Designation: F 2160 – 05

An American National Standard

Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)[1]

This standard is issued under the fixed designation F 2160; 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 material, dimensional, workmanship and performance requirements for polyethylene conduit, duct and innerduct manufactured for use in a non-pressure application with communication, CATV, or power wire and cables.

1.2 HDPE conduit meeting the requirements of this standard shall be made as OD controlled solid wall, with or without internal or external ribs. The sizing shall be Iron Pipe Size (IPS) with noted exceptions in tables. The internal or external surface may contain a coextruded layer provided the finished conduit meets the product requirements of this specification.

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

1.4 The following precautionary caveat pertains only to the test method portion, Section 6, 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 requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 618 Practice for Conditioning Plastics for Testing

D 638 Test Method for Tensile Properties of Plastics

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer

D 1505 Test Method for Density of Plastics by the Density-Gradient Technique

D 1600 Terminology for Abbreviated Terms Relating to Plastics

D 1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics

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

D 2444 Test Method for Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

D 4883 Test Method for Density of Polyethylene by the Ultrasound Technique

F 412 Terminology Relating to Plastic Piping Systems

3. Terminology

3.1 *Definitions*—General terms used in this Specification are as defined in Terminology F 412, and abbreviations are in accordance with Terminology D 1600, unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *CATV*, *n*—cable television.

3.2.2 *conduit (duct)*, *n*—a tubular raceway for carrying power, communications, or other wires and cables

3.2.3 *innerduct*, *n*—a conduit installed inside a conduit.

3.2.4 *kink*, *n*—a crease across the conduit where it has folded from excessive bending.

3.2.5 *ribs*, *n*—a series of ridges along the inside or outside surface of a conduit.

3.2.6 *true size*, *n*—denotes the use of a sizing system that requires a nominal inside diameter to be the equal or greater than the stated nominal size of the conduit (that is, a 1¼ in. conduit has a minimum ID of 1.25 in.).

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.26 on Olefin Based Pipe.

Current edition approved Mar. 1, 2005. Published March 2005. Originally approved in 2001. Last previous edition approved in 2001 as F2160–01.

[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.

4. Materials

4.1 *Polyethylene Plastics*—The PE materials used to make conduit under this Specification shall meet or exceed the following requirements:

4.1.1 *Compound*—PE resin compounds shall be classified in accordance with Specification D 3350 and Table 1.

4.1.2 *Rework Material*—Clean polyethylene compound from the manufacturers own production may be re-extruded into conduit, either alone or blended with virgin compound. Conduit containing the rework material shall meet all the material and product requirements of this specification.

4.1.3 *Material Physical Properties*:

4.1.3.1 *Density*—Density values shall be determined by Test Methods D 792, D 1505, or D 4883.

4.1.3.2 *Melt Index*—A melt index of up to 0.55 grams/10 minutes as per Test Method D 1238 Condition 190/2.16 is allowable provided that all other material requirements specified in Table 1 are met.

4.1.3.3 *Slow Crack Growth*—An ESCR as per Test Method D 1693, condition B, 10 % Igepal requirement of F10 > 96 h is allowable provided that all other material requirements in Table 1 are met.

4.2 *Coextruded Layer*—Any material used as a coextruded layer on the inside or outside surface of the PE conduit shall adhere to the surface of the PE and shall not delaminate in normal use. It shall not degrade or lower the performance of the PE conduit.

4.3 *Aerial Applications*—PE material for black conduit in long-term above ground applications, such as aerial suspension, shall be stabilized with a minimum of 2 % by weight carbon black having an average particle size less than or equal to 20 nanometers.

4.4 *Outdoor Storage Stability*:

4.4.1 *Black Conduit*—PE material for black conduit in non-UV exposed applications shall be stabilized with a minimum of 2 % by weight carbon black in accordance with Specification D 3350.

NOTE 1—Acceptable cell for Color and UV resistance properties in Table 1 may be achieved by utilizing a precompounded material or by blending a base natural material with a color concentrate.

4.4.2 *Colored Conduit*—PE material for colored conduit in non-UV exposed applications shall be suitably protected against UV degradation so that conduit may be stored outside and uncovered for a period of not less than one year.

5. Requirements

5.1 *Workmanship*—Each layer of the conduit shall be homogeneous throughout and essentially uniform in color, opacity, density and other properties. The inside and outside surfaces shall be free of visible cracks, holes, blisters, voids, foreign inclusions, or other deleterious defects.

5.2 *Dimensions and Tolerances*:

5.2.1 *Outside Diameters*—The outside diameters and tolerances shall be as shown in Table 2 for IPS sizes, Table 3 for Schedules 40 and 80 and Table 4 for "true" sizing, when measured in accordance with Test Method D 2122.

5.2.2 *Wall Thickness*—The wall thicknesses and tolerances shall be as shown in Tables 5-8 for IPS sizes, Table 9 for Schedule 40, Table 10 for Schedule 80, and Tables 11 and 12 for "True-sized" PE conduit when measured in accordance with Test Method D 2122.

5.2.3 *Special Sizes*—When mutually agreeable between the manufacturer and the purchaser, other sizes and wall thicknesses shall be acceptable. The tolerance on outside diameter shall be ± 0.5 percent of the nominal outside diameter. The lowest permissible wall thickness for any conduit outside diameter shall be 0.062 in. (1.57 mm). For wall thicknesses not listed, the tolerances shall be the same percentage of the calculated minimum wall thickness as the closest listed minimum wall thickness.

5.2.4 *Ribbed Conduit*—Conduit shall be permitted to contain either (*a*) spiral or oscillating spiral HDPE ribs inside of the conduit or (*b*) longitudinal ribs on the inside and/or outside of the conduit. The inside diameter of the conduit relative to this specification shall be measured between the ribs. For internally ribbed conduit, the manufacturer shall provide the maximum inside diameter and tolerance that can be circumscribed within the internal rib projections. For externally ribbed conduit, the manufacturer shall provide the minimum outside diameter and tolerance that circumscribes the external rib projections.

5.2.5 *Friction Reduction*—Internal lubrication or a coextruded layer on the inner wall of conduit for reducing frictional resistance shall be permitted. Lubrication materials shall be compatible with the conduit and any cable jacketing.

TABLE 1 D 3350 Cell Classification Material Requirement for PE Conduit

Properties	ASTM Test Method	Acceptable Cell
Density	D 1505, D 792, or D 4883	3
Melt index (190/2.16)	D 1238	3 or 4 or 2 in accordance with 4.1.3.2
Flexural modulus	D 790	4 or 5
Tensile strength	D 638	4 or 5
Slow crack growth resistance	D 1693	3 or 4 or 7 in accordance with 4.1.3.3
Hydrostatic design basis	D 2837	0, 1, 2, 3, or 4
Color and UV resistance	D 3350	C in accordance with 4.3 or 4.4.1, or E in accordance with 4.4.2

TABLE 2 Outside Diameter and Tolerance for PE Conduit, IPS

Nominal Size, in.	Outside Diameter		Tolerance	
	in.	(mm)	in.	(mm)
½	0.840	(21.34)	± 0.004	(± 0.11)
¾	1.050	(26.67)	± 0.005	(± 0.13)
1	1.315	(33.40)	± 0.007	(± 0.17)
1¼	1.660	(42.16)	± 0.008	(± 0.21)
1½	1.900	(48.26)	± 0.010	(± 0.24)
2	2.375	(60.33)	± 0.012	(± 0.30)
2½	2.875	(73.03)	± 0.014	(± 0.37)
3	3.500	(88.90)	± 0.018	(± 0.44)
4	4.500	(114.30)	± 0.023	(± 0.57)
5	5.563	(141.30)	± 0.028	(± 0.71)
6	6.625	(168.28)	± 0.033	(± 0.84)
8	8.625	(219.08)	± 0.043	(± 1.10)
10	10.750	(273.05)	± 0.054	(± 1.37)
12	12.750	(323.85)	± 0.064	(± 1.62)

TABLE 3 Outside Diameter and Tolerance for PE Conduit, Schedule 40 and 80

Nominal Size, in.	Outside Diameter		Tolerance	
	in.	(mm)	in.	(mm)
½	0.840	(21.34)	± 0.004	(± 0.11)
¾	1.050	(26.67)	± 0.005	(± 0.13)
1	1.315	(33.40)	± 0.007	(± 0.17)
1¼	1.660	(42.16)	± 0.008	(± 0.21)
1½	1.900	(48.26)	± 0.010	(± 0.24)
2	2.375	(60.33)	± 0.012	(± 0.30)
2½	2.875	(73.03)	± 0.014	(± 0.37)
3	3.500	(88.90)	± 0.018	(± 0.44)
4	4.500	(114.30)	± 0.023	(± 0.57)
5	5.563	(141.30)	± 0.028	(± 0.71)
6	6.625	(168.28)	± 0.033	(± 0.84)
8	8.625	(219.08)	± 0.043	(± 1.10)
10	10.750	(273.05)	± 0.054	(± 1.37)
12	12.750	(323.85)	± 0.064	(± 1.62)

TABLE 4 Outside Diameter and Tolerance for DR 9 and DR11 "True Sized" PE Conduit

Nominal Size, in.	Minimum ID		Outside Diameter		OD Tolerance	
	in.	(mm)	in.	(mm)	in.	(mm)
13 mm	0.512	13.00	0.659	16.74	± 0.003	± 0.08
¾	0.750	19.05	0.951	24.16	± 0.005	± 0.13
1	1.000	25.40	1.259	31.98	± 0.006	± 0.15
1⅛	1.125	28.58	1.412	35.86	± 0.007	± 0.18
1¼	1.250	31.75	1.569	39.85	± 0.008	± 0.20
1⅜	1.375	34.93	1.726	43.84	± 0.009	± 0.23
1½	1.500	38.10	1.883	47.83	± 0.009	± 0.23
2	2.000	50.80	2.510	63.75	± 0.013	± 0.33

TABLE 5 Minimum Wall Thickness and Tolerance for DR15.5 PE Conduit, IPS

Nominal Size,	Dimension Ratio	Minimum Wall Thickness		Tolerance	
in.	(DR)	in.	(mm)	in.	(mm)
½	15.5	0.062	(1.57)	0.020	(0.51)
¾	15.5	0.068	(1.73)	0.020	(0.51)
1	15.5	0.084	(2.13)	0.020	(0.51)
1¼	15.5	0.107	(2.72)	0.020	(0.51)
1½	15.5	0.123	(3.12)	0.020	(0.51)
2	15.5	0.153	(3.89)	0.020	(0.51)
3	15.5	0.226	(5.74)	0.027	(0.69)
4	15.5	0.290	(7.37)	0.035	(0.89)
5	15.5	0.359	(9.12)	0.043	(1.09)
6	15.5	0.427	(10.85)	0.051	(1.30)
8	15.5	0.556	(14.12)	0.067	(1.70)
10	15.5	0.694	(17.63)	0.083	(2.11)
12	15.5	0.823	(20.90)	0.099	(2.51)

5.2.6 *Toe-In*—When measured in accordance with 5.2.1, the outside diameter at the cut end of the conduit shall not be more than 1.5 % smaller than the outside diameter per 5.2.1. Outside diameter measurement shall be made no closer than 1.5 pipe diameters or 11.8 in. (300 mm), whichever distance is less, from the cut end of the conduit.

5.2.7 *Ovality*—The ovality (cross section) of 2 in. IPS and smaller conduit shall not exceed 7 % when measured in accordance with 6.4. Coiled conduit larger than 2 in. IPS through 3 in. IPS shall not exceed 10 % when measured in accordance with 6.4. Kinks in a coil shall not be acceptable.

NOTE 2— Deformations due to packaging requirements, when within five (5) ft. of the ends of coiled products, should not be considered. Conduit with deformation as noted above should not be utilized.

NOTE 3—Ovality is a packaging condition that occurs when roundable conduit is wound into a coil. Conduit flattens out as it is coiled. Larger diameter conduit may have significant ovality, for example, the inner coil layers of 6 in. IPS coiled conduit may have 20 % or more ovality. Ovality is corrected when joining equipment is applied to roundable conduit, or by

TABLE 6 Minimum Wall Thickness and Tolerance for DR 13.5 PE Conduit, IPS

Nominal Size, in.	Dimension Ratio (DR)	Minimum Wall Thickness		Tolerance	
		in.	(mm)	in.	(mm)
½	13.5	0.062	(1.57)	+0.020	(+0.51)
¾	13.5	0.078	(1.98)	+0.020	(+0.51)
1	13.5	0.097	(2.46)	+0.020	(+0.51)
1¼	13.5	0.123	(3.12)	+0.020	(+0.51)
1½	13.5	0.141	(3.58)	+0.020	(+0.51)
2	13.5	0.176	(4.47)	+0.021	(+0.53)
2½	13.5	0.213	(5.41)	+0.026	(+0.65)
3	13.5	0.259	(6.58)	+0.031	(+0.79)
4	13.5	0.333	(8.46)	+0.040	(+1.02)
5	13.5	0.412	(10.47)	+0.049	(+1.26)
6	13.5	0.491	(12.47)	+0.059	(+1.50)
8	13.5	0.639	(16.23)	+0.077	(+1.96)
10	13.5	0.796	(20.23)	+0.096	(+2.43)
12	13.5	0.944	(23.99)	+0.113	(+2.88)

TABLE 7 Minimum Wall Thickness and Tolerance for DR 11 PE Conduit, IPS

Nominal Size, in.	Dimension Ratio (DR)	Minimum Wall Thickness		Tolerance	
		in.	(mm)	in.	(mm)
½	11	0.076	(1.93)	+0.020	(+0.51)
¾	11	0.095	(2.41)	+0.020	(+0.51)
1	11	0.120	(3.05)	+0.020	(+0.51)
1¼	11	0.151	(3.84)	+0.020	(+0.51)
1½	11	0.173	(4.39)	+0.021	(+0.53)
2	11	0.216	(5.49)	+0.026	(+0.66)
2½	11	0.261	(6.64)	+0.031	(+0.80)
3	11	0.318	(8.08)	+0.038	(+0.97)
4	11	0.409	(10.39)	+0.049	(+1.24)
5	11	0.506	(12.85)	+0.061	(+1.54)
6	11	0.602	(15.29)	+0.072	(+1.83)
8	11	0.784	(19.91)	+0.094	(+2.39)
10	11	0.977	(24.82)	+0.117	(+2.98)
12	11	1.159	(29.44)	+0.139	(+3.53)

TABLE 8 Minimum Wall Thickness and Tolerance for DR 9 PE Conduit, IPS

Nominal Size, in.	Dimension Ratio (DR)	Minimum Wall Thickness		Tolerance	
		in.	(mm)	in.	(mm)
½	9	0.093	(2.36)	+0.020	(+0.51)
¾	9	0.117	(2.97)	+0.020	(+0.51)
1	9	0.146	(3.71)	+0.020	(+0.51)
1¼	9	0.184	(4.67)	+0.022	(+0.56)
1½	9	0.211	(5.36)	+0.025	(+0.64)
2	9	0.264	(6.71)	+0.032	(+0.81)
2½	9	0.319	(8.11)	+0.038	(+0.97)
3	9	0.389	(9.88)	+0.047	(+1.19)
4	9	0.500	(12.70)	+0.060	(+1.52)
5	9	0.618	(15.70)	+0.074	(+1.88)
6	9	0.736	(18.69)	+0.088	(+2.24)
8	9	0.958	(24.33)	+0.115	(+2.92)
10	9	1.194	(30.34)	+0.143	(+3.64)
12	9	1.417	(35.98)	+0.170	(+4.32)