Designation: F2947/F2947M – 14

Standard Specification for 150 to 1500 mm [6 to 60 in.] Annular Corrugated Profile-Wall Polyethylene (PE) Pipe and Fittings for Sanitary Sewer Applications[1]

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 *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 may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A666 Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

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 Test Method 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

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

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

D6992 Test Method for Accelerated Tensile Creep and Creep-Rupture of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method

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

G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.62 on Sewer.

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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**

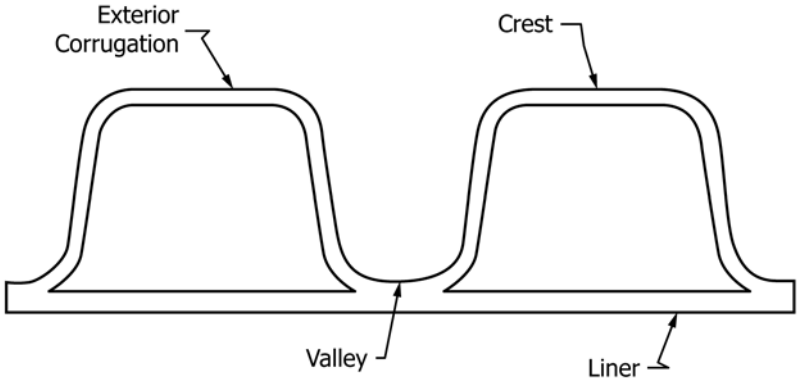

FIG. 1 Typical Annular Corrugated Pipe Profile

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

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.

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 Fitting type(s):

4.1.5.1 Size and type of fittings, including mainline and branch diameters, and

4.1.5.2 Number of fittings per diameter.

5. Materials and Manufacture

5.1 *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.

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.

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 2—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 Inside Diameter*—The manufacturer's stated mean inside diameter shall be as shown in Table 1, when measured in accordance with 7.3.1.

[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.

TABLE 1 Pipe Stiffness and Pipe Dimensions

Nominal Diameter		Mean Inside Diameter		Minimum Pipe Stiffness Stiffness @ 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

NOTE 3—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 4—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.

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 7.8. 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 7.9.

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 7.10.

NOTE 5—The 50-year creep rupture strength and 50-year creep modulus values, determined by the test methods in 7.9 and 7.10, 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.

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 ± 10° 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 ± 2°C [73.4 ± 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.

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

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

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 *Joint Proof-of-Design Pressure Test:*

7.8.1 Prepare and test joints in accordance with 7.8.3. Pipe shall have a watertight bell/spigot joint that complies with the laboratory tests defined and described in Test Method D3212.

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

7.8.3 *Specimen Preparation:*

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

7.8.3.2 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.

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

7.8.3.4 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.

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

7.9 *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.

7.10 *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 6—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.

10. Certification

10.1 When specified in the purchase order or contract, a manufacturer's or independent laboratory's certification shall be furnished to the owner that the products shipped, as identified by the lot description of section 11.1 and 11.2, were manufactured, sampled, tested, and inspected at the time of manufacture in accordance with this specification and have been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished. Where requested, certified actual inside diameter shall be provided.

11. Markings

11.1 *Pipe*—Each length of pipe in compliance with this specification shall be clearly marked with the following information: this designation ASTM F2947; the nominal size; the legend PE; the manufacturer's name, trade name or trademark; plant location; and date of manufacture. The marking shall be applied at the time of manufacture to the pipe in such a manner that it remains legible after installation and inspection. It shall be placed, at least, at each end of each length of pipe or spaced at intervals of not more than 3.0 m [10 ft].

11.2 *Fittings*—Each fitting in compliance with this specification shall be clearly marked with the following information: this designation ASTM F2947; the nominal size; the legend

PE; the manufacturer's name, trade name or trademark; plant location; and date of manufacture.

12. Packaging

12.1 All pipe and fittings shall, unless otherwise specified, be packaged for standard commercial shipment.

13. Quality Assurance

13.1 When the product is marked with this designation (ASTM F2947), the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

14. Keywords

14.1 corrugated HDPE pipe; fittings; interior liner; PE; pipe; polyethylene; profile wall; sanitary sewer

SUPPLEMENTARY REQUIREMENTS

S1. Responsibility for Inspection

S1.1 Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection and test requirements specified herein. The manufacturer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless the owner disapproves. The owner shall have the right to perform any of the inspections and tests set forth in this specification, where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

APPENDIXES

(Nonmandatory Information)

X1. AUTHORITIES

X1.1 Since this product has a wide variety of uses in sanitary sewer systems, approval for its use rests with various agencies. The installer should contact the relevant authority to obtain local installation guidelines.

X1.2 The pipe manufacturer(s) should be able to provide proof of product acceptance by specific agencies, when appropriate.

X2. RECOMMENDED LIMIT FOR INSTALLED DEFLECTION

X2.1 Design engineers, public agencies, and others who have the responsibility to establish specifications for maximum allowable limits for deflection of installed polyethylene sewer pipe have requested direction relative to such a limit.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F2947–12$^{\varepsilon 1}$) that may impact the use of this standard.

(1) Sections 5 and 6 were modified to permit the use of colored compounds with additional pertinent references added to Section 2.