 *Notification*—If the inspection is specified by the owner, the manufacturer shall notify the owner in advance of the date, time, and place of testing of the pipe so that the purchaser may be represented during the test.

8.3 *Access*—The owner's inspector or representative shall have free access to those parts of the manufacturer's plant and testing laboratory that are involved in the work and testing performed under this specification. The manufacturer shall afford the inspector all reasonable facilities for determining whether the pipe meets the requirements of this specification.

8.4 *Production Lot*—The manufacturer shall maintain records to identify the production line, date, resin compound, and production run for any pipe selected by the inspector for testing. When agreed upon by the owner and manufacturer under 8.1, the pipe inspected shall be taken from a lot shipped to the owner's project.

9. Rejection and Retesting

9.1 If the results of any test(s) do not meet the requirements of this specification, the test(s) shall be conducted again on the pipe from the same production lot with an agreement between the owner and the manufacturer. There shall be no agreement to lower the minimum requirement of the specification by such means as omitting tests that are a part of the specification, substituting or modifying a test method, or by changing the specification limits. In retesting, the product requirements of this specification shall be met, and the test methods designated in this specification shall be followed. If upon retest, failure occurs, the quantity of product represented by the test(s) does not meet the requirements of this specification.

10. Certification

10.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the owner that the products were manufactured, sampled, tested, and inspected at the time of manufacture in accordance with this specification and have been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

11. Product Marking

11.1 *Pipe*—Each length of pipe in compliance with this specification shall be clearly marked with the following information: this designation "ASTM F3390"; the nominal pipe size in inches (mm); the manufacturer's name, trade name or trademark, plant location, and date of manufacture. Pipe containing recycled materials shall be marked with the statement "CONTAINS RECYCLED MATERIALS."The marking shall be applied to the pipe in such a manner that it remains legible after installation and inspection. It shall be placed, at least, at each end of each length of pipe or spaced at intervals of not more than 10 ft (3.0 m).

12. Packaging and Package Marking

12.1 All pipe and accessories shall, unless otherwise specified, be packaged for standard commercial shipment. Typical pipe packaging may include individual straight lengths, bundles of straight lengths or coiled lengths.

13. Quality Assurance

13.1 When the product is marked with "ASTM F3390," 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.

14. Installation

14.1 When the pipe is installed with the use of a drainage plow consult the pipe manufacturer for recommended minimum plow boot radius.

15. Keywords

15.1 corrugated; flexible dual wall; perforated; polyethylene; underdrain

SUPPLEMENTARY REQUIREMENTS

S1. Responsibility for Inspection—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 his 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 destination 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.

APPENDIXES

X1. FITTINGS

(Nonmandatory Information)

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.

X2. AUTHORITIES

X2.1 This product has a wide variety of uses, approval for its use rests with various agencies. The installer should contact the relevant authority to obtain local installation guidelines. A partial list of authorities, according to product usage, is as follows:

X2.1.1 *Farm Drainage*—U.S. Department of Agriculture, Soil Conservation Service, local office: Reference, Engineering Standard 606.

X2.1.2 *Roadway Drainage*—Federal, state, county, or local highway authority.

X2.2 The pipe manufacturer should be able to provide proof of product acceptance by specific agencies, where appropriate.

X3. STRUCTURAL DESIGN

X3.1 The pipe liner is solely for the purpose of hydraulic flow capacity and shall not be considered as a structural member. The structural analysis shall exclude the contribution of the pipe liner as a structural member and pipe shall be considered as single wall for the purpose of structural analysis.

X3.2 After the design engineer satisfies project requirements, such as deflection, local and global buckling, and bending stress, it is advisable to review conditions with respect to long-term strain of 5 %.

X3.3 The following discussion is about tensile and compressive strains. It is presented in general form. The user is responsible for qualifying the pipe after reviewing the proposed conditions and the qualities of the manufacturer's product.

X3.3.1 *Tensile Strain:*

$$\varepsilon_T = \varepsilon_B - (\varepsilon_S + \varepsilon_H) \quad \text{(X3.1)}$$

where:

ε_T = total tensile strain,
ε_B = external hydrostatic compressive strain.
ε_S = tensile strain from pipe bending in either diametric, axial, or combined situations,
ε_H = compressive strain induced into the pipe walls by the soil weight above the pipe.

X3.3.2 *Compressive Strain:*

$$\varepsilon_C = \varepsilon_B + \varepsilon_S + \varepsilon_H \quad \text{(X3.2)}$$

where:

ε_C = total compressive strain

NOTE X3.1—AASHTO LRFD Bridge Design Specifications, Section 12 is typically used for evaluation of structural design of corrugated polyethylene pipe. Reference LRFD Section 12 for additional information for an analytical method for evaluating the structural integrity of the pipe.

X3.4 A modulus of elasticity and tensile strength for the material rated at 50 years is often used in the calculations leading to the determination of strain. This value will vary directly in proportion to the stress level and should be provided by the manufacturer for design purposes.

X4. EXAMPLE CALCULATIONS FOR MINIMUM UCLS FAILURE TIME DETERMINATION

X4.1 *Example 1*: Consider a pipe installed in a condition where the tensile design stress is 480 psi and the average in-ground service temperature is 64.4 °F (18 °C) [8]. To account for field variability of agricultural pipe systems, a stress factor 1.3 is applied to the calculated tensile stress resulting in a factored demand stress of 624 psi (4302.33 kPa). The desired service life is 50 years. To determine the minimum UCLS failure time, follow the procedure below:

X4.2 Example shown is with customary units utilized in NCHRP Report 870.

X4.2.1 Calculate the Popelar time and stress multiplication factors to shift the failure times from the elevated temperature test condition to the service condition:

$$SF_t = e^{0.109(T_t - T_{SVC})} \quad \text{(X4.1)}$$

$$SF_t = e^{0.109(80 - 18)} = e^{6.758} = 860.9 \quad \text{(X4.2)}$$

$$SF_\sigma = e^{0.0116(T_t - T_{SVC})} \quad \text{(X4.3)}$$

$$SF_\sigma = e^{0.0116(80 - 18)} = e^{0.7192} = 2.053 \quad \text{(X4.4)}$$

where:

SF_t = Popelar time shift factor
SF_s = Popelar stress shift factor
T_{SVC} = Service temperature, °C
T_t = Test temperature, °C

X4.2.2 Calculate the minimum required UCLS failure time for the test condition to ensure the desired service life is met using Eq X4.5:

$$t = \left(\frac{8760 \cdot t_{SVC}}{SF_t}\right) * \left(\frac{\sigma_{SVC}}{650 \cdot SF_\sigma}\right)^5 \quad \text{(X4.5)}$$

$$t = \left(\frac{8760 \cdot 50}{860.92}\right) * \left(\frac{480}{650 \cdot 2.053}\right)^5 = 11.38 hrs. \quad \text{(X4.6)}$$

where:

t = Minimum required average UCLS failure time at given test conditions, hours
s_{SVC} = Design service stress, psi
t_{SVC} = Required service life at service conditions, years

X4.2.3 Statistically adjust this minimum failure time to ensure 95% confidence using Eq X4.7, as illustrated below.

$$\bar{X}_{95\%} = 1.911 \cdot t = 1.911 \cdot 5.9 = 21.75 hrs. \quad \text{(X4.7)}$$

X4.2.4 Rounding up to the nearest integer, the minimum average failure time for 5 specimens shall not be less than **22 hours**, and no single specimen shall fail in less than **12 hours**.

X4.3 *Example 2*: Consider a pipe installed in a condition where the maximum factored tensile design stress is 400 psi and the average in-ground service temperature is 20 °C. To account for field variability of agricultural pipe systems, a stress factor 1.3 is applied to the calculated tensile stress resulting in a factored demand stress of 520 psi. The desired service life is 100 years. To determine the minimum UCLS failure time, follow the procedure below.

X4.3.1 Calculate the Popelar time and stress multiplication factors to shift the failure times from the elevated temperature test condition to the service condition:

$$SF_t = e^{0.109(80 - 20)} = e^{6.54} = 692.3 \quad \text{(X4.8)}$$

$$SF_\sigma = e^{0.0116(80 - 20)} = e^{0.696} = 2.006 \quad \text{(X4.9)}$$

X4.3.2 Calculate the minimum required UCLS failure time for the test condition to ensure the desired service life is met using Eq X4.5, as illustrated below.

$$t = \left(\frac{8760 \cdot 100}{692.3}\right) * \left(\frac{520}{650 \cdot 2.006}\right)^5 = 12.44 hrs. \quad \text{(X4.10)}$$

X4.3.3 Statistically adjust this minimum failure time to ensure 95 % confidence using Eq X4.7, as illustrated below:

$$\bar{X}_{95\%} = 1.911 \cdot t = 1.911 \cdot 3.44 = 24.4 hrs. \quad \text{(X4.11)}$$

X4.3.4 Rounding up to the nearest integer, the minimum average failure time for 5 specimens shall not be less than **25 hours**, and no single specimen shall fail in less than **13 hours**.

[8] Kurdziel, J. and Pluimer, M. "Engineering and Testing Requirements for Infrastructure Pipeline Applications Utilizing HDPE Recycled Materials" Proceedings of the nineteenth Plastic Pipes Conference, September 24-26, 2018, Las Vegas, Nevada