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Standard Specification for 150 to 1500 mm [6 to 60 in.] Annular Corrugated Profile-Wall Polyethylene (PE) Pipe and Fittings for Sanitary Sewer Applications¹

This standard is issued under the fixed designation F2947/F2947M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers requirements and test methods for annular, corrugated profile wall polyethylene pipe and fittings with an interior liner. The nominal inside diameters covered are 150 to 1500 mm [6 to 60 in.].

1.2 The requirements of this specification are intended to provide pipe and fittings suitable for underground use for non-pressure sanitary sewer systems. Pipe and fittings produced in accordance with this specification shall be installed in compliance with Practice **D2321**.

1.3 This specification covers pipe and fittings with an interior liner using a corrugated exterior profile (**Fig. 1**).

1.4 The products manufactured under this specification use either virgin or recycled (post-industrial or post-consumer) materials in accordance with the requirements specified for each.

1.5 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.6 The following precautionary caveat pertains only to the test method portion, Section 7, 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

[A666 Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar](#)

[D638 Test Method for Tensile Properties of Plastics](#)

[D618 Practice for Conditioning Plastics for Testing](#)

[D1600 Terminology for Abbreviated Terms Relating to Plastics](#)

[D1603 Test Method for Carbon Black Content in Olefin Plastics](#)

[D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings](#)

[D2321 Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications](#)

[D2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading](#)

[D2444 Practice for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup \(Falling Weight\)](#)

[D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications](#)

[D2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics](#)

[D3212 Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals](#)

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

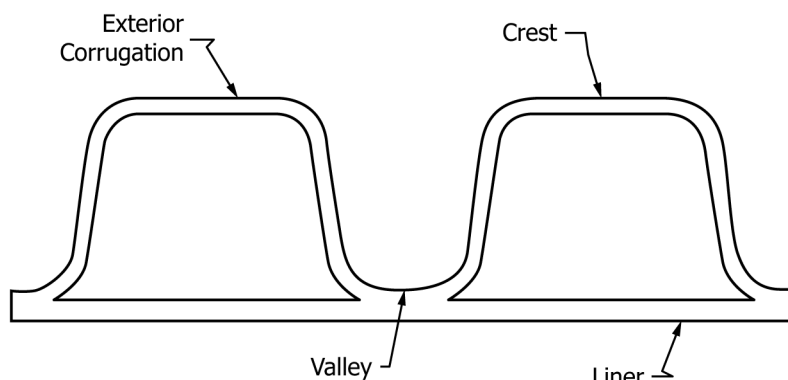


FIG. 1 Typical Annular Corrugated Pipe Profile

- [D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials](#)
- [D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry](#)
- [D4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique](#)
- [D4389 Specification for Finished Glass Fabrics Woven From Rovings](#)
- [D4703 Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets](#)
- [D4883 Test Method for Density of Polyethylene by the Ultrasound Technique](#)
- [D5630 Test Method for Ash Content in Plastics](#)
- [D6992 Test Method for Accelerated Tensile Creep and Creep-Rupture of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method](#)
- [D7399 Test Method for Determination of the Amount of Polypropylene in Polypropylene/Low Density Polyethylene Mixtures Using Infrared Spectrophotometry](#)
- [F412 Terminology Relating to Plastic Piping Systems](#)
- [F477 Specification for Elastomeric Seals \(Gaskets\) for Joining Plastic Pipe](#)
- [F2136 Test Method for Notched, Constant Ligament-Stress \(NCLS\) Test to Determine Slow-Crack-Growth Resistance of HDPE Resins or HDPE Corrugated Pipe](#)
- [F3181 Test Method for The Un-notched, Constant Ligament Stress Crack Test \(UCLS\) for HDPE Materials Containing Post-Consumer Recycled HDPE](#)
- [F3308 Practice for Sampling and Testing Frequency for Recycled Materials in Polyethylene \(PE\) Pipe for Non-Pressure Applications](#)
- [G154 Practice for Operating Fluorescent Ultraviolet \(UV\) Lamp Apparatus for Exposure of Nonmetallic Materials](#)
- [G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials](#)
- 2.2 [AASHTO Standard](#).³
- [LRFD, Section 12 AASHTO LRFD Bridge Design Specifications Section 12–Buried Structures and Tunnel Liners](#)
- 2.3 [NCHRP \(National Cooperative Highway Research Program\) Reports](#)⁴
- [NCHRP Report 631 – Updated Test and Design Methods for Thermoplastic Drainage Pipe](#)
- [NCHRP Report 870 – Performance of Corrugated Pipe Manufactured with Recycled Content](#)
- 2.4 [ISO Standard](#):⁵
- [ISO 15270 Guidelines for the Recovery and Recycling of Plastic Waste](#)

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology [F412](#) and abbreviations are in accordance with Terminology [D1600](#), unless otherwise specified. The abbreviation for polyethylene is PE.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *profile wall, n*—in this case, the profile pipe wall construction provides an interior liner in the waterway and includes ribs, corrugations, or other shapes, which can be either solid or hollow, that helps brace the pipe against diametrical deformation.

3.2.2 *service temperature, n*—the average ambient temperature of the in situ conditions at which the pipe will be operating for the life of the project.

³ Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, <http://www.transportation.org>.

⁴ The National Academies of Sciences, Engineering, and Medicine 500 Fifth Street, NW Washington, DC 20001, <http://www.trb.org/NCHRP/NCHRP.aspx> Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.

⁵ Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

4. Ordering Information

4.1 Orders for product made to this specification shall include the following information to adequately describe the desired product:

- 4.1.1 This ASTM designation and year of issue,
- 4.1.2 Diameters,
- 4.1.3 Total footage of each pipe diameter involved,
- 4.1.4 Pipe laying length,
- 4.1.5 Virgin or recycled materials,
- 4.1.6 Fitting type(s):
 - 4.1.6.1 Size and type of fittings, including mainline and branch diameters, and
 - 4.1.6.2 Number of fittings per diameter.

5. Materials and Manufacture

5.1 *Virgin Resin Pipe and Fabricated Fittings*—The pipe and fabricated fittings shall be made from virgin PE compound meeting the requirements of Specification **D3350** with a minimum cell classification of 435400C or 435400E. Black compound shall have a carbon black content equal to or greater than 2.0 wt % and shall not exceed 3.0 wt % per **6.1.2**. Colored compounds shall contain sufficient UV stabilizers to protect against UV degradation. For quality assurance purposes, the cell classification shall be performed on compression molded plaque, made according to Test Method **D4703** and cooled at 15 °C/min [27 °F/min]. The pipe density shall be corrected for percentage carbon black according to Specification **D3350**. Compounds that have a higher cell classification in one or more performance properties shall be permitted provided all other product requirements are met.

5.1.1 For slow crack growth resistance, extruded pipe shall be evaluated using the notched constant ligament stress (NCLS) test according to the requirements and procedures described in **6.7**.

NOTE 1—Pipe users should consult with the pipe manufacturer about the outdoor exposure life of the product under consideration. Evaluation of UV stabilizer in Code E color PE compound using Practice **D2565**, Practice **G154** or Practice **G155** may be useful for this purpose. Exposure to sunlight during normal construction periods is not harmful. It is good practice to store pipe and fittings under suitable cover prior to installation.

5.2 *Rework*—Clean rework generated from the manufacturer's own pipe and fittings production of this product shall be permitted to be used by the same manufacturer. Rework shall be the same cell classification as new PE compound with which it is blended and the pipe produced shall meet all the requirements of this specification.

5.3 *Recycled Material Pipe:*

5.3.1 *Recycled Material Pipe*—The pipe containing any post-consumer or post-industrial (pre-consumer) recycled materials shall be made of PE plastic compound recovered and recycled in accordance with Guide ISO 15270 such that the compound is a blend of virgin compound and post-consumer/post-industrial compound that meets the following additional requirements in accordance with Specification **D3350**:

- 5.3.1.1 Cell classification 435400C or 435400E in accordance with Specification **D3350**.
- 5.3.1.2 The carbon black content in compounds meeting cell classification 435400C shall be equal to or greater than 2 % but not exceed 4 % when tested in accordance with Test Method **D4218**. Compounds that have a higher cell classification in one or more properties shall be permitted provided the density of the compound shall not exceed 0.955 g/cm³ as tested in accordance with Test Method **D4883** and all other product requirements are met.

5.3.1.3 For slow crack growth resistance, extruded pipe shall be evaluated using the notched constant ligament stress (NCLS) test according to the requirements and procedures described in **6.7**.

5.3.1.4 Crack initiation shall be tested in accordance with the procedures in **7.10**. The average failure time of five test specimens shall exceed the minimum required for the applied tensile stress, service temperature and required service life required for the application.

5.3.1.5 Maximum level of polypropylene present by volume shall not be greater than 5 percent when tested in accordance with the procedures in **7.8**.

5.3.1.6 Maximum ash content shall not be more than 2% in accordance with the procedures in **7.9**.

5.3.1.7 Samples taken from the extruded pipe supplied to the project shall have a minimum Oxidative-Induction-Time of 25 minutes when tested in accordance with Test Method **D3895** and break strain of 150% when tested in accordance with Test Method **D638**.

5.3.1.8 Service prediction shall be done in accordance with **7.10**.

5.3.1.9 All sampling and testing requirements and frequencies for recycled material pipe shall be conducted in accordance with Practice **F3308**.

5.3.2 *Recycled Material Fittings*—Fittings made from recycled materials are not permitted under this standard.

NOTE 2—Post-consumer recycled materials contain a wide assortment of polyethylene compounds, which may have a combination of high and low environmental stress crack resistance. Post-industrial recycled materials will have much more consistent quality of compounds, but they will be of the same stress-crack resistance. They may, therefore, have higher or lower environmental stress crack resistance than postconsumer materials. The ASTM **F3181** test method will, however, provide predictable and reproducible results for either material.

6. General Requirements

6.1 *Workmanship*—The pipe and fittings shall be black or color; shall be homogeneous throughout; and shall be as uniform as commercially practical in color, opacity, and density. The pipe walls shall be free of cracks, holes, blisters, voids, foreign inclusions, or other defects that are visible to the naked eye and that may affect the wall integrity. The ends shall be cut cleanly and squarely through valleys.

6.1.1 Visible defects, cracks, creases, splits, and delaminations in pipe are not permissible.

6.1.2 Carbon black content in this pipe or fitting shall be tested in accordance with Test Method **D1603** or Test Method **D4218**.

6.2 *Dimensions and Tolerance:*

6.2.1 *Nominal Size*—The nominal size for the pipe and fittings shall be the inside diameter shown in **Table 1**.

NOTE 3—The actual inside diameter of a pipe depends on the material distribution, construction and stiffness. It may be considerably higher than the minimums specified in this table. For more information, see the manufacturer’s documentation.

6.2.2 *Mean/Minimum Inside Diameter*—The manufacturer’s stated mean/minimum inside diameter shall be as shown in **Table 1**, when measured in accordance with **7.3.1**.

NOTE 4—The outside diameters and the corrugation pitch of products manufactured to this specification are not specified; therefore, compatibility between pipe and fittings made to this specification from different manufacturers must be verified.

6.2.3 *Laying Length*—The pipe shall be supplied in any laying length agreeable to both the owner and the manufacturer. Laying length shall not be less than 99 % of stated quantity when measured in accordance with **7.3.2**.

6.2.4 *Liner Thickness*—The minimum liner thickness of the pipe shall meet the requirements given in **Table 1** when measured in accordance with **7.3.3**.

6.3 *Pipe Stiffness*—Minimum pipe stiffness at 5 % deflection shall meet the requirements given in **Table 1** when tested in accordance with **7.4**.

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

6.4 *Pipe Flattening*—There shall be no evidence of splitting, cracking, breaking, separation of corrugation seams, separation of the valley and liner, or combinations thereof, when tested in accordance with **7.5**.

6.5 *Pipe Impact Strength*—There shall be no evidence of splitting, cracking, breaking, separation of corrugation seams, separation of the valley and liner, or combinations thereof, on any specimen when tested in accordance with **7.6**.

6.6 *Fittings and Joining Systems:*

6.6.1 Only fittings fabricated from pipe meeting this specification and supplied or recommended by the pipe manufacturer shall be used. Fabricated fittings shall be installed in accordance with the manufacturer’s recommendations.

6.6.2 The joining system(s) shall be of a design that preserves alignment during construction and prevents separation at the joints.

6.6.3 Pipe and fittings shall have a watertight bell/spigot joint that complies with the laboratory tests defined and described in Test Method **D3212** and utilizes a gasket that complies with the requirements of Specification **F477**. All joints shall show no signs of leakage when tested in accordance with Specification **D3212**. Note that special provisions must be taken in order that joints made to field cut pipe meet the requirements of Specification **D3212**. Any component used in the joining material shall be resistant to effluents being carried in the pipe.

TABLE 1 Pipe Stiffness and Pipe Dimensions

Nominal Diameter		Mean/Minimum Inside Diameter		Minimum Pipe Stiffness Stiffness at 5% Deflection		Minimum Liner Thickness	
mm	[in.]	mm	[in.]	kPa	[lb/in./in.]	mm	[in.]
150	6	145	5.91	441	64	1.0	0.039
200	8	195	7.87	414	60	1.1	0.043
225	9	220	8.86	407	59	1.2	0.047
250	10	245	9.84	400	58	1.3	0.051
300	12	294	11.57	372	54	1.4	0.055
375	15	369	14.51	310	45	1.7	0.067
400	16	392	15.43	303	44	1.8	0.071
450	18	450	17.72	297	43	1.9	0.074
500	20	490	19.29	276	40	2.0	0.079
600	24	588	23.15	262	38	2.2	0.087
750	30	751	29.56	228	33	2.4	0.094
800	32	785	30.91	200	29	2.6	0.102
900	36	902	35.49	179	26	2.7	0.106
1000	40	985	38.79	179	26	2.9	0.114
1050	42	1051	41.39	172	25	3.2	0.126
1200	48	1185	46.65	152	22	3.5	0.138
1500	60	1501	59.10	138	20	4.0	0.157

6.6.4 *Optional Bell Restraining Bands*—Bell restraining bands, when used, shall be made of corrosion resistant materials such as fiberglass (Specification [D4389](#)) or stainless steel (Specification [A666](#)).

6.6.5 *Joint Proof-of-Design*—To assess the effects of long-term properties of the pipe and gasket material under a joint assembly, a joint proof-of-design test shall be conducted on the pipe joints using the test method outlined in [7.87.11](#). Each joint proof of design pressure test shall be conducted by an independent third party, which provides written certification for each test. This test is a one-time validation test for the specific pipe diameter, profile geometry, gasket and joint configuration supplied by the manufacturer. This proof-of-design test shall be conducted on at least one pipe diameter within the prescribed diameter range and shall be conducted on each diameter that differs in joint design. If the joint design does not change within the prescribed range, the largest diameter shall be tested. If the diameter range includes more than 5 different pipe diameters, then two sizes shall be tested; the largest and smallest diameters.

6.7 *Slow Crack Growth Resistance—Pipe*—For slow crack-growth resistance, the pipe shall be evaluated using the notched constant ligament stress (NCLS) test according to the procedure described in [7.7](#). The NCLS test shall be conducted on molded plaques, and the average failure time of the five test specimens shall exceed 41 h with no single test specimen's failure time less than 29 h.

6.8 *Structural Design:*

6.8.1 The manufacturer shall supply appropriate data necessary to satisfy the requirements of deflection, thrust, buckling, bending stress and long-term strain in accordance with the design criteria of the AASHTO LRFD Bridge Design Specification (LRFD, Section 12). The design engineer shall verify that the data provided by the manufacturer satisfy the product requirements.

6.8.2 The minimum long-term (50-year) design values for modulus of elasticity and tensile strength for the PE compounds shall be 152 MPa (22 000 psi) and 6.2 MPa (900 psi), respectively. The maximum allowable long-term (50-year) tensile strain limit for design shall be 5 %.

6.8.2.1 *Creep Rupture Strength*—Specimens fabricated in the same manner and composed of the same materials as the finished pipe shall have a 50-year creep rupture tensile strength at 23 °C (73 °F) not less than 6.2 MPa (900 psi), when determined in accordance with [7.97.12](#).

6.8.2.2 *Creep Modulus*—Specimens fabricated in the same manner and composed of the same materials as the finished pipe shall have a 50-year tensile creep modulus at 23 °C (73 °F) at the stress level of 3.5 MPa (500 psi) not less than 152 MPa (22,000 psi). The creep modulus shall be determined in accordance with [7.107.13](#).

NOTE 6—The 50-year creep rupture strength and 50-year creep modulus values, determined by the test methods in [7.97.12](#) and [7.107.13](#), are used to define the slope of the logarithmic regression curves to describe the required material properties sampled from the product. They are not to be interpreted as service life limits.

7. Test Methods

7.1 *Conditioning:*

7.1.1 *Referee Testing*—When conditioning is required for referee tests, condition the specimens in accordance with Procedure A of Practice [D618](#) at 23 ± 2 °C [73.4 ± 3.6 °F] for not less than 40 h prior to test. Conduct tests under the same conditions of temperature. The random selection of the sample or samples of the pipe and fittings shall be as agreed upon between the owner and the seller. In case of no prior agreement, any sample selected by the testing laboratory shall be permitted.

7.1.2 *Quality Control Testing*—Condition specimens for a minimum of 4 h prior to test in air or 1 h in water at 23 ± 2 °C [73.4 ± 3.6 °F] without regard to relative humidity.

7.2 *Test Conditions*—Conduct tests other than those for routine quality control purposes in the standard laboratory atmosphere of 23 ± 2 °C [73.4 ± 3.6 °F], in the referenced test method or in this specification.

7.3 *Dimensions:*

7.3.1 *Inside Diameter*—Measure the inside diameter in accordance with Test Method [D2122](#).

7.3.2 *Laying Length*—Measure pipe laying length in accordance with Test Method [D2122](#). These measurements may be taken at ambient temperature.

7.3.3 *Minimum Inner-Liner Thickness*—Measure the thickness of the inner liner in accordance with Test Method [D2122](#). Each specimen shall be cut perpendicular to the seam line of the pipe directly through a corrugation allowing a plain view of the inner wall 360° around the circumference in order to obtain a minimum of eight measurements in accordance with Test Method [D2122](#).

7.4 *Pipe Stiffness*—Select three pipe specimens and test for pipe stiffness in accordance with Test Method [D2412](#), except for the following conditions:

7.4.1 The test specimens shall be at least one diameter or 600 mm [24 in.] in length, whichever is less. However, the test specimen shall not be less than three full corrugations in length.

7.4.2 Each specimen shall be cut mid-valley to mid-valley (see [Fig. 1](#)) while still meeting or exceeding the minimum length requirement.

7.4.3 Determine the minimum inner wall thickness and locate the first specimen in the loading machine with the minimum inner wall thickness located at 9:00 or 3:00 when viewing the specimen from the end. The specimen shall lie flat on the plate within

3 mm [0.117 in.]. Use the first location as a reference point for rotation and testing the other two specimens. Rotate the other specimens 60° and 120°, respectively, from the original orientation. Test each specimen in only one position.

7.5 Flattening—Flatten the three test specimens from 7.4 between parallel plates until the pipe inside diameter is reduced by 40 %. The rate of loading shall be 12.5 mm/min [0.5 in./min], and may be increased after 5 % deflection is obtained for pipe stiffness so the remainder of the test is completed within 2 to 5 minutes. Additionally, at or below the deflection limit defined in Eq 1, the specimen shall be considered as failing this test when the load does not increase continuously with increasing deflection. Buckling Deflection Limit:

$$\Delta b = \frac{6.15\% \cdot 0.5 \cdot D}{D_f \cdot 0.6 \cdot h_p} \quad (1)$$

where:

- Δb = Minimum buckling deflection limit (%)
- D = Mean diameter (centroid) of the pipe (in [mm])
- D_f = Shape factor (dimensionless fixed value of 4.27 for parallel plate test)
- h_p = Corrugation height (in [mm])

NOTE 7—Eq 1 is based on the results from NCHRP Report 631 and is defined as being derived from the standard parallel plate test equation. The constant value 6.15% (0.0615) in Eq 1 is the factored combined strain limit for HDPE pipe per AASHTO LRFD Section 12. The constant value 0.6 in this equation is an estimated centroidal distance for typical profiles produced in accordance with this specification.

7.6 Impact Resistance—Test pipe specimens in accordance with Test Method D2444 except six specimens shall be tested once each at random orientations or six impacts shall be made on one specimen. In the latter case, as a referee test, successive impacts shall be separated by $60 \pm 10^\circ$ 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. Impact strength shall not be less than the requirements in Table 2. Tests shall be conducted using either a 9 kg [20 lb] Tup B or 14 kg [30 lb] Tup B and a flat-plate specimen Holder B. Condition the specimens for 24 h at a temperature of $23 \pm 2^\circ\text{C}$ [$73.4 \pm 3.6^\circ\text{F}$], 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.

7.6.1 All the impact specimens shall be cut valley to valley. In sizes 300 to 450 mm [12 to 18 in.], the minimum length of the test specimens shall be the nominal diameter. In sizes greater than 450 mm [18 in.], the minimum length shall be 450 mm in. [18 in.].

7.7 Slow-Crack Growth Resistance—PE Pipe—Pipe test specimens shall be molded into test specimens from the pipe. Test 5 pipe specimens using the same protocol for molded bars in Test Method F2136 test, except for the following modifications:

7.7.1 The applied stress for the NCLS test shall be 4.1 MPa [600 psi].

7.7.2 The test specimen is taken from the extruded pipe and is chopped and molded into a specimen.

7.8 Determination of Percent Polypropylene for Recycled Material Compounds—Test samples of the recycled material compound in accordance with Test Method D7399.

7.9 Determination of Ash Content in Recycled Compounds—Test a two gram sample at 800°C [1472°F] in accordance with Test Method D5630.

7.10 Determination of Crack Initiation and Service Prediction of Pipes Manufactured with Recycled Compounds:

TABLE 2 Minimum Impact Strength

Nominal Diameter		Impact Strength	
mm	[in.]	J	[ft-lb]
150	6	100	74
200	8	110	81
225	9	120	89
250	10	140	104
300	12	190	141
375	15	190	141
400	16	190	141
450	18	190	141
500	20	190	141
600	24	190	141
750	30	190	141
800	32	190	141
900	36	190	141
1000	40	190	141
1050	42	190	141
1200	48	190	141
1500	60	190	141

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

7.10.2 For service conditions where the tensile wall stress is equal to or less than 3447 kPa [500 psi] and the service temperature is equal to or less than 25 °C [77 °F], the average failure time of five specimens shall be greater than or equal to 48 h and no specimen shall fail in less than 25 h.

7.10.3 For service conditions other than stated in 7.10.2, see Table X2.1.

7.10.4 An example calculation providing the basis for these average and minimum UCLS failure times is provided in Appendix X2.

NOTE 8—The UCLS test method and results are based on NCHRP Research Report 870.

NOTE 9—Increasing temperatures decrease the predicted pipe's service condition, while cooler temperatures extend it. The temperature utilized for sanitary sewer applications in this standard has been increased over those normally used for storm or highway applications (23 °C [74 °F]) to account for higher temperature discharges that may be present in effluent from buildings and homes. If higher peak temperatures are consistently experienced at a site, the average ambient temperature should be increased accordingly.

7.11 *Joint Proof-of-Design Pressure Test:*

7.11.1 Prepare and test joints in accordance with 7.8.37.11.3. Pipe shall have a watertight bell/spigot joint that complies with the laboratory tests defined and described in Test Method D3212.

7.11.2 Failure of any of the specimens shall constitute failure of the test.

7.11.3 *Specimen Preparation:*

7.11.3.1 Condition assembled test specimens a minimum of 2 h at the test temperature to be used prior to initiating the test procedure.

7.11.3.2 Test joints shall be assembled on the appropriate size pipe in accordance with the manufacturer's joining procedure. Lubricate and assemble the joint according to the manufacturer's instructions with the associated Specification F477 gasket in place.

7.11.3.3 Testing shall be conducted at standard laboratory temperature of 23 ± 2 °C [73.4 ± 3.6 °F] unless otherwise specified.

7.11.3.4 Maintain assembled joint configuration for a minimum of 1000 h under ambient temperature conditions 24 ± 3 °C [75 ± 5 °F]. Upon completion of this hold time, conduct a complete Specification D3212 test on the assembled joint. For entire 1000 h hold time, joint shall remain undisturbed and fully assembled. Joint may not be disassembled and reassembled at any point prior to completion of full Specification D3212 testing.

7.11.3.5 Aside from stiffeners that are part of the joint design being tested, no stiffeners may be used in the specimen.

7.12 *Creep Rupture Strength*—Determine creep rupture strength in accordance with the tensile creep test methods in D2990, except as follows. Test shall include an additional stress level selected so as to produce rupture at approximately 10,000 h. Alternately, it is permissible to use time-temperature superposition methods to determine the creep rupture strength.

7.13 *Creep Modulus*—Determine creep modulus in accordance with tensile creep test methods in D2990, except the test duration shall be 10,000 h and the test shall include a minimum of 5 stress levels that are selected in approximately even increments up to and including 3.45 MPa (500 psi). Alternately, it is permissible to use time-temperature superposition methods to determine the creep modulus.

NOTE 10—The time-temperature superposition method in Test Method D6992 is an accepted means to determine the tensile creep modulus and tensile creep rupture strength. These tests are intended to validate a material's proof-of-performance qualification and are not standard quality assurance tests.

8. Inspection

8.1 Inspection of the product shall be as agreed upon between the owner and the manufacturer as part of the purchase contract. Unless otherwise specified in the contract or purchase agreement, the manufacturer is responsible for the performance of all inspection and test requirements specified herein.

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

8.3 *Access*—The inspector shall have free access to those parts of the manufacturer's plant that are involved in work performed under this specification. The manufacturer shall afford the inspector all reasonable facilities for determining whether the pipe or fittings, or both, meet the requirements of this specification.

9. Rejection and Rehearing

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