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Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe[1]

This standard is issued under the fixed designation F 894; 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 materials, dimensions, workmanship, ring stiffness, flattening, joint systems, and a form of marking for large diameter, 10 to 120 in. (250 to 3050 mm), inside diameter based polyethylene (PE) pipe of profile wall construction and with butt-fused, bell and spigot, and other mechanical joints for use in low pressure and gravity flow applications, such as for sewers and drains.

NOTE 1—Pipe produced to this specification should be installed in accordance with Practice D 2321 and with the manufacturer's recommendations.

NOTE 2—For purposes of this specification, low pressure is defined as 50 ft (15.2 m) of water column or less.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are provided for information only.

1.3 The following safety hazards caveat pertains only to the test method portion, Section 8, 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:*

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 1600 Terminology for Abbreviated Terms Relating to Plastics[2]

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings[3]

D 2321 Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity–Flow Applications[3]

D 2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Pipe Loading[3]

D 2657 Practice for Heat Joining of Polyolefin Pipe and Fittings[3]

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials[3]

D 3212 Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals[3]

D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials[4]

F 412 Terminology Relating to Plastic Piping Systems[3]

F 477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe[3]

F 585 Practice for Insertion of Flexible Polyethylene Pipe into Existing Sewers[3]

2.2 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[5]

2.3 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[5]

3. Terminology

3.1 Definitions—Definitions are in accordance with Terminology F 412 and abbreviations are in accordance with Terminology D 1600, unless otherwise specified. The abbreviation for polyethylene is PE.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *closed profile (CP)*—a profile wall pipe wall construction that presents essentially smooth internal and external surfaces.

3.2.2 *extrusion welding*—a joining technique that is accomplished by extruding a molten polyethylene bead between two prepared surface ends.

3.2.3 *open profile (OP)*—a profile wall pipe wall construction that presents an essentially smooth internal surface with a ribbed or corrugated external surface.

3.2.4 *profile wall*—a pipe wall construction that presents an essentially smooth surface in the waterway but includes ribs or other shapes, which can be either solid or hollow, that help brace the pipe against diametrical deformation (see Fig. 1).

3.2.5 *ring stiffness constant (RSC)*—the value obtained by dividing the parallel plate load in pounds per foot of pipe

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.04.

[4] *Annual Book of ASTM Standards*, Vol 08.02.

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

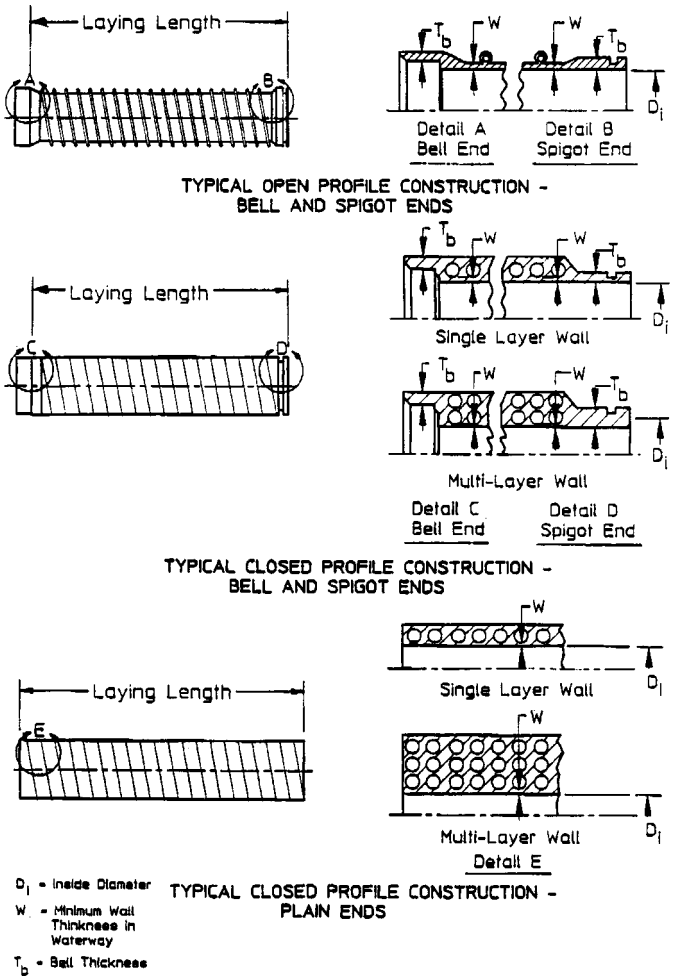

FIG. 1 Typical Construction of Profile Wall PE Pipe

length, by the resulting deflection, in percent, at 3 % deflection. The ring stiffness constant (RSC) that is used in this specification to classify pipe is a measure of the pipe's deformation resistance to diametrical point loading, such as is experienced during handling and installation. A pipe should resist these loads sufficiently well to allow its installation to prescribed deflection limits.

4. Classifications and Uses

4.1 *Uses*—The requirements of this specification are intended to provide pipe suitable for underground or overground gravity and low pressure drainage of sewer, surface water, and industrial waste.

NOTE 3—Industrial waste disposal lines should be installed only upon the specific approval of the governing code, or other authority, and after determining the suitability of the product under the anticipated environment, temperature, and other end-use conditions. Users should consult the manufacturer for the required product information.

4.2 *Classifications*—This specification covers PE profile wall pipe products made in four standard ring stiffness constant (RSC) classifications, namely 40, 63, 100, and 160. These are referred to as RSC 40, RSC 63, RSC 100, and RSC 160.

NOTE 4—Other RSC classifications may be supplied, as agreed upon between the purchaser and the manufacturer, provided that such product complies in every other respect with the applicable dimensional tolerances and testing requirements of this specification.

4.3 *Joining Systems*:

4.3.1 *Bell and Spigot, Gasketed Type*—Seal is affected by a gasket compressed between the spigot and billed ends of the pipe (see Fig. 2).

4.3.2 *Bell and Spigot, Extrusion Weld Type*—Seal is affected by extrusion welding of the bell and spigot pipe ends (see Fig. 2).

4.3.3 *Heat Fusion*—Heat fusion joints are in accordance with Practice D 2657. Seal is affected by joining molten pipe ends under controlled temperature and pressure (see Fig. 3).

4.3.4 *Plain End Extrusion Weld*—Seal is effected by extrusion welding prepared plain ends of the pipe (see Fig. 4).

4.3.5 *Other*—Where these connections are impractical or undesirable because of space, layout, or other requirement, joining methods such as flanging, restrained integral connectors, and others may be used. Methods proposed should be evaluated by the engineer for suitability.

5. Materials

5.1 *Base Materials*—The pipe shall be made of PE plastic compound meeting the requirements of cell classification PE 334433C (or E) or higher cell classification in accordance with Specification D 3350. The material shall have an established hydrostatic design basis (HDB) of not less than 1250 psi (8.6 MPa) for water at 73.4°F (23°C) determined in accordance with Test Method D 2837.

NOTE 5—A source of hydrostatic design basis (HDB) recommendations for commercial thermoplastic pipe materials is the Plastics Pipe Institute. These are developed on the basis of Test Method D 2837 and additional requirements. A listing of recommended HDB's and the criteria for development may be obtained from the Plastics Pipe Institute, a Division of the Society of the Plastic Industry, Suite 600K, 1801 K Street, NW, Washington, DC 20006-1301.

5.2 *Other Pipe Materials*—Materials other than those specified under base materials may be used as part of the profile construction, for example, as a core tube to support the shape of the profile during processing, provided that these materials are compatible with the base PE material, are completely encapsulated in the finished product, and in no way compromise the performance of the PE pipe products in the intended use. Examples of suitable materials include polyethylene and polypropylene.

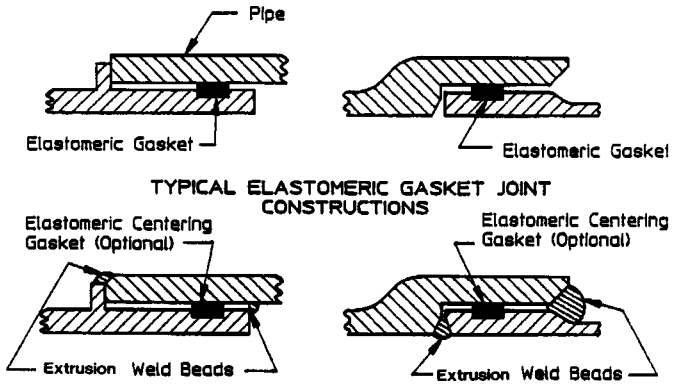

FIG. 2 Typical Extrusion Weld Joint Constructions

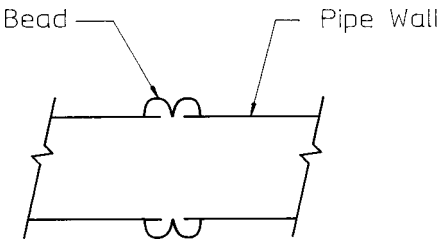

FIG. 3 Heat Fusion

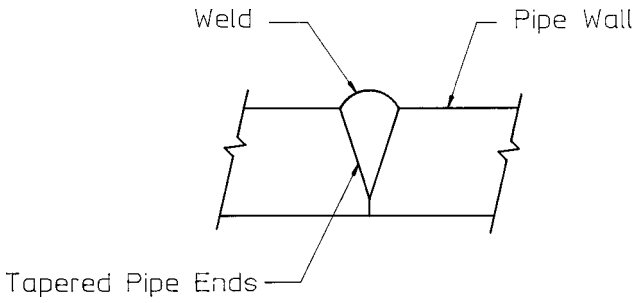

FIG. 4 Extrusion Weld

5.3 *Rework Material*—Clean rework PE material generated from the manufacturer's own pipe production may be used by the same manufacturer provided the pipe produced meets all the requirements of this specification. Rework material of the type described in 5.2, may only be used to make product if it has been shown to be compatible with the base PE material and allows the production of pipe that meets all the requirements of this specification.

5.4 *Gaskets*—Elastomeric gaskets shall comply with the requirements specified in Specification F 477.

5.5 *Lubricant*—The lubricant used for assembly of gasket joints shall have no detrimental effect on the gasket or on the pipe.

5.6 *Thermal Welding Material*—The material used for thermally welding the pipe material shall meet the requirements established for the base material.

6. Joining System

6.1 *Bell and Spigot* (See Fig. 2):

6.1.1 The pipe ends shall consist of integrally formed bell and spigot, one of which is designed to accommodate a gasket, which when assembled forms a watertight seal by the radial compression of the gasket between the spigot and the bell ends. Alternatively, the pipe ends may act as either spigot or bell to an externally supplied coupling.

6.1.2 The joint shall be designed to avoid displacement of the gasket when it is assembled in accordance with the manufacturer's recommendations.

6.1.3 The assembly of the gasket joints shall be in accordance with the manufacturer's recommendations.

6.2 *Bell and Spigot Thermal Weld Type*:

6.2.1 The pipe ends shall consist of an integrally formed bell and spigot which, when assembled, come together to form an interface between bell and spigot, such that it is suitable for permanent sealing by thermal welding using the extrusion welding process, in accordance with the manufacturer's recommended procedure. Alternatively, the pipe ends may act as either spigot or bell to an externally supplied coupling.

6.2.2 Permanently sealed joints may be effected by welding from inside the pipe or outside, or both.

6.2.3 The assembly of the welded joints shall be in accordance with the manufacturer's recommendations.

6.3 *Heat Fusion* (See Fig. 3):

6.3.1 The pipe ends shall be plain and suitable for machine facing to square.

6.3.2 The assembly of the joint shall be in accordance with Practice D 2657 and the manufacturer's recommendations.

6.4 *Extrusion Welding Plain End* (See Fig. 4):

6.4.1 The pipe ends shall be chamfered as for welding.

6.4.2 Permanently sealed joints may be effected by welding from inside the pipe or outside, or both.

6.4.3 The assembly of the welding joints shall be in accordance with the manufacturer's recommendations.

7. Requirements

7.1 *Workmanship*—The pipe shall be essentially uniform in color, opacity, density, and other properties. The inside and outside surfaces shall be matte or semi-glossy in appearance and be free of chalking, sticky, or tacky material. Slight lines and mold marks (see Note 6) are permissible provided that they do not result in variation of the inside diameter of more than ⅛ in. (3.2 mm) from that obtained on adjacent unaffected portions of the surface, and provided that such pipe meets all of the test requirements set forth in this specification. Apart from the built-in voids and hollows associated with some profile wall designs, the pipe walls shall be free of cracks, blisters, foreign inclusions, or other defects that are visible to the naked eye and that may affect the wall integrity. Bloom or chalking may develop in pipe exposed to direct rays of the sun (ultraviolet radiant energy) for extended periods and consequently the above requirements do not apply to pipe after extended exposure to direct rays of sun.

NOTE 6—Processes currently available for the production of pipe meeting this specification involve tools or molds that may leave small parting lines or flash marks on the surface of the pipe. These are typical of any molding process and in no way affect the performance of the pipe.

7.2 *Pipe Dimensions:*—

7.2.1 *Diameter* The average inside diameter of the pipe, including the diameter in integral spigot sections where present, shall meet the requirements given in Table 1 or Table 2, when measured in accordance with 8.4.1.

7.2.2 *Pipe Wall Thickness*—The minimum wall thickness of the waterway of the pipe (see Fig. 1) shall meet the requirements given in Table 1 or Table 2, when measured in accordance with 8.4.2.

7.2.3 *Bell and Spigot Wall Thickness*—With the exception of the tapered lead-in section, where present, the minimum wall thickness in the bell of the pipe (see Fig. 1) shall meet the values specified in Table 1 or Table 2. The minimum wall thickness of the thinnest section of the spigot shall not be less than that established for the pipe waterway.

7.2.4 *Laying Length*—Standard pipe laying length, measured from the bottom of the bell to the tip of the spigot (see Fig. 1), shall be 20 ft (6.1 m) when measured in accordance with Test Method D 2122. Other laying lengths shall be as agreed upon between the purchaser and the manufacturer. The tolerance on the laying length shall be ±2 in. (50 mm). For

TABLE 1 Open Profile Pipe Dimensions and Tolerances

Nominal Pipe Size, in. (mm)	Average Inside Diameter, in. (mm)	Tolerance on Average Inside Diameter, in. (mm)	Min Wall Thickness in Pipe Waterway, *W*				Min Bell Thickness, *Tb*, in. (mm)
			RSC 40, in. (mm)	RSC 63, in. (mm)	RSC 100, in. (mm)	RSC 160, in. (mm)	
18 (460)	18.00 (457.2)	±0.38 (9.65)	0.18 (4.57)	0.18 (4.57)	0.18 (4.57)	0.22 (5.59)	0.70 (17.78)
21 (530)	21.00 (533.4)	±0.38 (9.65)	0.18 (4.57)	0.18 (4.57)	0.18 (4.57)	0.24 (6.10)	0.70 (17.78)
24 (610)	24.00 (609.6)	±0.38 (9.65)	0.18 (4.57)	0.18 (4.57)	0.22 (5.59)	0.24 (6.10)	0.70 (17.78)
27 (690)	27.00 (685.8)	±0.38 (9.65)	0.18 (4.57)	0.18 (4.57)	0.24 (6.10)	0.24 (6.10)	0.70 (17.78)
30 (760)	30.00 (762.0)	±0.38 (9.65)	0.18 (4.57)	0.22 (5.59)	0.24 (6.10)	0.26 (6.60)	0.70 (17.78)
33 (840)	33.00 (838.2)	±0.38 (9.65)	0.18 (4.57)	0.24 (6.10)	0.24 (6.10)	0.30 (7.62)	0.95 (24.13)
36 (910)	36.00 (914.4)	±0.38 (9.65)	0.18 (4.57)	0.24 (6.10)	0.26 (6.60)	0.30 (7.62)	1.05 (26.67)
42 (1070)	42.00 (1066.8)	±0.42 (10.67)	0.24 (6.10)	0.24 (6.10)	0.30 (7.62)	0.38 (9.65)	1.15 (29.21)
48 (1220)	48.00 (1219.2)	±0.48 (12.19)	0.24 (6.10)	0.26 (6.60)	0.30 (7.62)	0.38 (9.65)	1.25 (31.75)
54 (1370)	54.00 (1371.6)	±0.54 (13.72)	0.24 (6.10)	0.30 (7.62)	0.38 (9.65)	0.42 (10.67)	1.25 (31.75)
60 (1520)	60.00 (1524.0)	±0.60 (15.24)	0.26 (6.60)	0.30 (7.62)	0.38 (9.65)	0.52 (13.21)	1.30 (33.02)
66 (1680)	66.00 (1676.4)	±0.66 (16.76)	0.30 (7.62)	0.38 (9.65)	0.42 (10.67)	0.67 (17.02)	1.30 (33.02)
72 (1830)	72.00 (1828.8)	±0.72 (18.29)	0.30 (7.62)	0.38 (9.65)	0.42 (10.67)	0.90 (22.86)	1.30 (33.02)
78 (1980)	78.00 (1981.2)	±0.78 (19.81)	0.30 (7.62)	0.38 (9.65)	0.52 (13.21)	0.90 (22.86)	1.35 (34.29)
84 (2130)	84.00 (2133.6)	±0.84 (21.34)	0.38 (9.65)	0.42 (10.67)	0.67 (17.02)	0.90 (22.86)	1.35 (34.29)
90 (2290)	90.00 (2286.0)	±0.90 (22.86)	0.38 (9.65)	0.42 (10.67)	0.90 (22.86)	0.95 (24.13)	1.35 (34.29)
96 (2440)	96.00 (2438.4)	±0.96 (24.38)	0.38 (9.65)	0.52 (13.21)	0.90 (22.86)	0.95 (24.13)	1.35 (34.29)
108 (2740)	108.00 (2743.2)	±1.08 (27.43)	0.42 (10.67)	0.67 (17.02)	0.90 (22.86)	0.95 (24.13)	1.35 (34.29)
120 (3050)	120.00 (3048.0)	±1.20 (30.48)	0.52 (13.21)	0.67 (17.02)	0.90 (22.86)	0.95 (24.13)	1.35 (34.29)

TABLE 2 Closed Profile Pipe Dimensions and Tolerances

Nominal Pipe Size, in. (mm)	Average Inside Diameter, in. (mm)	Tolerance on Average Inside Diameter, in. (mm)	Min Wall Thickness in Pipe Waterway, *W*, All RSC, in. (mm)	Min Bell Thickness, *Tb*, in. (mm)
10 (250)	10.0 (254.0)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
12 (300)	12.0 (304.8)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
15 (380)	15.0 (381.0)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
18 (460)	18.0 (457.2)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
21 (530)	21.0 (533.4)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
24 (610)	24.0 (609.6)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
27 (690)	27.0 (685.8)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
30 (760)	30.0 (762.0)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
33 (840)	33.0 (838.2)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
36 (910)	36.0 (914.4)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
40 (1020)	40.0 (1016.0)	±0.38 (9.65)	0.18 (4.57)	0.5 (12.7)
42 (1070)	42.0 (1066.8)	±0.42 (10.67)	0.18 (4.57)	0.5 (12.7)
48 (1220)	48.0 (1219.2)	±0.48 (12.19)	0.18 (4.57)	0.5 (12.7)
54 (1370)	54.0 (1371.6)	±0.54 (13.72)	0.18 (4.57)	0.5 (12.7)
60 (1520)	60.0 (1524.0)	±0.60 (15.24)	0.18 (4.57)	0.6 (15.2)
66 (1680)	66.0 (1676.4)	±0.66 (16.76)	0.18 (4.57)	0.6 (15.2)
72 (1830)	72.0 (1828.8)	±0.72 (18.29)	0.18 (4.57)	0.6 (15.2)
78 (1980)	78.0 (1981.2)	±0.78 (19.81)	0.18 (4.57)	0.6 (15.2)
84 (2130)	84.0 (2133.6)	±0.84 (21.34)	0.18 (4.57)	0.7 (17.8)
90 (2290)	90.0 (2286.0)	±0.90 (22.86)	0.18 (4.57)	0.7 (17.8)
96 (2440)	96.0 (2438.4)	±0.96 (24.38)	0.18 (4.57)	0.7 (17.8)
108 (2740)	108.0 (2743.2)	±1.08 (27.43)	0.18 (4.57)	0.7 (17.8)
120 (3050)	120.0 (3048.0)	±1.20 (30.48)	0.18 (4.57)	0.8 (20.3)

pipe with an integral bell, the pipe laying length is measured from the bottom of the bell to the tip of the spigot.

7.3 *Ring Stiffness Constant*—Ring stiffness constant (RSC) for the pipe between bell and spigot sections shall comply with the minimum values given in Table 3, when tested in accordance with 8.5.1 or with the corresponding values established by statistical correlation, developed by the manufacturer and agreed by the purchaser, when measured in accordance with 8.5.2. However, in cases of disagreement the pipe shall comply with the values in Table 3, when tested in accordance with 8.5.1. Where an integral bell is present, the RSC for the pipe is determined between bell and spigot sections.

TABLE 3 Minimum Ring Stiffness Constant (RSC) Values

Nominal Pipe Classification	RSC (lb/ft of Length)
40	36
63	56
100	90
160	144

7.4 *Flattening*—There shall be no evidence of splitting, cracking, or breaking when pipe, including the bell or spigot section, is tested in accordance with 8.6.

7.5 *Joint Tightness*:

7.5.1 Bell and spigot connections, whether gasket style or thermal weld type when joined in accordance with the manufacturer's recommendations, shall show no sign of leakage

when tested in accordance with 8.7. In the case of gasket type, all surfaces of the joint upon which the gasket may bear, shall be smooth and free of such imperfections, ridges, fractures, or cracks that could adversely affect sealability.

NOTE 7—Testing for joint tightness is not intended to be a routine quality control test. The test is intended to qualify pipe joint designs to a specified level of performance.

7.5.2 Heat fusion connections shall be tested in accordance with Practice D 2657 Technique II: Butt Fusion.

7.5.3 Thermal weld connections shall be tested in accordance with 8.7 with the exception that the load be applied relative to the centerline of the wall. No leakage is allowed.

7.6 *Gaskets*:

7.6.1 Gaskets shall meet the requirements of Specification F 477 and be molded into a circular form or extruded to the proper section, then spliced into circular form, and shall be made of a properly cured high grade elastomeric compound.

7.6.2 The basic polymer shall be natural rubber, synthetic elastomer, or a blend of both.

7.6.3 The gasket shall be designed with an adequate compressive force, so as to effect a positive seal under all combinations of joint tolerances.

8. Test Methods

8.1 *Conditioning*:

8.1.1 *Referee Testing*— kWhen conditioning is required for referee tests, condition the specimens in accordance with Procedure A of Methods D 618 at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 40 h prior to test. Conduct tests under the same conditions of temperature and humidity, unless otherwise specified.

8.1.2 *Quality Control Testing*—Unless otherwise specified, condition specimens for a minimum of 4 h prior to test in air or 1 h in water at 73.4 ± 3.6°F (23 ± 2°C). Test the specimens at 73.4 ± 3.6°F without regard to relative humidity.

8.2 *Test Conditions*—Conduct tests other than those for routine quality control purposes in the Standard Laboratory Atmosphere of 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity, unless otherwise specified in the referenced test method or in this specification. In cases of disagreement, retesting shall be conducted with the temperature and relative humidity tolerances limited to ±1.8°F (1°C) and ±2 % respectively.

8.3 *Sampling*—The selection of samples of the pipe shall be as agreed upon between the purchaser and the seller. In case of no prior agreement, any sample selected by the testing laboratory shall be deemed adequate.

8.4 *Dimensions*:

8.4.1 *Average Inside Diameter*—Determine the average inside diameter using a circumferential wrap tape. Make sure to use only a wide-band steel tape. Place it inside and around the pipe making sure that it is at right angles to the pipe axis and is flat against the pipe surface. Observe the diameter, estimating to the nearest 0.005 in. (0.1 mm) or 0.001 in. (0.02 mm), as required. As an alternative method, use an internal micrometer or telescoping gage, accurate to ±0.01 in. (±0.2 mm). Take sufficient readings, a minimum of 4, at the same position with respect to the end of the pipe to ensure that the maximum and minimum values have been determined. Calculate the average diameter as the arithmetic mean of diameters measured.

8.4.2 *Wall Thickness*—Measure the wall thickness in accordance with the requirements of Test Method D 2122. Make sufficient readings, a minimum of 8, around the circumference to ensure that the minimum thickness has been determined. Use of a properly calibrated ultrasonic thickness tester is also permitted under this specification. For nondestructive testing, this is the preferred method. Make sufficient readings to ensure that the minimum thickness has been determined.

8.4.2.1 *Pipe Wall*—Measure the wall thickness, in the waterway, in the gaps between the profile or other bracing shapes.

8.4.2.2 *Spigot and Bell*—Measure the wall at any point along the bell and spigot, except at the bell entrance taper or contour.

8.5 *Ring Stiffness Constant (RSC)*:

8.5.1 *Qualification Testing*—Determine the RSC by dividing the parallel plate load, in pounds per foot of pipe, by the resulting deflection, in percent, at 3 % deflection. The test shall be conducted in accordance with Test Method D 2412, except that the rate of loading shall be 2 in./min and the length of the test pieces shall be as follows:

8.5.1.1 Test three specimens, each squarely cut from a pipe section. For pipe sizes up to 48-in. diameter, the test specimen shall have a length of two pipe diameters or 4 ft (1.22 m), whichever is less. For sizes larger than 48-in. diameter, the length of the test specimen shall be one pipe diameter or 6 ft (1.83 m), whichever is less. The RSC of each of the three specimens shall equal or exceed the minimum values in Table 3.

8.5.2 *Quality Control Testing*—For purposes of quality control, RSC testing of full lengths of pipe is permitted under this specification, provided a statistical correlation has been established between the full length testing and testing of short pieces as detailed in 8.5.1. The testing procedure shall be in accordance with Test Method D 2412, with the exceptions that the rate of loading shall be 2 in./min, the conditioning and test temperature shall be in accordance with 8.1.2, and the parallel plate load shall be applied at any location along the pipe's length but not closer than 1.5 diameters from either of its ends in sizes up to 48-in. diameter and 6 ft (2.13 m) from either of its ends in larger sizes. The RSC values thus obtained must always meet or exceed the values established for full length testing that correspond with the Table 3 values obtained on short-test specimens. In case of disagreement, referee tests shall be conducted in accordance with 8.1.1 and 8.5.1.

NOTE 8—The 3 % deflection criteria, which was selected for testing convenience, should not be interpreted as a product limitation with respect to in-use deflection. The engineer is responsible for establishing the acceptable deflection limit based on pipe material properties and job design considerations.

NOTE 9—The value of the parallel plate load/deflection ratio obtained by this test is significantly higher than the RSC value obtained in accordance with 8.5.1. The pipe adjacent to the parallel plates tends to "reinforce" the section under test. However, it is indicated that there is a correlation of values obtained under the two test variations and this permits the use of this nondestructive type test to more conveniently, frequently, and economically perform quality control tests for ring stiffness properties.

8.6 *Flattening*—Flatten three specimens of pipe, prepared in accordance with 8.5.1, in a suitable press until the internal diameter has been reduced to 40 % of the original inside diameter of the pipe. The rate of loading shall be uniform and at 2 in./min. The test specimens, when examined under normal light and the unaided eye, shall show no splitting, cracking, breaking, or separation of the pipe walls or bracing profiles.

8.7 *Joint Tightness*—Test for joint tightness in accordance with Specification D 3212, with the exception that the shear load transfer bars and supports shall be replaced with 6 in. wide support blocks that can be either flat or contoured to conform to the pipe's outer contour.

9. Sampling, Inspection, and Retest

9.1 *Sampling*—The selection of the sample, or samples, and the inspection of the product, shall be as agreed upon by the purchaser and the seller.

9.2 *Notification*—If inspection is specified by the purchaser, the manufacturer shall notify the purchaser in advance of the date, time, and place of testing of the pipe in order that the purchaser may be represented at the test by his inspector.

9.3 *Access*—The purchaser's inspector shall have free access to those parts of the manufacturer's plant that are involved in testing work performed under this specification. The manufacturer shall afford the inspector, without charge, all reasonable facilities for determining whether the pipe meets the requirements of this specification.

9.4 *Retest and Rejection*—If the results of any test(s) do not meet the requirements of this specification, the test(s) may be conducted again in accordance with an agreement between the purchaser and the seller. 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.

NOTE 10—Sampling, and any retesting, are normally done at the time of manufacture.

10. Certification

10.1 When specified in the purchase order or contract, a producer's or supplier's certification shall be furnished to the purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

11. Marking

11.1 *Quality of Marking*—The marking shall be applied to the pipe in such a manner that it remains legible (easily read) 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 10 ft (3.0 m).

11.2 *Markings*—Each standard and random length of pipe in compliance with this specification shall be clearly marked by the producer with the following information: this designation, ASTM F 894; the nominal pipe size, in inches; the legend PE sewer and drain pipe; the RSC classification; either the material grade designation or the cell classification number in accordance with Specification D 3350; the manufacturer's name, trade name, or trademark and the manufacturer's production code, identifying plant location, machine and date of manufacture.

12. Packaging

12.1 All pipe, unless otherwise specified, shall be packed or loaded onto a carrier, for standard commercial shipment.

13. Quality Assurance

13.1 When the product is marked with this designation, F 894, 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.

SUPPLEMENTARY REQUIREMENTS

GOVERNMENT/MILITARY PROCUREMENT

These requirements apply *only* to Federal/Military procurement, not domestic sales or transfers.

S1. *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless the purchaser disapproves. The purchaser 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.

NOTE S1.1—In U.S. Federal contracts, the contractor is responsible for inspection.

S2. *Packaging and Marking for U.S. Government Procurement:*

S2.1 *Packaging*—Unless otherwise specified in the contract, the materials shall be packaged in accordance with the supplier's standard practice in a manner ensuring arrival at destination in satisfactory condition and which will be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification rules or National Motor

Freight Classification rules.

S2.2 *Marking*—Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

NOTE S2.1—The inclusion of U.S. Government procurement requirements should not be construed as an indication that the U.S. Government uses or endorses the products described in this document.

APPENDIXES

(Nonmandatory Information)

X1. RELATION OF RSC TO PIPE PROPERTIES AND PIPE STIFFNESS

X1.1 The RSC, as determined by the method specified in this specification, is related to the pipe materials effective modulus of elasticity *(E)* and moment of inertia *(I)* of the pipe wall by the following equation:

$$RSC = 6.44\, EI/D^{2} \quad \text{(X1.1)}$$

where:

RSC = experimentally derived value (in units of pounds load per foot of pipe per percent reduction of pipe diameter normal to the applied load) of a parallel plate applied load divided by the resultant relative decrease in pipe diameter,
E = effective modulus of elasticity of pipe material under conditions of testing (psi),
I = pipe wall moment of inertia (in.^{4}/in.), and
D = mean pipe diameter (in.).

X1.1.1 The RSC, as measured by this test, is related to pipe stiffness (PS) as derived in accordance with the requirements of Test Method D 2412 by the following equation:

$$PS = C \times \frac{8.337\,(RSC)}{D} \quad \text{(X1.2)}$$

where:

PS = pipe stiffness (psi) at 5 % and at ½ in./min,
RSC = as defined in X1.2,
D = as defined in X1.2, and
C = factor to adjust the calculated pipe stiffness to values obtainable by testing in accordance with Test Method D 2412.

X1.2 The adjustment factor will vary in accordance with material, pipe size, and geometrical configuration of the pipe wall. An approximate value is 0.80. For specific products, consult the manufacturer for the most appropriate adjustment factor. Tabulated values for the minimum pipe stiffness for the specified RSC's are shown in Table X1.1. This table represents minimum values only, and for specific products, consult the manufacturer for the appropriate value.

X1.3 It has been demonstrated that pipe stiffness is not a controlling factor in design of buried polyethylene piping systems installed in accordance with Practice D 2321 or equivalent recommended practices **(1–15)**[6] Control of deflection is achieved primarily through control of the earthwork surrounding buried systems. Practice D 2321 should be followed to achieve this control.

TABLE X1.1 Minimum Pipe Stiffness for Specified RSC'S (psi)

Pipe Diameter	RSC 40	RSC 63	RSC 100	RSC 160
10	24.5	38.2	61.3	98.1
12	19.7	30.7	49.3	78.9
15	15.2	23.7	38.1	60.9
18	12.9	20.2	32.2	51.6
21	11.0	17.4	27.8	44.4
24	9.8	15.3	24.4	39.0
27	8.6	13.7	21.7	34.7
30	7.8	12.3	19.5	31.2
33	7.1	11.2	17.8	28.4
36	6.6	10.2	16.2	25.8
40	5.9	9.3	14.8	23.7
42	5.6	8.8	14.1	22.6
48	4.9	7.7	12.3	19.7
54	4.3	6.9	11.0	17.7
60	3.9	6.2	9.8	15.8
66	3.6	5.6	9.0	14.3
72	3.3	5.2	8.3	13.3
78	3.0	4.8	7.7	12.3
84	2.8	4.4	7.0	11.3
90	2.6	4.2	6.6	10.6
96	2.5	3.8	6.2	9.8
108	2.2	3.4	5.5	8.8
120	2.0	3.1	5.0	7.9

X1.4 When polyethylene pipe is to be installed by insertion into older existing pipes or is to be laid where no support from the surrounding environment is possible. Practice F 585 should be considered.

X1.5 The design factors that are important to the long-term performance of buried polyethylene pipe and that should be considered by the engineer include:

X1.5.1 Allowable wall compressive strength,
X1.5.2 Buckling resistance,
X1.5.3 Allowable strain, and
X1.5.4 Allowable long-term deflection.

[6] The boldface numbers in parentheses refer to the list of references at the end of this specification.

X2. BASE INSIDE DIAMETER FOR CALCULATION OF DEFLECTION LIMITS

X2.1 Table X2.1 is provided to establish a uniform number representing the inside diameter, to be used as a base for calculation of deflection limits. For the purpose of monitoring the quality of installation, a specifier may apply a deflection limit that he deems appropriate to the base inside diameter to arrive at a minimum acceptable diameter.

X2.2 The base inside diameter is not a product quality control requirement, nor should it be used for flow calculations.

X2.3 The base inside diameter is derived by subtracting a tolerance package from the pipe's average inside diameter, D_i(inches). The tolerance package is defined as follows:

$$\text{Tolerance Package} = \sqrt{A^2 + B^2}$$

where:
A = tolerance on average inside diameter from Table 1, and
B = out-of-roundness tolerance = 0.03 D_i, in. (mm).

X2.4 The minimum acceptable diameter for deflection is obtained by reducing the base inside diameter by the allowable deflection. This procedure is demonstrated here for the 7½ % recommended limit of Appendix X3 (*example*: ((100 % − 7.5 %)/100 %) × 17.42 = 16.11).

TABLE X2.1 Base Inside Diameters and Minimum Acceptable Diameter for 7.5 % Deflection

Nominal Pipe Size, in. (mm)	Average Inside Diameter, in. (mm)	Base Inside Diameter, in. (mm)	Minimum Acceptable Diameter for 7.5 % Deflection in. (mm)
10 (250)	10.00 (254.0)	9.52 (241.8)	8.81 (223.8)
12 (300)	12.00 (304.8)	11.48 (291.6)	10.62 (269.7)
15 (380)	15.00 (381.0)	14.41 (366.0)	13.33 (338.6)
18 (460)	18.00 (457.2)	17.34 (440.4)	16.04 (407.4)
21 (530)	21.00 (533.4)	20.26 (514.6)	18.74 (476.0)
24 (610)	24.00 (609.6)	23.19 (589.0)	21.45 (544.8)
27 (690)	27.00 (685.8)	26.11 (663.2)	24.15 (613.4)
30 (760)	30.00 (762.0)	29.02 (737.1)	26.84 (681.7)
33 (840)	33.00 (838.2)	31.94 (811.3)	29.54 (750.3)
36 (910)	36.00 (914.4)	34.86 (885.4)	32.25 (819.2)
40 (1020)	40.00 (1016.0)	38.74 (984.0)	35.83 (910.1)
42 (1070)	42.00 (1066.8)	40.67 (1033.0)	37.62 (955.5)
48 (1220)	48.00 (1219.2)	46.48 (1180.6)	42.99 (1091.9)
54 (1370)	54.00 (1371.6)	52.29 (1328.2)	48.37 (1228.6)
60 (1520)	60.00 (1524.0)	58.10 (1475.7)	53.74 (1365.0)
66 (1680)	66.00 (1676.4)	63.91 (1623.3)	59.12 (1501.6)
72 (1830)	72.00 (1828.8)	69.72 (1770.9)	64.49 (1638.0)
78 (1980)	78.00 (1981.2)	75.53 (1918.5)	69.87 (1774.7)
84 (2130)	84.00 (2133.6)	81.34 (2066.0)	75.24 (1911.1)
90 (2290)	90.00 (2286.0)	87.15 (2213.6)	80.61 (2047.5)
96 (2440)	96.00 (2438.4)	92.96 (2361.2)	85.99 (2184.1)
108 (2740)	108.00 (2743.2)	104.58 (2656.3)	96.74 (2457.2)
120 (3050)	120.00 (3048.0)	116.21 (2951.7)	107.49 (2730.2)

X3. RECOMMENDED LIMIT FOR INSTALLED DEFLECTION

X3.1 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.

X3.2 Polyethylene sewer piping made to this specification and designed for 7.5 % deflection in accordance with X1.5 can be expected to perform satisfactorily when installed in accordance with Practice D 2321 and deflection is measured in not less than 30 days following completion of installation.

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