
Standard Specification for

**Corrugated Polyethylene Pipe,
300- to 1500-mm (12- to 60-in.)
Diameter**

AASHTO Designation: M 294-18

Technical Subcommittee: 4b, Flexible and Metallic Pipe

Release: Group 2 (June)



**American Association of State Highway and Transportation Officials
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1. SCOPE

- 1.1. This specification covers the requirements and methods of tests for corrugated polyethylene (PE) pipe, couplings, and fittings for use in surface and subsurface drainage applications.
 - 1.1.1. Nominal sizes of 300 to 1500 mm (12 to 60 in.) are included.
 - 1.1.2. Materials, workmanship, dimensions, pipe stiffness, slow-crack-growth resistance, joining systems, brittleness, perforations, and form of markings are specified.
- 1.2. Corrugated PE pipe is intended for surface and subsurface drainage applications where soil provides support to its flexible walls. Its major use is to collect or convey drainage water by open gravity flow, as culverts, storm drains, etc.

Note 1—When PE pipe is to be used in locations where the ends may be exposed, consideration should be given to protection of the exposed portions due to combustibility of the PE and the deteriorating effects of prolonged exposure to ultraviolet radiation.
- 1.3. *Units*—The values stated in SI units are to be regarded as standard. Within the text, the U.S. Customary units are shown in parentheses, and may not be exact equivalents.
- 1.4. This specification does not include requirements for bedding, backfill, or earth cover load. Successful performance of this product depends on proper type of bedding and backfill, and care in installation. The structural design of corrugated PE pipe and the proper installation procedures are given in *AASHTO LRFD Bridge Design Specifications*, Section 12, and *LRFD Bridge Construction Specifications*, Section 30, respectively. Upon request of the user or engineer, the manufacturer shall provide profile wall section detail required for a full engineering evaluation.
- 1.5. The following precautionary caveat pertains only to the test method portion, Section 9.4, 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*

- T 341, Determination of Compression Capacity for Profile Wall Plastic Pipe by Stub Compression Loading
- *AASHTO LRFD Bridge Construction Specifications*
- *AASHTO LRFD Bridge Design Specifications*

2.2.

ASTM Standards:

- D618, Standard Practice for Conditioning Plastics for Testing
- D638, Standard Test Method for Tensile Properties of Plastics
- D883, Standard Terminology Relating to Plastics
- D2122, Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
- D2412, Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
- D2444, Standard Practice for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
- D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
- D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
- D3895, Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
- D4218, Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
- D4703, Standard Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets
- D4883, Standard Test Method for Density of Polyethylene by the Ultrasound Technique
- F412, Standard Terminology Relating to Plastic Piping Systems
- F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
- F2136, Standard Test Method for Notched, Constant Ligament-Stress (NCLS) Test to Determine Slow-Crack-Growth Resistance of HDPE Resins or HDPE Corrugated Pipe
- F3181, Standard Test Method for the Un-notched, Constant Ligament Stress Crack Test (UCLS) for HDPE Materials Containing Post-Consumer Recycled HDPE

2.3.

Federal Standard:

- 29 CFR 1910.1200; see also Permissible Exposure Limits—Annotated Tables, available from <https://www.osha.gov/dsg/annotated-pels>

2.4.

Other:

- Pluimer, Michael L. (2016). Evaluation of Corrugated HDPE Pipes Manufactured with Recycled Materials in Commuter Railroad Applications (Doctoral dissertation). Proquest Publishing, Villanova University.
- Pluimer, Michael, Joel Sprague, Richard Thomas, Leslie McCarthy, Andrea Welker, Shad Sargand, Ehab Shaheen, and Kevin White. *National Cooperative Highway Research Report 870: Field Performance of Corrugated Pipe Manufactured with Recycled Polyethylene Content*. NCHRP, Transportation Research Board, Washington, DC, 2018. See Appendix L, AASHTO's proposed *Standard Practice for Service Life Determination of Corrugated HDPE Pipes Manufactured with Recycled Materials*. Available online at <http://www.trb.org/NCHRP/Blurbs/176741.aspx>

3. TERMINOLOGY

- 3.1. The terminology used in this standard is in accordance with the definitions given in ASTM D883 and ASTM F412 unless otherwise specified.
- 3.2. *buckling*—During pipe flattening testing, any decrease or downward deviation in the pipe load-deflection test curve at or below the calculated buckling deflection limit shall be considered a buckling point.
- 3.3. *contaminant*—inorganic particulate matter or other non-HDPE organic material that creates inclusions or stress risers in the crystalline structure of HDPE.
- 3.4. *crack*—any break or split that extends through the wall or liner.
- 3.5. *crack initiation*—the portion of the slow-crack-growth mechanism associated with the initial development of a craze zone and micro-cracks around a contaminant, void, or discontinuity; also referred to as slow-crack-growth initiation or stress-crack initiation.
- 3.6. *crack propagation*—the portion of the slow-crack-growth mechanism associated with successive yielding of HDPE material ahead of a crack tip; also referred to as slow-crack-growth propagation or stress-crack propagation.
- 3.7. *crease*—a visible irrecoverable indentation.
- 3.8. *buckling deflection limit*—the percentage reduction of the inside diameter of the pipe for the extreme fiber of the wall profile to reach the factored combined compressive strain limit of 6.15 percent for HDPE pipe per *AASHTO LRFD Bridge Design Specifications*, Section 12.
- 3.9. *delamination*—A separation between the inner liner and outer corrugated wall of Type S pipe as evidenced by a visible gap extending completely through at least one corrugation valley at any point around the circumference of the pipe. For Type D pipe, delamination is a separation of the liner and outer wall as evidenced by a visible gap extending completely between the internal supports and liner or outer wall at any point around the circumference of the pipe.
- 3.10. *polyethylene (PE) plastics*—plastics based on polymers made with ethylene as essentially the sole monomer (ASTM D883).
- 3.11. *post-consumer recycled (PCR) PE*—PE materials from products that have served a previous consumer purpose (for example, laundry detergent bottles, milk bottles, and other containers for consumer goods).
- 3.12. *post-industrial recycled (PIR) PE*—PE materials diverted from the waste stream during a manufacturing process that have never reached the end user.
- 3.13. *reworked plastic*—a plastic from a processor's own production that has been reground, pelletized, or solvated after having been previously processed by molding, extrusion, etc. (ASTM D883).
- 3.14. *slow crack growth (SCG)*—a phenomenon by which a stress crack may form. A stress crack is an external or internal crack in plastic caused by tensile stresses less than its short-time mechanical strength. The slow-crack-growth mechanism is comprised of a crack initiation phase and a crack-propagation phase.
- 3.15. *virgin polyethylene material*—PE plastic material in the form of pellets, granules, powder, floc, or liquid that has not been subject to use or processing other than required for initial manufacture.

4. CLASSIFICATION

- 4.1. *The corrugated PE pipe covered by this specification is classified as follows:*
 - 4.1.1. *Type C*—This pipe shall have a full circular cross section, with a corrugated surface both inside and outside. Corrugations shall be annular.
 - 4.1.1.1. *Type CP*—This pipe shall be Type C with perforations.
 - 4.1.2. *Type S*—This pipe shall have a full circular cross section, with an outer corrugated pipe wall and a smooth inner liner. Corrugations shall be annular.
 - 4.1.2.1. *Type SP*—This pipe shall be Type S with perforations.
 - 4.1.3. *Type D*—This pipe shall consist of an essentially smooth liner braced circumferentially or spirally with projections or ribs joined to an essentially smooth outer wall.
 - 4.1.3.1. *Type DP*—This pipe shall be Type D with perforations.
- 4.2. Two classes of perforations are as described in Sections 7.3.1 and 7.3.2.
- 4.3. This standard allows pipes to be manufactured with virgin or recycled materials, or blends of both. If only virgin materials are allowed, it shall be specified in the ordering information. All pipes shall be marked accordingly as described in Sections 11.1.4 and 11.1.5.

5. ORDERING INFORMATION

- 5.1. *Orders using this specification shall include the following information, as necessary, to adequately describe the desired product:*
 - 5.1.1. AASHTO designation and year of issue;
 - 5.1.2. Type of pipe (Section 4.1);
 - 5.1.3. Virgin or recycled resins, or blends of both (Section 4.3);
Note 2—This is a performance-based specification and does not include minimum or maximum limits on the recycled or virgin content, provided the performance requirements of the final blend are met. Specific limits on the recycled or virgin content, if desired, along with any specific marking requirements for such limits, shall be specified on the order.
 - 5.1.4. Diameter and length required, either total length or length of each piece and number of pieces;
 - 5.1.5. Number of couplings;
 - 5.1.6. Class of perforations (Class 2 is furnished if not specified) (Section 7.3); and
 - 5.1.7. Certification, if desired (Section 12.1).

6. MATERIALS

- 6.1. *Basic Materials:*

- 6.1.1. *Extruded Pipe and Blow Molded Fittings*—Pipe and fittings shall be made of virgin or recycled PE resin compounds, or blends of both, meeting the requirements of ASTM D3350 and cell classification 435400C, except that the carbon black content shall not exceed 4.0 percent. The cell classification shall be based on the virgin or recycled PE resin compounds, or blends of both, without carbon black when tested in accordance with ASTM D4218. Resins that have higher cell classifications in one or more properties, with the exception of density, are acceptable provided product requirements are met. For slow-crack-growth resistance, acceptance of resins shall be determined by using the notched constant ligament-stress (NCLS) test according to the procedure described in Section 9.4. For slow-crack-growth resistance, the requirements in Sections 6.1.1.1 and 6.1.1.2 shall be met.
- 6.1.1.1. To ensure adequate resistance to SCG propagation, Notched Constant Ligament Stress (NCLS) testing shall be conducted on specimens die cut either directly from the finished pipe liner or from ground-up pieces of pipe (from the liner or outer wall, or both) that have been compression-molded into a plaque. Testing shall be conducted in accordance with ASTM F2136 and the procedures described in Section 9.4.
- 6.1.1.1.1. If testing is conducted on specimens taken directly from the finished pipe liner, the average failure time of five specimens shall not be less than 18 h.
- 6.1.1.1.2. If testing is conducted on specimens taken from ground-up pieces of pipe that have been compression molded into a plaque, the average failure time of five test specimens shall not be less than 24 h.
- 6.1.1.2. For pipes manufactured with recycled PE materials (PCR or PIR, or both), Un-notched Constant Ligament Stress (UCLS) testing shall be conducted in accordance with ASTM F3181 and the procedures described in Section 9.4 to ensure the desired service life is met. The minimum UCLS failure time shall be prescribed based on the service conditions (temperature and factored design stress) and desired service life as detailed in A2 of the Annex. In the absence of design data, a service life of 100 years at a service temperature of 23°C and factored tensile design stress of 500 psi shall be conservatively specified. For this condition, the average UCLS failure time for five specimens shall not be less than 34 h, with no single specimen failing in less than 18 h.
- 6.1.1.3. Pipes manufactured from recycled PE materials (PCR or PIR, or both) shall have an Oxidation Induction Time (OIT) of 20 minutes when tested in accordance with ASTM D3895 and a break strain of 150 percent when tested in accordance with ASTM D638. Density of pipe compounds containing recycled PE materials (PCR or PIR, or both) should be conducted by the ultrasound technique in accordance with ASTM D4883.
- Note 3**—The ultrasound density technique is not affected by colorants and other inorganic compounds that may be present in these recycled PE materials (PCR or PIR, or both).
- 6.1.2. *Rotational Molded Fittings and Couplings*—Fittings and couplings shall be made of virgin PE resins meeting the requirements of ASTM D3350 and cell classification 213320C, except that the carbon black content shall not exceed 5 percent. Resins that have higher cell classifications in one or more properties are acceptable provided product requirements are met.
- 6.1.3. *Injection Molded Fittings and Couplings*—Fittings and couplings shall be made of virgin PE resins meeting the requirements of ASTM D3350 and cell classification 314420C, except that the carbon black content shall not exceed 5 percent. Resins that have higher cell classifications in one or more properties are acceptable provided product requirements are met.
- 6.2. *Reworked Plastic*—Clean reworked plastic may be used by the manufacturer, provided that it meets the cell class requirements as described in Section 6.1.

- 6.3. *Resin Blending*—When blended resins are used, the components of the blend must be PE and the final blend must meet all of the requirements of Section 6.1.1 for extruded pipe and blow molded fittings, Section 6.1.2 for rotational molded fittings and couplings, and Section 6.1.3 for injection molded fittings and couplings.

7. REQUIREMENTS

- 7.1. *Workmanship*—The pipe and fittings shall be free of visible foreign inclusions and visible defects as defined herein. The ends of the pipe shall be cut squarely and cleanly so as not to adversely affect joining or connecting.
- 7.1.1. *Visible Defects*—Cracks, creases, delaminations, and unpigmented or nonuniformly pigmented pipe are not permissible in the pipe or fittings as furnished. There shall be no evidence of delamination when tested in accordance with Section 9.7.
- 7.2. *Pipe Dimensions:*
- 7.2.1. *Nominal Size*—The nominal size for the pipe and fittings is based on the nominal inside diameter of the pipe. Nominal diameters shall be 300, 375, 450, 525, 600, 675, 750, 900, 1050, 1200, 1350, and 1500 mm (12, 15, 18, 21, 24, 27, 30, 36, 42, 48, 54, and 60 in.).
- 7.2.2. *Liner Thickness*—The liner of Type S pipe, and both liner and outer wall of Type D pipe shall have the following minimum thicknesses when measured in accordance with Section 9.6.4:

Diameter, mm (in.)	Liner Thickness, Min ^a , mm (in.)
300 (12)	0.9 (0.035)
375 (15)	1.0 (0.04)
450 (18)	1.3 (0.05)
525 (21)	1.5 (0.06)
600 (24)	1.5 (0.06)
675 (27)	1.5 (0.06)
750 (30)	1.5 (0.06)
900 (36)	1.7 (0.07)
1050 (42)	1.8 (0.07)
1200 (48)	1.8 (0.07)
1350 (54)	2.0 (0.08)
1500 (60)	2.0 (0.08)

^a For Type D profile, the minimum liner thickness shall also apply to the outer wall.

- 7.2.3. *Inside Diameter Tolerances*—The tolerance on the specified inside diameter shall be 4.5 percent oversize and 1.5 percent undersize, but not more than 37 mm (1.5 in.) oversize when measured in accordance with Section 9.6.1.
- 7.2.4. *Length*—Corrugated PE pipe may be sold in any length agreeable to the user. Lengths shall not be less than 99 percent of the stated quantity when measured in accordance with Section 9.6.2.
- 7.3. *Perforations*—When perforated pipe is specified, the perforations shall conform to the requirements of Class 2, unless otherwise specified in the order. Class 1 perforations are for pipe intended to be used for subsurface drainage or combination storm and underdrain. Class 2 perforations are for pipe intended to be used for subsurface drainage only. The perforations shall be cleanly cut so as not to restrict the inflow of water. Pipe connected by couplings or bands may be unperforated within 100 mm (4 in.) of each end of each length of pipe. Pipe connected by bell and spigot joints may not be perforated in the area of the bells and spigots.