Standard Specification for

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

AASHTO Designation: M 294-16
Release: Group 2 (June 2016)

AASHTO
American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001

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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, 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 upon 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 *LFRD 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*:

- R 16, Regulatory Information for Chemicals Used in AASHTO Tests
- 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 Test Method 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
- 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
- D5397, Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
- 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

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 stiffness testing, any decrease or downward deviation in the pipe stiffness test curve at or below the calculated buckling deflection limit shall be considered a buckling point. Additionally, any irrecoverable longitudinal crease or similar irrecoverable artifact that spans three or more corrugations and is present after 30 minutes following removal of the test specimen from the parallel plate test machine shall be considered as buckling.

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

3.4. *crease*—a visual irrecoverable indentation, generally associated with wall buckling.

3.5. *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.

3.6. *polyethylene (PE) plastics*—plastics based on polymers made with ethylene as essentially the sole monomer (ASTM D883).

3.7. *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).

3.8. *slow crack growth*—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.

3.9. *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.

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. Diameter and length required, either total length or length of each piece and number of pieces;

5.1.4. Number of couplings;

5.1.5. Class of perforations (Class 2 is furnished if not specified) (Section 7.3); and

5.1.6. 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 PE resin compounds 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 PE resin compounds without carbon black. 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, acceptance of pipe shall be determined by tests on the finished pipe using the NCLS test according to the procedure described in Section 9.4. The average failure time of the pipe liner shall not be less than 18 h. If profile geometries do not have a flat portion of sufficient length to produce an NCLS tensile specimen of 25 mm (1 in.) length, usually 15-in. diameter or less, the pipe sample shall be ground and a test plaque made in accordance with ASTM D4703 Procedure C at a cooling rate of 15°C/min (27°F/min) and tested per ASTM F2136. The average failure time of test specimens from plaques shall not be less than 24 h.

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*—In lieu of virgin PE, 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 virgin 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 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.

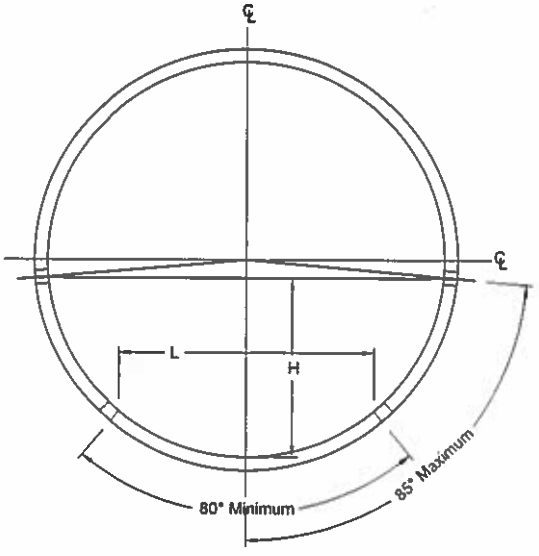


Figure 1—Requirements for Perforations

Table 1—Rows of Perforations, Height *H* of the Centerline of the Uppermost Rows above the Invert, and Chord Length *L* of Unperforated Segment, for Class 1 Perforations

Nominal Diameter, mm (in.)	Rows of Perforations[a]	*H*, Max,[b] mm (in.)	*L*, Min,[b] mm (in.)
300 (12)	6	138 (5.4)	192 (7.5)
375 (15)	6	172 (6.75)	240 (9.5)
450 (18)	6	207 (8.15)	288 (11.3)
525 (21)	6	241 (9.5)	336 (13.2)
600 and larger (24 and larger)	8	[c]	[c]

[a] Minimum number of rows. A greater number of rows for increased inlet area shall be subject to agreement between purchaser and manufacturer. Note that the number of perforations per meter in each row (and inlet area) is dependent on the corrugation pitch.

[b] See Figure 1 for location of dimensions *H* and *L*.

[c] *H*(max) = 0.46*D*; *L*(min) = 0.64D, where *D* = nominal diameter of pipe, mm.

7.3.1. *Class 1 Perforations*—The perforations shall be approximately circular and shall have nominal diameters of not less than 5 mm (0.2 in.) nor greater than 10 mm (0.4 in.) and shall be arranged in rows parallel to the axis of the pipe. For Type CP and SP pipe, the perforations shall be located in the external valleys with perforations in each row for each corrugation. (The perforations shall not cut into the corrugation sidewalls.) For Type DP pipe, perforations shall be located in the center of the cells. The perforations shall not cut into the vertical sections of the cells. The rows of perforations shall be arranged in two equal groups placed symmetrically on either side of the lower unperforated segment corresponding to the flow line of the pipe. The spacing of the rows shall be uniform. The distance between the centerlines of the rows shall not be less than 25 mm (1 in.). The minimum number of longitudinal rows of perforations, the maximum height of the centerlines of the uppermost rows of perforations above the bottom of the invert, and the inside chord lengths of the unperforated segments illustrated in Figure 1 shall be as specified in Table 1.

7.3.2. *Class 2 Perforations*—Circular perforations shall be a minimum of 5 mm (0.2 in.) and shall not exceed 10 mm (0.4 in.) in diameter. The width of slots shall not exceed 3 mm (0.1 in.). The length of slots shall not exceed 70 mm (2.75 in.) for 300 mm (12 in.) and 375 mm (15 in.) pipe and 75 mm (3 in.) for 450 mm (18 in.) and larger pipe. Perforations shall be placed in the external valleys for Type CP and SP pipe and in the center of the cells for Type DP pipe. Perforations shall be uniformly spaced along the length and circumference of the pipe. The water inlet area shall be a minimum of 30 cm^2/m (1.5 $in.^2$/ft) for pipe sizes 300 to 450 mm (12 to 18 in.) and 40 cm^2/m (2 $in.^2$/ft) for pipe sizes larger than 450 mm (18 in.). All measurements shall be made in accordance with Section 9.6.3.

7.4. *Pipe Stiffness*—The pipe shall have a minimum pipe stiffness at 5 percent deflection as follows when tested in accordance with Section 9.1.

Diameter, mm (in.)	Pipe Stiffness, kPa (psi)
300 (12)	345 (50)
375 (15)	290 (42)
450 (18)	275 (40)
525 (21)	260 (38)
600 (24)	235 (34)
675 (27)	205 (30)[a]
750 (30)	200 (29)[a]
900 (36)	155 (22.5)[a]
1050 (42)	145 (21)[a]
1200 (48)	135 (20)[a]
1350 (54)	120 (18)[a]
1500 (60)	105 (15)[a]

[a] For diameters 675 mm (27 in.) and larger, the stiffness test is conducted at a higher loading rate than ASTM D2412 as described in Section 9.1.

7.5. *Pipe Flattening*—Pipe specimens shall show no visual evidence of cracking, splitting, delamination, or buckling. Pipe specimens shall not show a decrease or downward deviation in the load-deflection curve during the pipe flattening test when the pipe is tested in accordance with Section 9.2. Either visual evidence or a downward deviation in the load-deflection curve would constitute a failing test result.

7.6. *Brittleness*—Pipe specimens shall not crack or split when tested in accordance with Section 9.3. Five nonfailures out of six impacts will be acceptable.

7.7. *Stub Compression Test*—Profile compression capacity in any specimen in the stub compression test shall not be less than 50 percent of the gross cross-sectional area times the minimum specified yield strength when tested in accordance with Section 9.8. The stub compression test, AASHTO T 341, shall be a material and wall design qualification test conducted twice a year or whenever there are changes in wall design or material distribution. Computing the minimum capacity requires determining the cross-sectional area of the pipe wall. This can be accomplished conveniently by optically scanning the profile and determining the section properties using a computer drafting program.

7.8. *Fitting Requirements*:

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

7.8.2. Common corrugated fittings include in-line joint fittings, such as couplings and reducers, and branch or complementary assembly fittings such as tees, wyes, and end caps. These fittings are installed by various methods.

7.8.3. All fittings shall be within an overall length dimensional tolerance ±12 mm (0.5 in.) of the manufacturer's specified dimensions when measured in accordance with Section 9.6.2.

7.8.4. Fittings shall not reduce the inside diameter of the pipe being joined by more than 12 mm (0.5 in.). Reducer fittings shall not reduce the cross-sectional area of the small size.

7.8.5. Couplings shall be corrugated to match the pipe corrugations and shall provide sufficient longitudinal strength to preserve pipe alignment and prevent separation at the joints. Couplings shall be bell and spigot or split collar. Split couplings shall engage at least two full corrugations on each pipe section.

7.8.6. The design of the fittings shall be such that when connected with the pipe, the axis of the assembly will be level and true when tested in accordance with Section 9.5.2.

7.8.7. Other types of coupling bands or fastening devices that are equally effective as those described, and that comply with the joint performance criteria of *AASHTO LRFD Bridge Construction Specifications*, Section 30, may be used when approved by the purchaser.

7.9. Only fittings supplied or recommended by the pipe manufacturer should be used. Fabricated fittings should be supplied with joints compatible with the overall system. All joints shall meet the requirements of a soiltight joint unless otherwise specified by the owner/designer.

7.9.1. *Soiltight joints* are specified as a function of opening size, channel length, and backfill particle size. If the size of the opening exceeds 3 mm (0.12 in.), the length of the channel must be at least four times the size of the opening. A backfill material containing a high percentage of fine-graded soils requires investigation for the specific type of joint to be used to guard against soil infiltration. Information regarding joint soiltightness criteria can be found in *AASHTO LRFD Bridge Construction Specifications*, Section 30, "Thermoplastic Pipe."

7.9.2. *Silt-tight joints* should be used where the backfill material has a high percentage of fines. Silt-tight bell and spigot joints will utilize an elastomeric rubber seal meeting ASTM F477. Silt-tight joints must be designated to pass a laboratory pressure test of at least 14 kPa (2 psi).

7.9.3. *Watertight joints* must meet a 74 kPa (10.8 psi) laboratory test per ASTM D3212 and utilize a bell and spigot design with a gasket meeting ASTM F477.

8. CONDITIONING

8.1. *Conditioning*—Condition the specimen prior to test at 21 to 25°C (70 to 77°F) for not fewer than 24 h in accordance with Procedure A in ASTM D618 for those tests for which conditioning is required, and unless otherwise specified.

8.2. *Conditions*—Conduct all tests at a laboratory temperature of 21 to 25°C (70 to 77°F) unless otherwise specified herein.

9. TEST METHODS

9.1. *Pipe Stiffness*—Select a minimum of two (2) pipe specimens and test for pipe stiffness (PS), as described in ASTM D2412 except for the following: (1) the test specimens shall be a minimum of one diameter length for 300-mm (12-in.) to 600-mm (24-in.) diameter pipe, and one-half diameter length for pipe diameters greater than 600 mm (24 in.); (2) locate the first specimen in the loading machine with an imaginary line connecting the two seams formed by the corrugation mold (end view) parallel to the loading plates, when applicable. The specimen must lie flat on the plate within 3 mm (0.12 in.) and may be straightened by hand bending at room temperature to accomplish this. Use the first location as a reference point for rotation and testing of the other specimen. Rotate the second specimen 90 degrees from the orientation of the first specimen and test. Test each specimen in one position only; (3) the deflection indicator shall be readable and accurate to ±0.02 mm (0.001 in.); (4) the residual curvature found in tubing frequently results in an erratic initial load-deflection curve. When this occurs, the beginning point for deflection measurement shall be at a load of 20 ± 5 N (4.5 lbf ± 1.1 lbf). The point shall be considered as the origin of the load-deflection curve; (5) the crosshead speed shall be the faster of 12.7 mm min (0.5 in./min) or 2 percent of the nominal inside diameter per minute.

Note 2—The parallel plates must exceed the length of the test specimen as specified above.

Note 3—Additional pipe specimens may be tested at other orientations for pipe stiffness and flattening if desired.

9.2. *Pipe Flattening*—Flatten the two pipe specimens from Section 9.1 until the vertical inside diameter is reduced to the buckling deflection limit calculated in Section 9.2.1. The rate of loading shall be the same as in Section 9.1. The specimen shall fail if the load-deflection curve decreases in load-carrying capacity (i.e., buckling) at or below the deflection point determined by the equation in Section 9.2.1. The specimen shall fail if buckling, cracking, splitting, or delamination is observed with the unaided eye. The observations for cracking, splitting and delamination shall be made while the specimen is at maximum deflection, and immediately after the load is released from the specimen; observation for buckling shall be as defined in Section 3.4.

9.2.1. The buckling deflection limit shall be determined by the following equation:

$$\Delta b = \frac{6.15\% \times 0.5D}{D_f \times 0.6 \times hp}$$

which simplifies to:

$$\Delta b = \frac{1.20D}{hp}$$

where:

Δb = Minimum buckling deflection limit, percent (%)
D = Inside diameter of pipe, mm (in.)
D_f = Shape factor = 4.27
hp = Corrugation height, mm (in.)

Note 4—The constant value 6.15 percent in the equation is the factored combined strain limit for HDPE pipe per *AASHTO LRFD Bridge Design Specifications*, Section 12.

Note 5—The constant value 0.6 in the equation is an estimated centroidal distance for typical profiles produced per this specification.

9.2.2. It is permissible to run the pipe stiffness test in conjunction with the pipe flattening test as long as individual evaluations are made for their respective criteria as specified under Sections 7.4 and 9.1 (stiffness) and Sections 7.5, 9.2, and 9.2.1 (flattening).

9.3. *Brittleness*—Test pipe specimens in accordance with ASTM D2444 except six specimens shall be tested, or six impacts shall be made on one specimen. In the latter case, successive impacts shall be separated by 120 ± 10 degrees for impacts made on one circle, or at least 300 mm (12 in.) longitudinally for impacts made on one element. Impact points shall be at least 150 mm (6 in.) from the end of the specimen. Tup B shall be used, with a mass of 4.5 kg (10 lb). The height of drop shall be 3.0 m (10 ft). Use a flat plate specimen holder. Condition the specimens for 24 h at a temperature of −4 ± 2°C (25 ± 3.6°F), and conduct all tests within 60 s of removal from this atmosphere. The center of the falling tup shall strike on a corrugation crown for all impacts.

9.4. *Slow Crack Growth Resistance of Polyethylene Pipe*—Test specimens from the pipe liner for stress crack resistance in accordance with ASTM F2136, the NCLS test, except for the following modifications:

9.4.1. The applied stress for the NCLS test shall be 4100 kPa (600 psi).

Note 6—The notched depth of 20 percent of the nominal thickness of the specimen is critical to this procedure.

9.4.2. The liner NCLS test specimens shall be die cut longitudinally from the pipe liner and notched on the outer surface of the liner, perpendicular to the direction of flow, as shown below in Figure 2.

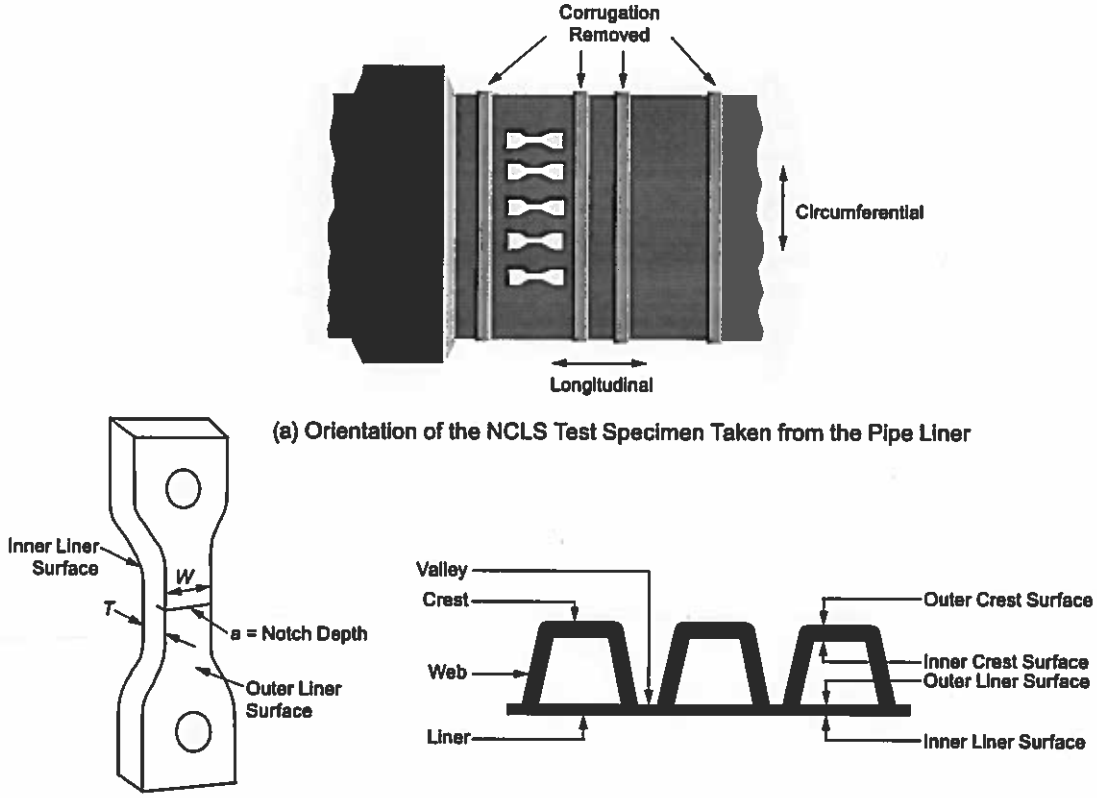


Figure 2—Liner NCLS Test Specimen Procedure

9.4.3. When the pipe liner cannot be sampled, then a specimen may be taken from the profile wall of the pipe. Where the pipe wall profile does not have flat longitudinal sections of sufficient size to obtain a tensile specimen, a sample of the pipe wall shall be ground and made into plaques per ASTM D4703 Procedure C. Specimens die cut from those plaques shall be tested as noted in Section 6.1.1.

9.5. *Joints and Fittings*:

9.5.1. *Joint Integrity*—Pipes that have a welded bell shall be tested to verify the strength of the weld as follows: Assemble the joint in accordance with the manufacturer's recommendations. Use pipe samples at least 300 mm (12 in.) in length. Assemble a specimen at least 600 mm (24 in.) in length with the connection at the center. Load the connected pipe and joint between parallel plates at the rate of 12.5 mm/min (0.5 in./min) until the vertical inside diameter is reduced by at least 20 percent of the nominal diameter of the pipe. Inspect for damage while at the specified deflection and after load removal.

9.5.2. *Alignment*—Assure that the assembly or joint is correct and complete. If the pipe is bent, it should be straightened prior to performing this test. Lay the assembly or joint on a flat surface and verify that it will accommodate straight-line flow.

9.6. *Dimensions*:

9.6.1. *Inside Diameter*—Measure the inside diameter of the pipe with a tapered plug in accordance with ASTM D2122. As an alternative, measure the inside diameter with a suitable device accurate to ±3.0 mm (0.12 in.) by taking two inside diameter measurements, the first at the seam and the second 90 degrees from the seam, and averaging the two measurements. The average inside diameter shall meet the requirements of Section 7.2.3.

9.6.2. *Length*—Measure pipe with any suitable device accurate to ±6.0 mm in 3 m (0.25 in. in 10 ft). Make all measurements on the pipe while it is stress-free and at rest on a flat surface in a straight line. These measurements may be taken at ambient temperature.

9.6.3. *Perforations*—Measure dimensions of perforations on a straight specimen with no external forces applied. Make linear measurements with instruments accurate to 0.2 mm (0.008 in.).

9.6.4. *Liner Thickness*—Measure the liner thickness in accordance with ASTM D2122.

9.7. *Delamination*—Examine Type S pipe for evidence of delamination as defined and described in Section 3.9 by cutting the pipe at the corrugation crest as shown in Figure 3 and attempting to insert a feeler gauge between the liner and the corrugation valley as shown in Figure 4. The feeler gauge should not pass through the corrugation valley into a void at any location along the circumference of the pipe.

Examine Type D pipe for evidence of delamination as defined and described in Section 3.9 by cutting a section through the pipe as shown in Figure 3 and attempting to insert a feeler gauge between the internal supports and the liner and outer wall as shown in Figure 4. The feeler gauge should not pass between the internal support and the liner or outer wall at any point along the circumference of the pipe.

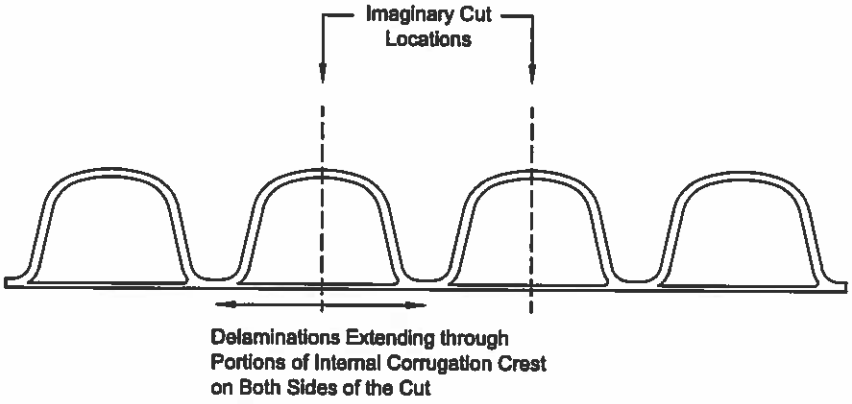


Figure 3—Location of Pipe Cut

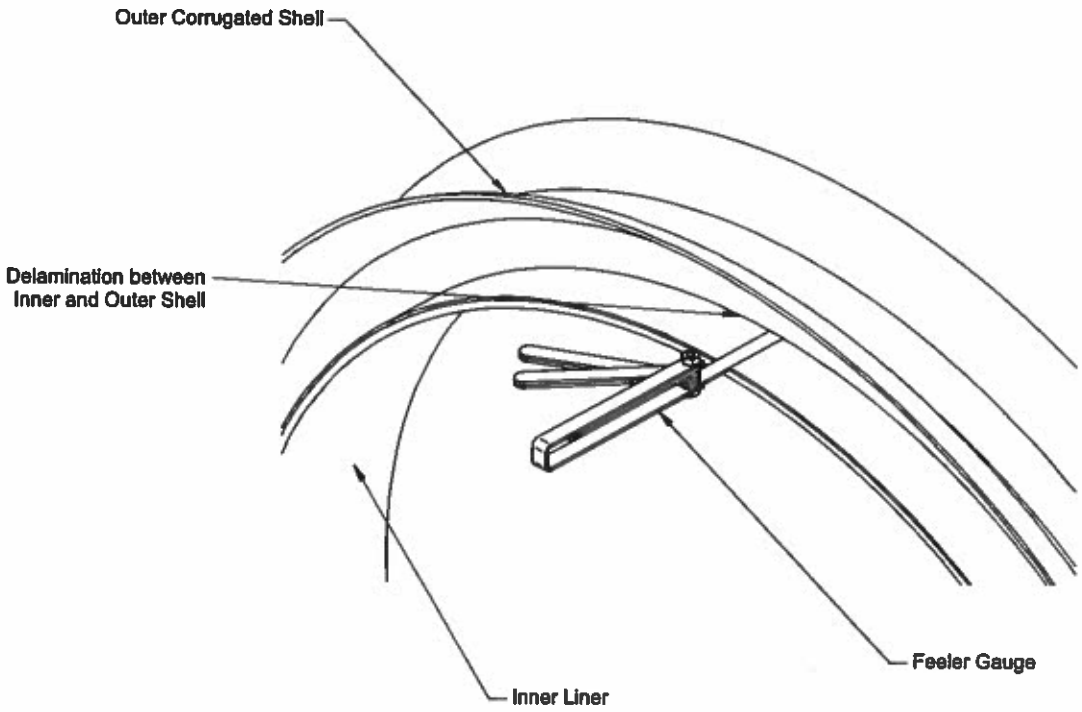


Figure 4—Feeler Gauge Insertion

9.8. *Stub Compression Capacity*—Determine the stub compression capacity of the pipe section in accordance with T 341. Conduct four tests on specimens cut from the same ring of pipe at 90-degree intervals around the circumference.

10. INSPECTION AND RETEST

10.1. *Inspection*—Inspection of the material shall be made as agreed upon by the purchaser and the seller as part of the purchase contract.

10.2. *Retest and Rejection*—If any failure to conform to these specifications occurs, the pipe or fittings may be retested to establish conformity in accordance with agreement between the purchaser and seller. Individual results, not averages, constitute failure.

11. MARKING

11.1. *All pipe shall be clearly marked at intervals of no more than 3 m (10 ft) as follows*:

11.1.1. Manufacturer's name or trademark;

11.1.2. Nominal size;

11.1.3. This specification designation, M 294;

11.1.4. The plant designation code; and

11.1.5. The date of manufacture or an appropriate code. If a date code is used, a durable manufacturer sticker that identifies the actual date of manufacture shall be adhered to the inside of each length of pipe.

Note 7—A durable sticker is one that is substantial enough to remain in place and be legible through installation of the pipe.

11.2. Fittings shall be marked with the designation number of this specification, M 294, and with the manufacturer's identification symbol.

12. QUALITY ASSURANCE

12.1. A manufacturer's certificate that the product was manufactured, tested, and supplied in accordance with this specification, together with a report of the test results, and the date each test was completed, shall be furnished upon request. Each certification so furnished shall be signed by a person authorized by the manufacturer.

12.2. *Manufacturer Records*—Manufacturers shall keep records of the following: (1) resin manufacturer's data sheets and certification that the base resin meets minimum cell class requirements of the product specification; (2) manufacturer's data sheets and quantities for all additives blended with the resin by the pipe manufacturer; (3) test results to demonstrate that, if resins of two different cell classifications are blended, the resulting mixture meets the requirements of the specified cell classification; (4) correlation of resin shipment source with pipe markings.

ANNEX

(Mandatory Information)

A1. GUIDELINES FOR PIPE MADE FROM BLENDED RESINS

A1.1. If pipe is made from a blend of component resins or from off-prime resin or blends that are not PPI certified, the pipe manufacturer should have a resin testing program in place that includes the testing of each component resin and resin blend lot for density and melt index and have the means of conducting (in-house or contract lab) the remaining cell class and NCLS testing as specified in this standard. The manufacturer shall test each resin or resin blend lot for full cell class and NCLS, unless a regular quality assurance program is in place to correlate cell class results to density and melt index. In any case, full cell class and NCLS testing should be performed on all approved/certified resin blends at least quarterly. Additionally, the pipe manufacturer shall have the resin blend independently tested and prequalified based on a "recipe" with component percentage tolerances of no more than ±1.5 percent substantiated by annual independent testing.

A1.2. When blends of virgin resins are used for pipe manufacture, the final blended resin must meet the requirements of the standard. It is not necessary for the individual components of the blend to meet the cell class or NCLS requirements of this standard, provided that the final blend meets all the requirements.

A1.2.1. Final resin blends shall have a minimum NCLS value of 33 h when tested in accordance with ASTM F2136 unless manufacturers have sufficient test data to show a lower resin NCLS value corresponds to a finished product liner NCLS value of at least 18 h.

A1.2.2. *Sampling and testing of the final blended resin shall be performed as follows*:

A1.2.2.1. The sample shall be prepared either by direct sampling from the feed hopper of the extruder (after the material has already been weigh-blended by the blenders or other means), or by manually weigh-blending the individual components to the specified finished blend ratios. The manufacturer shall have current calibration records for the automated or manual weigh-blending equipment.

A1.2.2.2. The blended sample shall not contain carbon black concentrate. If carbon black concentrate is present in the sampled material, the carbon black concentrate shall be removed prior to further sample preparation.

A1.2.2.3. The dry-blended sample shall be fully homogenized by melt blending via a twin screw lab extruder or other melt homogenization technique that has been verified to provide similar levels of homogenization prior to testing for physical properties.

A1.2.2.4. The melt-blended sample shall be tested for melt index, density, and NCLS in accordance with the number of hours per the requirements of the standard.

APPENDIX

(Nonmandatory Information)

X1. QUALITY CONTROL/QUALITY ASSURANCE PROGRAM

X1.1. *Scope*:

X1.1.1. As required in Sections 10 and 12, the acceptance of these products relies on the adequate inspection and certification agreed to between the buyer and the seller/producer. This appendix should serve as a guide for both the manufacturer and the user. It places the responsibility on the producer to control the quality of the material it produces and to provide the quality control information needed for acceptance by the buyer/user. The producer is required to perform quality control sampling, testing, and record keeping on materials it ships. It also sets forth quality assurance sampling, testing, and record keeping that should be performed by the buyer/user to confirm the performance of the producer's control plan.

X1.2. *Program Requirements*:

X1.2.1. The producing company must have a quality control plan approved by the specifying agency.

X1.2.2. The producing plant must have an approved quality control plan.

X1.2.3. The plant must have an approved laboratory, either within the company or an independent laboratory.

X1.2.4. The producing plant(s) must have a designated quality control technician.

X1.3. *Quality Control Plan*:

X1.3.1. The producer must supply to the specifying agency a written quality control plan that shows how the producer will control the equipment, materials, and production methods to ensure that the specified products are supplied. The following information must be included in the plan:

X1.3.1.1. Titles of the personnel responsible for production quality at the plant(s);

X1.3.1.2. The physical location of the plant(s);

X1.3.1.3. The methods of identification for each lot of material during manufacture, testing, storage, and shipment. The method of identification shall allow the specifying agency to trace the finished product to the material provider;

X1.3.1.4. The method of sampling and testing of raw materials and finished product, including lot sizes and types of tests performed; and

X1.3.1.5. A plan for dealing with nonconforming product, including how the producer plans to initiate immediate investigation and how corrective action will be implemented to remedy the cause of the problem.

X1.4. *Approved Laboratory*:

X1.4.1. All tests must be conducted at laboratories approved by the specifier. Each manufacturer may establish and maintain its own laboratory for performance of quality control testing or may utilize an approved independent laboratory. Records of instrument calibration and maintenance and sample collection and analysis must be maintained at the laboratory.

X1.5. *Quality Control Technician*:

X1.5.1. All samples must be taken and tested by the quality control technician designated by the producer. The designated quality control technicians will be responsible for overall quality control at the producing plant.

X1.6. *Annual Update*:

X1.6.1. An annual update may be required. If required, the annual update may be submitted by the manufacturer to the specifying agency by December 31st of each calendar year.

X1.7. *Plant Approval*:

X1.7.1. The plant approval process requires the manufacturer to submit an annual update to the specifying agency. The update must identify the specific product manufactured at the plant.

X1.7.2. The specifying agency will review the manufacturer's written quality control plan and a plant inspection may be scheduled. This inspection will verify that the quality control plan has been implemented and is being followed and that at least one designated quality control technician is on-site and will be present when material is being produced under this program. The laboratory will be inspected and approved if it meets the requirements.

X1.8. *Sampling and Testing*:

X1.8.1. The quality assurance plan approved for each manufacturer, and/or manufacturer's location, shall detail the methods and frequency of sampling and testing for all raw materials and products purchased or manufactured at that location. All testing shall be in accordance with current specifications and procedures referenced in M 294.

X1.8.2. Samples of materials and pipe may be taken by the specifying agency.

X1.8.3. The specifying agency may require an annual third-party independent assurance test.

X1.9. *Sample Identification and Record Keeping*:

X1.9.1. Manufacturer's Quality Control samples are to be uniquely identified by the producing plant.

X1.9.2. Quality control and quality assurance data are to be retained by the manufacturer for 2 years and made available to the specifying agency upon request.

X1.9.3. Quality control test reports shall include the lot identification.

X1.9.4. Unless requested at the time of ordering, test reports do not have to be filed for specific projects.

X1.9.5. Reports shall indicate the action taken to resolve nonconforming product.

HANCOR SURE-LOK® ST IB PIPE (per AASHTO) SPECIFICATIONS

Scope
This specification describes 4- through 60-inch (100 to 1500 mm) Hancor Sure-Lok ST IB pipe (per AASHTO) for use in gravity flow drainage applications.

Pipe Requirements
Sure-Lok ST IB pipe (per AASHTO) shall have a smooth interior and annular exterior corrugations.
- 4- through10-inch (100 to 250 mm) shall meet AASHTO M252, Type S.
- 12- through 60-inch (300 to 1500 mm) shall meet AASHTO M294, Type S or ASTM F2306.
- Manning's "n" value for use in design shall be 0.012.

Joint Performance
Pipe shall be joined using a bell & spigot joint meeting AASHTO M252, AASHTO M294 or ASTM F2306. The joint shall be soil-tight and gaskets, when applicable, shall meet the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable wrap to ensure the gasket is free from debris. A joint lubricant supplied by the manufacturer shall be used on the gasket and bell during assembly.

Fittings
Fittings shall conform to AASHTO M252, AASHTO M294, or ASTM F2306. Bell and spigot connections shall utilize a spun-on or welded bell and valley or saddle gasket meeting the soil-tight joint performance requirements of AASHTO M252, AASHTO M294 or ASTM F2306.

Material Properties
Virgin material for pipe and fitting production shall be high density polyethylene conforming with the minimum requirements of cell classification 424420C for 4- through 10-inch (100 to 250 mm) diameters, or 435400C for 12- through 60-inch (300 to 1500 mm) diameters, as defined and described in the latest version of ASTM D3350, except that carbon black content should not exceed 4%. The 12- through 60-inch (300 to 1500 mm) virgin pipe material shall comply with the notched constant ligament-stress (NCLS) test as specified in Sections 9.5 and 5.1 of AASHTO M294 and ASTM F2306, respectively.

Installation
Installation shall be in accordance with ASTM D2321 and Hancor recommended installation guidelines with the exception that minimum cover in trafficked areas for 4- through 48-inch (100 to 1200 mm) diameters shall be one foot (0.3 m) and for 54- and 60-inch (1350 and 1500 mm) diameters shall be 2 ft (0.6 m) in single run applications. Backfill for minimum cover situations shall consist of Class 1, Class 2 (minimum 90% SPD) or Class 3 (minimum 90%) material. Maximum fill heights depend on embedment material and compaction level; please refer to Technical Note 2.01. Contact your local Hancor representative or visit our website at www.hancor.com for a copy of the latest installation guidelines.

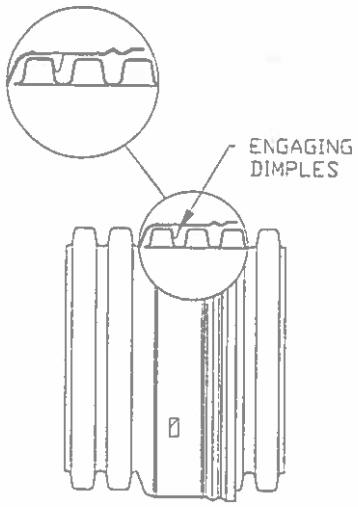
Pipe Dimensions

	Nominal Diameter, in (mm)													
Pipe I.D. in (mm)	4 (100)	6 (150)	8 (200)	10 (250)	12 (300)	15 (375)	18 (450)	24 (600)	30 (750)	36 (900)	42 (1050)	48 (1200)	54* (1350)	60 (1500)
Pipe O.D.** in (mm)	4.8 (122)	6.9 (175)	9.1 (231)	11.4 (290)	14.5 (368)	18 (457)	22 (559)	28 (711)	36 (914)	42 (1067)	48 (1219)	54 (1372)	61 (1549)	67 (1702)
Perforations	All diameters available with or without perforations													

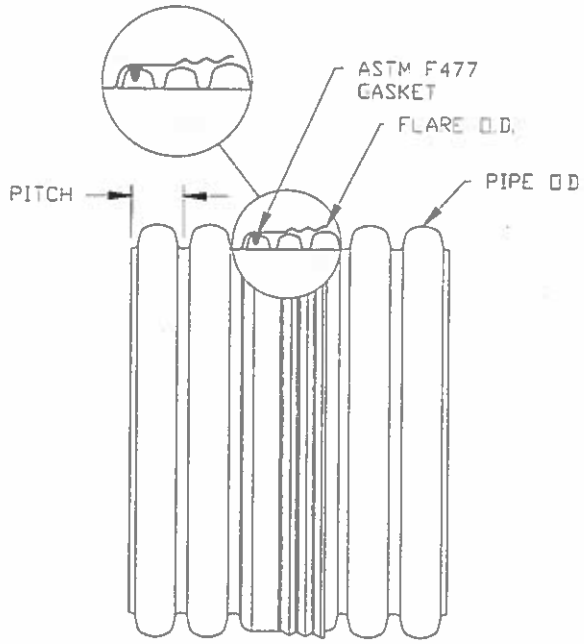
*Check with sales representative for availability by region.
**Pipe O.D. values are provided for reference purposes only, values stated for 12- through 60-inch are ± 1 inch. Contact a sales representative for exact values.

SURE-LOK® ST IB PIPE (per AASHTO) JOINING SYSTEM

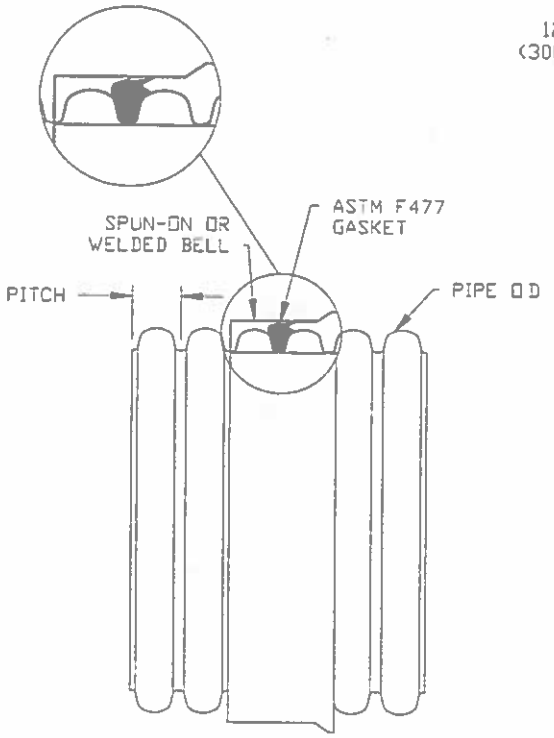
(Joint configuration & availability subject to change without notice. Product detail may differ slightly from actual product appearance.)



4" - 10"
(100-250 MM)



12" - 60"
(300-1500 MM)



4" - 60"
(100-1500 MM)