Standard Specification for

Steel-Reinforced Polyethylene (SRPE) Corrugated Pipe

AASHTO Designation: MP-42

Technical Subcommittee: 4b, Flexible and Metallic Pipe

Release: Group 2 (June)

AASHTO

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1. SCOPE

1.1. This specification covers the requirements and methods of tests for steel-reinforced polyethylene (SRPE) corrugated pipe, couplings, and fittings for use in surface and subsurface drainage applications.

1.1.1. Nominal sizes of 300 to 1800 mm (12 to 72 in.) are included.

1.1.2. Materials, workmanship, dimensions, pipe stiffness, impact resistance, joining systems, and form of markings are specified.

1.2. SRPE corrugated 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 SRPE corrugated pipe is to be used in locations where the ends may be exposed, above ground, consideration should be given to protection of the exposed portions due to combustibility of polyethylene and the effects of prolonged exposure to ultraviolet radiation, as well as corrosion of steel reinforcement.

1.3. This specification only deals with this pipe's materials requirements. The structural design of steel reinforced thermoplastic culverts and the proper installation procedures are given in the *AASHTO LRFD Bridge Design Specifications*, Section 12, and *AASHTO LRFD Bridge Construction Specifications*, Section 26, respectively. Upon request of the specifying agency or engineer, the manufacturer shall provide profile wall section detail required for a full engineering evaluation.

1.4. 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.

1.5. The following precautionary caveat pertains only to the test method portion, Section 9, 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 STANDARDS

2.1. *AASHTO Standards*:

- M 288, Geosynthetic Specification for Highway Applications
- T 341, Determination of Compression Capacity for Profile Wall Plastic Pipe by Stub Compression Loading
- *AASHTO LRFD Bridge Design Specifications*, Section 12
- *AASHTO LRFD Bridge Construction Specifications*, Section 26

2.2. *ASTM Standards*:

- A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- A1008/A1008M Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
- D618, Standard Practice for Conditioning Plastics for Testing
- 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
- D4703, Standard Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets
- D7091, Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals
- 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. *Definitions*:

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

3.2.2. *crease*—a visible irrecoverable indentation.

3.2.3. *delamination*—a gap extending through the fused PE between two adjacent Corrugated Profiles.

3.2.4. *encapsulation thickness*—the thickness of the high density polyethylene (HDPE) bonded to either side of the steel reinforcement (see Figure 2).

3.2.5. *gravity flow*—a condition in which liquid flow through a piping system results from a downward pipeline slope, but flow is less than full, except during conditions when the system may become temporarily surcharged, in which case the system is subject to temporary internal hydrostatic pressure that is limited to 74 kPa [10.8 psi].

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

3.2.7. *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).

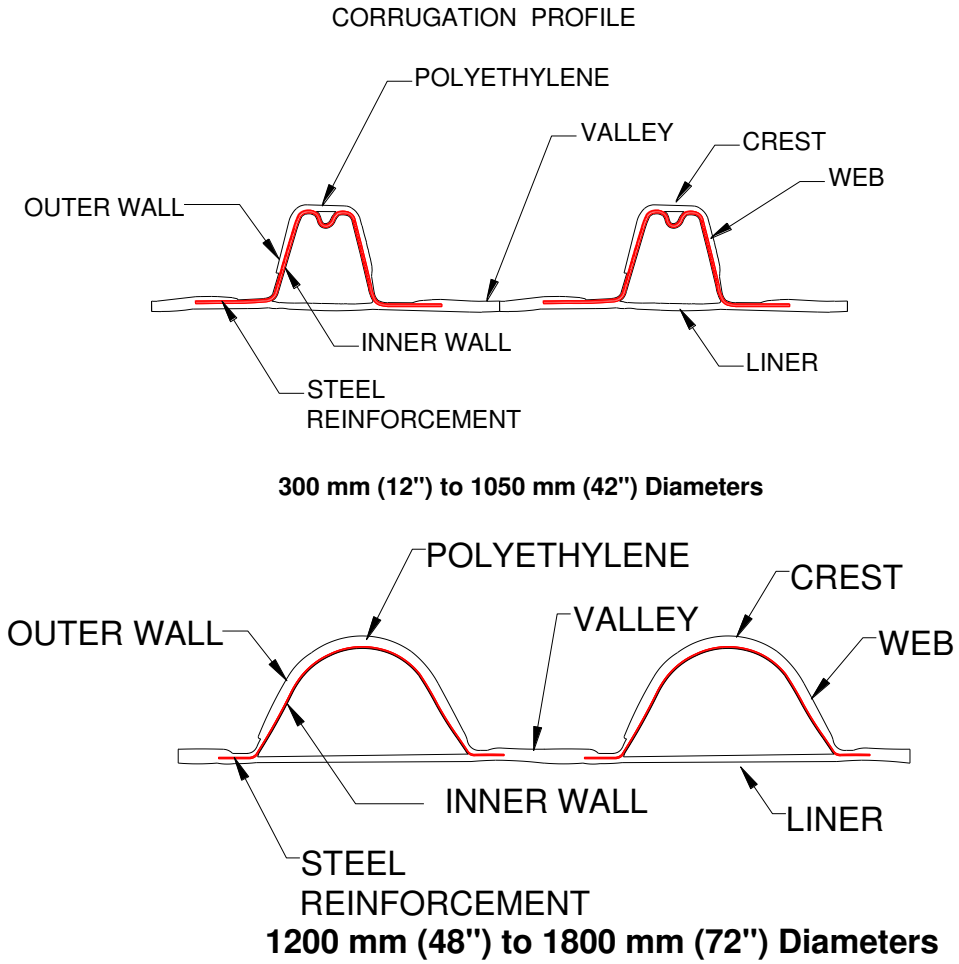

Figure 1—Cross Section of Corrugated Profile

3.2.8. *steel-reinforced polyethylene corrugated pipe*—Polyethylene pipe with a corrugated profile containing reinforcing steel (see Figure 1).

3.2.9. *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-term mechanical strength.

3.2.10. *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 SRPE corrugated pipe covered by this specification is classified as follows*:

4.1.1. *Type S*—This pipe shall have a full circular cross section with an essentially smooth inner wall.

4.1.2. *Type SP*—This pipe shall be Type S with perforations.

4.2. Perforations are described in Section 7.5.

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 MP zzz;

5.1.2. Perforation, if applicable (Section 7.5);

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

5.1.4. Certification, if desired (Section 12.1); and

5.1.5. Type of pipe joint (Section 7.11.1).

6. MATERIALS

6.1. *Polyethylene Materials*:

6.1.1. *Pipe and Fittings*—Pipe and fittings shall be made of virgin PE, conforming to the requirements of ASTM D3350 and having a cell classification of 334452C or E. Resins that have higher cell classifications in one or more properties are acceptable provided the product requirements are met.

6.1.2. *Rotational Molded Fittings and Couplings*—Fittings and couplings shall be made of virgin PE, conforming to the requirements of ASTM D3350 and having a cell classification of 213320C or E. Resins that have higher cell classifications in one or more properties are acceptable provided product requirements are met. For slow crack resistance, acceptance of resins shall be determined by using notched, constant ligament-stress (NCLS) test according to the procedure described in Section 9.4. The average failure time of the five test specimens must exceed 24 h with no single specimen's failure time less than 17 h.

6.1.3. *Injection Molding Fittings and Couplings*—Fittings and couplings shall be made of virgin PE, conforming to the requirements of ASTM D3350 and having a cell classification of 324452C or E. Resins that have higher cell classifications in one or more properties are acceptable provided product requirements are met.

6.1.4. *Carbon Black Content*—The carbon black content shall not exceed 4.0 percent of the total PE compound weight.

6.1.5. *Other Materials*—It is permissible to use materials other than the cell classification in Section 6.1.1 as part of the pipe manufacturing, for example to weld pipe joints, provided these materials have higher cell classifications in one or more properties and in no way compromise the performance of the pipe products in the intended use.

6.1.6. *Reworked Plastics*—In lieu of virgin PE, it is permissible to use clean, reworked plastic generated from the manufacturer's own pipe production, provided that it meets the cell classification requirements as described in Section 6.1.1.

6.2. *Steel Materials*:

6.2.1. *Steel Dimensions and Properties*—The minimum thickness of the steel sheet shall be as listed in Table 1. The steel substrate shall conform to Specification ASTM A1008/A1008M or ASTM A653/A653M, and the minimum yield strength of the steel sheet shall not be less than 358 MPa [52 ksi]. All steel materials shall be galvanized per the requirements of ASTM A653/A653M with a G40 minimum coating weight.

6.2.2. *Steel Content*—The steel content shall not exceed 75 percent of the total weight of the pipe. The steel material shall be fully encapsulated by the polyethylene material with a minimum thickness of the polyethylene as shown in Table 1and Figure 2.

6.3. *Gaskets*—Elastomeric gaskets shall meet the requirements of ASTM F477.

6.4. *Industrial Sealant*—Sealants, such as moisture cure urethane or asphalt-based sealant materials used for repairs, cut pipe end or assembly of coupling joints, as recommended by the manufacturer may be used.

7. REQUIREMENTS

7.1. *Workmanship*—The pipe and fittings shall be free of foreign inclusions and visible defects as defined herein. Visible defects shall not affect the wall integrity or the encapsulation of the steel reinforcement. The steel reinforcing materials shall not be exposed.

7.2. *Visible Defects*—Cracks, creases, delaminations, and unpigmented or non-uniformly pigmented pipe that are visible by the unaided eye are not permissible in the pipe or fittings.

7.3. There shall be no evidence of delamination when tested in accordance with Section 9.2.

7.4. *Pipe Dimensions and Tolerances*:

7.4.1. *Inside Diameter*—The tolerance on the inside diameter shall be ±2.0 percent, when measured in accordance with Section 9.6.1. Pipe dimensions (for both perforated and nonperforated pipe) shall comply with Table 1.

7.4.1.1. Other diameters that are within the range of pipe sizes shown in Table 1 are permissible. The minimum wall thickness and other properties shall be interpolated from the adjacent values given in Table 1.

Table 1—Pipe Sizes, Diameters, Steel Thickness and Minimum Valley Wall Thicknesses[a]

Nominal Pipe Size, mm (in.)	Inside Diameter, mm [in.]	Outside Diameter, mm [in.]	Minimum Steel Thickness mm [in.]	Minimum Valley Wall Thickness mm [in.]	Minimum Encapsulation Thickness mm [in.]	Minimum Inner Wall Thickness mm [in]
300 (12)	305 [12.01]	338 [13.31]	0.30 [0.012]	3.3 [0.13]	0.9 [0.035]	2.3 [0.09]
375 (15)	381 [15.00]	413 [16.26]	0.30 [0.012]	3.3 [0.13]	1.0 [0.039]	2.3 [0.09]
450 (18)	457 [17.99]	489 [19.25]	0.30 [0.012]	4.2 [0.17]	1.3 [0.051]	2.9 [0.11]
600 (24)	610 [24.02]	653 [25.71]	0.30 [0.012]	4.2 [0.17]	1.5 [0.059]	2.9 [0.11]
750 (30)	762 [30.00]	817 [32.17]	0.30 [0.012]	5.2 [0.20]	1.5 [0.059]	3.6 [0.14]
900 (36)	915 [36.02]	970 [38.19]	0.30 [0.012]	6.9 [0.27]	1.7 [0.067]	4.8 [0.19]
1050 (42)	1067 [42.01]	1128 [44.41]	0.30 [0.012]	9.7 [0.38]	1.8 [0.071]	6.8 [0.27]
1200 (48)	1220 [48.03]	1320 [51.97]	0.30 [0.012]	10.8 [0.43]	1.8 [0.071]	7.6 [0.30]
1500 (60)	1524 [60.00]	1656 [65.20]	0.30 [0.012]	11.9 [0.47]	2.0 [0.079]	8.3 [0.33]
1800 (72)	1842 [72.52]	1982 [78.03]	0.30 [0.012]	13.0 [051]	2.0 [0.079]	9.1 [0.36]

[a] Conversions of SI units to U.S. Customary units in this table are "soft" conversions; i.e., the metric measurement is mathematically converted to its exact (or nearly exact) equivalent in inch–pound measurement.

7.4.2. *Valley Wall*—Minimum wall thickness shall be as required in Table 1 and measured in accordance with Section 9.6.2.

7.4.3. *Length*—The pipe shall be sold in any length agreeable to the user. Length shall not be less than 99 percent of the specified length, when measured in accordance with Section 9.6.3.

7.4.4. *Encapsulation Thickness*—The minimum thickness of the PE encapsulation of steel reinforcement, measured at any location, shall be as specified in Table 1. Factory cut pipe ends shall have the cut corrugation ends encapsulated with PE material meeting the requirements of Section 6.1, to maintain the requirements of Table 1. Encapsulation thicknesses shall be measured in accordance with Section 9.6.4. Field cut pipe ends shall have the cut corrugation ends encapsulated with industrial sealant meeting the requirements of Section 6.4.

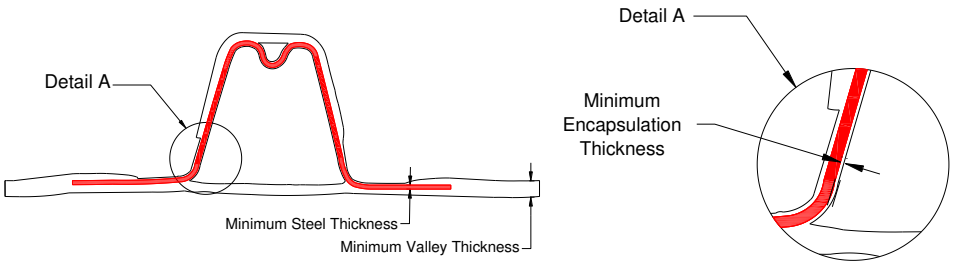

Figure 2—Encapsulation and Wall Thickness

7.5. *Perforations*—When perforated pipe is specified, the perforations shall be cleanly cut and uniformly spaced along the length and circumference of the pipe. Circular perforations shall be a minimum of 5 mm (0.2 in.) and shall not exceed 10 mm (0.4 in.) in diameter. 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 (2.0 $in.^2$/ft) for pipe sizes larger than 450 mm (18 in.). All measurements shall be made in accordance with Section 9.6.5. The perforations shall be cleanly cut so as not to restrict the inflow of water. Perforations shall be located in the valley portion of the pipe between the corrugations. The reinforcing steel material shall not be exposed by these perforations.

7.6. *Pipe Stiffness*—The pipe shall have minimum pipe stiffness at 5 percent deflection as listed in Table 2. Pipe stiffness shall be tested in accordance with Section 9.1.

Table 2—Pipe Stiffness

Nominal Pipe Size, mm (in.)	Pipe Stiffness, kPa [psi] [a]
300 (12)	400 [58]
375 (15)	400 [58]
450 (18)	275 [40]
600 (24)	235 [34]
750 (30)	200 [29]
900 (36)	155 [22.5]
1050 (42)	145 [21]
1200 (48)	140 [20]
1500 (60)	105 [15]
1800 (72)	105 [15]

Note 2—The 5 percent deflection criterion was selected for testing convenience and should not be considered as a limitation with respect to in-use deflection.

7.7. *Pipe Flattening*—There shall be no evidence of splitting, cracking, or breaking when tested in accordance with Section 9.2. Additionally, there shall be no downturn of the load-deflection curve prior to 20 percent vertical deflection.

7.8. *Bonding of the Steel to the Polyethylene*—The mechanical bond between the steel reinforcement and the polyethylene shall be greater than the tensile strength of the polyethylene resin required for this standard. It shall not be possible to separate any two layers with a probe or with the point of a knife blade so that the layers separate cleanly, or the probe or knife moves freely between the layers. There shall be no separation of the polyethylene from the steel reinforcing plate, when the pipe is deflected 40 percent, in accordance with Section 9.2.

7.9. *Impact*—There shall be no evidence of splitting, cracking, or breaking when tested in accordance with Section 9.3.

7.10. *Fitting Requirements*:

7.10.1. Only fittings supplied or recommended by the manufacturer shall be used. Fabricated fittings shall be supplied with joints compatible with the overall system requirements.

7.10.2. 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 9.6.3.

7.10.3. The fittings shall not impair the overall integrity or function of the pipe.

7.10.4. Common fittings include in-line joint fittings, reducers, and branch or complementary assembly fittings such as tees and wyes. These fittings shall be installed or coupled to the pipe by split couplers or other methods meeting the requirements of Section 7.11.

7.10.5. 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 diameter by more than 3 percent.

7.11. *Jointing Requirements*:

7.11.1. Pipe joints and couplings shall be split-collar bands or screw-on collars meeting the material requirements of Section 6.1. Split-collar bands or screw-on collars shall be corrugated to match the pipe corrugations and shall provide sufficient longitudinal strength to preserve pipe alignment and prevent separation at the joints. If required, the pipe joint shall incorporate a flat, O-ring, or profile

gasket. Split-collar bands or screw-on collars shall engage at least two full corrugations of each pipe section. The two ends of the split-collar band shall overlap a minimum of 50.8 mm (2.0 in.). Split-collar bands or screw-on collars shall meet the soil-tight requirements of Section 7.11.2.1 or the silt-tight requirements of Section 7.11.2.2.

7.11.1.1. Other types of couplings or fastening devices that are equally effective as one of those described in Section 7.11.2 may be used when approved by the purchaser.

7.11.1.2. *Internal Coupling, Sealant Type*—Joint seal is affected by applying an industrial sealant between the external surface of the coupling and the internal surface of the pipe. This jointing system may be used when approved by the purchaser.

7.11.1.3. Other types of jointing methods such as flanging, internal coupling (gasket type), extrusion welding, electro-fusion, butt fusion, and others may be used when approved by the purchaser.

7.11.2. *Joint Tightness*—The pipe or fitting joint shall meet the requirements defined as one of the following types:

7.11.2.1. *Soil-Tight Joints*—Soil-tight joints are specified as a function of opening size (maximum dimension normal to the direction that soil may infiltrate), channel length (length of the path along which the soil may infiltrate), and backfill particle size. If the size of the opening exceeds 3 mm ($^1/_8$ in.), the length of the channel must be at least four times the size of the opening. No opening may exceed 25 mm (1 in.). 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.

7.11.2.2. *Silt-Tight Joints*—A silt-tight joint is resistant to infiltration of particles that pass the No. 200 sieve. Silt-tight joints are specified to provide protection against infiltration of backfill material containing a high percentage of fines, and typically utilize some type of filtering or sealing component, such as a geotextile wrap or an elastomeric rubber seal.

7.11.2.2.1. Geotextile wraps are manufactured to tolerances that assure silt will not pass through them. The successful performance of these wraps in the field is dependent on their installation. If a geotextile wrap is specified for use, the material specified should meet the requirements of M 288, with an apparent opening size (AOS) greater than 70.

7.11.2.2.2. For joints that utilize an elastomeric rubber seal, silt-tight performance shall have been demonstrated in a laboratory test to meet the hydrostatic requirements of ASTM D3212, with the exception that the hydrostatic test pressure shall be a minimum of 14 kPa (2 psi).

7.11.2.3. *Leak-Resistant Joints*—Leak-resistant joints shall be bell and spigot and utilize an elastomeric rubber seal meeting the requirements of ASTM F477. Alternative methods of joining (e.g., external joint wraps) shall be allowed provided the requirements of Section 7.11.2.3.1 are achieved.

7.11.2.3.1. Leak resistance shall be verified in the lab by meeting all of the requirements of ASTM D3212. The hydrostatic test pressure and vacuum specified in the test method shall be 74 kPa (10.8 psi).

7.11.3. *Special Design Joints*—Special design joints shall include joints requiring special strength in bending or shear, pull-apart capabilities, or unusual features such as restrained joints placed on severe slopes, welded joints, flanged and bolted joints for high pressures, high heads, or velocities. Watertight joints that provide zero leakage for a specified head or pressure application are included in this type of joint.

7.12. *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 section of the steel reinforcing area times the minimum specified yield strength of the steel when tested in accordance with Section 9.7. The stub compression test, 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.

8. CONDITIONING

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

8.2. 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 three pipe specimens from the pipe and test for pipe stiffness $F/\Delta y$, as described in ASTM D2412, except for the following conditions:

9.1.1. Specimens shall be cut mid valley to mid valley along the corrugation, and then cut across the corrugation.

9.1.2. Specimens shall exceed 457 mm (18 in.) in length.

9.1.3. Locate the first specimen in the loading machine with the imaginary line between two corrugations parallel to the loading plates. The specimen must lie flat on the plate within 3 mm (⅛ in.) . Use the first location as a reference point for rotation of the other two specimens. Rotate the second specimen 45 degrees and the third specimen 90 degrees. Test each specimen in one position only.

9.1.4. Testing speed of the specimens shall be 12.7 mm (0.5 in.) per min for testing up to 5 percent deflection. For testing beyond 5 percent deflection, test at a speed of 127 mm (5 in.) per min.

9.1.5. The deflection indicator shall be readable and accurate to +0.02 mm (+0.001 in.) .

9.1.6. The parallel plates must exceed the samples in length.

9.2. *Pipe Flattening*—Flatten the three pipe samples from Section 9.1 until the vertical inside diameter is reduced by 40 percent. The length of the test specimen and the rate of loading shall be the same as in Section 9.1. Examine the specimen with the unaided eye for cracking, splitting, or delamination.

9.3. *Pipe Impact*—Test pipe specimens in accordance with ASTM D2444 except that six specimens shall be tested. Specimens shall be at least 457 mm (18 in.) in length and impact points shall be at least 152 mm (6 in.) from the end of the specimen. Impact resistance shall not be less than 136 J. Tup B and a flat plate specimen holder shall be used. Condition the specimens for 24 h (± 0.25 h) at a temperature of 0 ± 1°C (32 ± 2°F), and conduct all tests within 60 s of removal from this atmosphere.

9.4. *Slow Crack Growth Resistance of HDPE Resin Compounds*—Test basic resin compounds for stress crack resistance in accordance with ASTM F2136, the NCLS test, except for the following modifications:

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

9.6. The specimens shall be prepared from pieces of the pipe liner that have been compression molded into a plaque in accordance with ASTM D4703, Procedure C.

Note 3—The notched depth of 20 percent of the nominal thickness of the specimen is critical to this procedure.

9.7. *Delamination*—Test the fusion of the bond between the inner and outer wall of the corrugated profile width (see Figure 2) with a probe or knife point. It shall not be possible to cleanly separate the two walls. Test samples at eight equally spaced points around its circumference.

9.8. *Dimensions*:

9.8.1. *Inside Diameter*—Measure the inside diameter of three specimens, each a minimum of 300 mm (12 in.) long with any suitable device accurate to 0.8 mm (0.03 in.), at two positions, namely, at any point in the circumferential direction and at 90 degrees from this point, and average the six measurements. The inside diameter shall meet the requirements of Section 7.4.1.

9.8.2. *Valley Wall*—Locate and measure the wall thickness between the corrugations at four equally spaced locations around the circumference of the pipe, in accordance with ASTM D2122.

9.8.3. *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 resting on a relatively flat surface, in a straight line, with no external tensile or compressive forces exerted on the pipe. These measurements may be taken at ambient temperatures.

9.8.4. *Encapsulation Thickness*—Locate and measure the encapsulation thickness by cutting a minimum of two equally spaced cross sections. Pipe specimens shall be cleanly cut and burrs removed. A flat-anvil micrometer or Vernier calipers, accurate to ±0.02 mm (±0.001 in) shall be used to measure the encapsulation thickness at eight equally spaced locations around the pipe circumference. Encapsulation thickness shall be measured for inner wall and outer wall.

Note 4—Alternatively, direct measurements may be used. To measure inner wall encapsulation thickness, remove HDPE from outer wall. Measure the combined thickness of the steel and inner wall. Care should be taken to avoid misalignment of the anvil or Vernier calipers with the longitudinal axis of the specimen. Remove the HDPE from the inner wall. Measure the thickness of the steel reinforcement. Subtract the steel reinforcement thickness from combined thickness of the steel and inner wall thickness to obtain the inner wall encapsulation thickness. To measure the outer wall, repeat this process by interchanging the outer and inner wall thickness described above. Care should be taken to avoid removing steel thickness when removing the HDPE.

9.8.5. *Perforations*—Measure dimensions of perforations on a straight profile specimen with no external forces applied. Make linear measurements with instruments accurate to 0.2 mm (0.08 in.).

9.9. *Stub Compression Capacity*:

9.9.1. 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 on by the purchaser and the seller as part of the purchase contract.

10.2. *Retest and Rejection*—Retesting in the event of a test failure shall be conducted on samples from the failed lot only under an agreement between purchaser and seller. There shall be no changes to the test procedures or the requirements.

11. MARKING

11.1. *All pipe shall be clearly marked at intervals of no more than 3 m (10.0 ft) as follows*:

11.1.1. Manufacturer's name or trademark.

11.1.2. AASHTO MP zzz.

11.1.3. Nominal pipe size.

11.1.4. The plant designation code.

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 5—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 standard number of this specification 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 on request. Each certification so furnished shall be signed by a person authorized by the manufacturer.

13. KEYWORDS

13.1. Crack; crease; delamination; gravity flow; SRPE.

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/manufacturer. This appendix should serve as a guide for both the manufacturer and the specifying agency. It places the responsibility on the manufacturer to control the quality of the material they produce and to provide the quality control.

X1.2. *Program Requirements*:

X1.2.1. The manufacturing company must have a quality control plan, as described in Section X1.3 which has been approved by the specifying agency.

X1.2.2. The manufacturing plant must have a quality control plan, as described in Section X1.3, and in X1.7, which has been approved by the specifying agency.

X1.2.3. The plant must use a specifying agency-approved laboratory, either within the company or an independent laboratory as noted in Section X1.4.

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

X1.3. *Quality Control Plan*:

X1.3.1. The manufacturer 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 of each lot of material during manufacturing, 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 of finished product, including lot sizes and types of tests performed.

X1.3.1.5. A plan for dealing with nonconforming product, including how the manufacturer 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 of 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 quality control technicians designated by the manufacturer. The designated quality control technicians will be responsible for overall quality control at the manufacturing plant.

X1.6. *Annual Update*:

X1.6.1. An annual update may be 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, or manufacturer's location, or both, 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 Sections 6, 7, and 9.

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 y and made available to the specifying agency on 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.