INTERNATIONAL

Designation: D3485 – 22

An American National Standard

Standard Specification for Coilable High Density Polyethylene (HDPE) Cable in Conduit (CIC)[1]

This standard is issued under the fixed designation D3485; 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 cable in conduit (CIC), which is a smooth-walled, coilable, high-density polyethylene (HDPE) conduit (duct) that contains preassembled wires and cables. The outside diameter of the conduit is controlled and the wire or cable encased within may be comprised of single or multiple configurations consisting of electrical/power wires or cables, fiber optic, traditional copper communication, coaxial cable, or any combination thereof. CIC configurations are preassembled into the conduit during the extrusion process and in industry-specific designs for use in commercial, industrial, transportation, government, and utility applications

1.2 This specification does not attempt to identify every possible preassembled conduit/cable configuration but is intended to identify material and minimum assembled product properties for optimizing reliability and service life.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

NOTE 1—UL 1990 and CSA C22.2 No.327 have a similar scope to D3485; however, there are differences in scope and requirements.

NOTE 2—End users may elect to field install single or multiple wire or cable configurations into field-installed conduit. In the case where polyethylene conduit is to have the wire or cable configurations field installed, then the more appropriate specifications to select for establishing the conduit's material, dimensional, workmanship, and property tests would be Specification F2160, UL 651A, CSA C22.2 No.327 or NEMA TC-7.

NOTE 3—Whenever two sets of values are presented, in different units, the imperial units are the standard, while those in the parentheses (metric units) are provided for informational purposes.

1.4 *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.*

1.5 *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]

D618 Practice for Conditioning Plastics for Testing
D638 Test Method for Tensile Properties of Plastics
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
D1505 Test Method for Density of Plastics by the Density-Gradient Technique
D1600 Terminology for Abbreviated Terms Relating to Plastics
D1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics
D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
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)
D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials
D4883 Test Method for Density of Polyethylene by the Ultrasound Technique
F2160 Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)

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

Current edition approved July 1, 2022. Published July 2022. Originally approved in 1976. Last previous edition approved in 2015 as D3485– 15. DOI:10.1520/D3485-22.

[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**

F412 Terminology Relating to Plastic Piping Systems

2.2 *Other References:*

NFPA 70 National Electrical Code[3]

NEMA TC 7 Smooth-Wall Coilable Electrical Polyethylene Conduit[4]

Underwriter Laboratories, Inc – UL 1990 , Nonmetallic Underground Conduit with Conductors.[5]

Underwriter Laboratories, Inc – UL 651A Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit[5]

IEEE Standard 1210 Standard Tests for Determining Compatibility of Cable-Pulling Lubricants with Wire and Cable[6]

CSA C22.2 No. 327 HDPE conduit, conductors-in-conduit, and fittings[7]

2.3 *Plastic Pipe Institute Standards:*[8]

Handbook of Polyethylene Pipe

TN-48 Guidelines for Choosing Wall Thickness for HDPE Conduit Based on "mini-HDD"

TR-47 Pipe Stiffness and Flattening Tests in Coilable HDPE conduit; and Its Relationship to burial Depth in Conduit Applications

3.1 *Definitions*—General terms used in this specification are as defined in Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *continuous runs*—buried sections of coilable CIC comprised of long lengths having no joints between access structures as opposed to the assembling short sections such as 20 foot lengths of conduit and field installation of the cable or cables.

3.2.2 *delaminate, v*—coextruded layers such as, a color layer on the outside of the conduit, shall be permanently bonded and homogeneous to the conduit wall.

3.2.3 *obstructions, n*—Anything that crosses the path or interrupts a continuous run of conduit or power cable such as, other utilities and road crossings.

3.2.4 *termination points*—end points of continuous runs of CIC that provide access to the conduit and cable within structures such as vaults, hand holes and manholes for connecting cable to a device or splicing of the cable ends.

3.3 *Acronyms:*

CIC = Cable in Conduit
HDPE = High Density Polyethylene

4. Application and Installation

4.1 *General*—This specification covers conduit made from non-pressure rated HDPE resins available in five wall types that are outside diameter controlled with installed cables.

4.2 HDPE conduit for underground electrical distribution systems utilizing insulations suitable for use with power and electrical conductors not exceeding 194 °F (90 °C) for normal allowable cable operating temperature. The minimum recommended installation temperature for the HDPE conduit is -13 °F (-25 °C), but in no case should be lower than the minimum installation temperature of the cable.

4.3 CIC is ideally suited for underground or buried installations that allow it to be placed in continuous runs between termination points with a limited number of obstructions in the route. CIC can be installed using any of the following installation methods; in a trench, plowed or horizontal directionally drilled.

4.4 Concrete encasement of CIC made from HDPE for providing added mechanical protection is an acceptable option.

4.5 CIC may be required by local, state or federal agencies or other governing bodies or codes to be approved for use. For example, CIC with electrical cables may need to be installed in accordance with the NFPA 70 National Electric Code (NEC) and have third party testing, be properly labeled and listed by a certified testing laboratory.

5. Materials and Manufacture

5.1 *Polyethylene Plastics*—the high-density polyethylene (HDPE) materials used to make the conduit under this specification shall meet or exceed the following requirements:

5.1.1 *Compound*—PE resin compounds shall be classified in accordance with Specification D3350 and Table 1.

5.1.2 *Rework Material*—Clean polyethylene compound from the manufacturer's internal production may be compounded into the conduit, either alone or blended with virgin compound. Conduit containing the rework material must meet all the material and property requirements of this specification. Where rework material is known to contain cadmium, lead, mercury and/or hexavalent chromium, the loading of rework shall be limited such that the final conduit product shall not

TABLE 1 Minimum Compound Requirements Based on Cell Classification per Specification D3350

Properties	ASTM Test Method	Minimum Acceptable Cell / Value
Density	D1505, D792, or D4883	≥3 / > 0.940 grams/cm^3
Melt Index, (190/2.16)	D1238	≥3 / <0.40 or 2^A
Flexural Modulus	D790	≥4 / ≥ 80 000 psi
Tensile Strength	D638	≥4 / ≥ 3 000 psi
Slow Crack Growth Resistance	D1693	≥4, or 8 as defined in 5.1.4.3
Hydrostatic Design Basis	No test required	≥0 Pressure rated compounds are not required
Color and UV resistance	D3350	C or E as defined in 5.4.1

^{A} Cell class 2 allows for a higher melt index up to 1.00 but for this standard the maximum allowed is 0.55 provided all of the conditions of 5.1.4.2 are met.

[3] Available from the National Fire Protection Assn., 470 Atlantic Ave., Boston, MA 02210.

[4] Available from National Electrical Manufacturers Association (NEMA), 1300 N. 17th St., Suite 1752, Rosslyn, VA 22209, http://www.nema.org.

[5] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

[6] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., Piscataway, NJ 08854, http://www.ieee.org.

[7] Available from Canadian Standards Association (CSA), 178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3, https://www.csagroup.org/store/

[8] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

contain more than 0.01 % by weight cadmium and no more than 0.1 % by weight each of lead, mercury, and hexavalent chromium.

NOTE 4—Conformance with the metal requirements of 5.1.2 can be demonstrated by either a determination of heavy metals in the final product or a calculation of the maximum heavy metals expected to be present based on their presence in the rework material.

5.1.3 *Color Compounds*—Color concentrate compounds used to color the conduit shall have no cadmium, lead, mercury, and hexavalent chromium added as an intentional ingredient and shall contain no more than 0.01 % by weight cadmium and no more than 0.1 % by weight each of lead, mercury, and hexavalent chromium.

NOTE 5—Conformance with the requirements of 5.1.3 can be demonstrated based on letters of compliance from color compound manufacturers, for example, RoHS9[9] compliance letter.

5.1.4 *Material Physical Properties:*

5.1.4.1 *Density*—Density values shall be determined by Test Methods D792, D1505 or D4883.

5.1.4.2 *Melt Index*—Melt index of up to 0.55 grams/10 minutes as per Test Method D1238 condition 190/2.16 is allowable provided that all other material requirements specified in Table 1 are met.

5.1.4.3 *Slow Crack Growth*—The minimum requirement as per Test method D1693, Condition B, 10% Igepal solution, with a requirement of F10 > 96 hours as defined per cell classification 8 in D3350. Cell class 4 or higher are also acceptable.

5.1.4.4 The requirements listed in this section, shall be confirmed for the PE compound by the resin or conduit manufacturer. In addition, the CIC manufacturer shall conduct the quality control tests listed in Section 7.

NOTE 6—Standard industry conduit has cell classification of PE334480C/E (select C for black or E for color). Not all permutations of cell classes are commercially available.

5.2 *Coextruded Layer*—Any material used as a coextruded layer on the inside or outside surfaces for lubrication or color-coding of the conduit shall adhere to the surface of the PE and shall not delaminate during normal use. Further, coextruded materials shall not degrade or lower the performance of the PE conduit.

5.3 *Above Grade Applications*—PE material installed in above ground application that will be subjected to long term UV exposure, such as aerial suspension, shall have UV stabilization additives compounded into the HDPE. The UV stabilization additives shall be compounded to create homogenous dispersion for assuring long-term product protection. For example, UV stabilization of black conduit shall have a minimum of 2 % by weight of carbon black having an average particle size less than or equal to 45 nanometers and be thoroughly dispersed throughout the conduit wall.

5.3.1 Using smaller particle sizing than 45 nanometers is not recommended due to processing complexities in dispersion and mixing that may adversely impact the conduit's final homogeneity resulting in reduced performance properties. When using the smaller particle size as specified for above ground applications, the end-user should receive assurance of processing capability from the manufacturer.

5.3.2 Where conduit that is to be extruded with colors other than black and is intended for above grade installation with UV exposure during its service life, the end user should consult with the manufacturer for assurance that the colorant used in extruding the conduit has sufficient UV stabilizer additives that will achieve the service life requirements for the application.

5.4 *Outdoor Storage Stability:*

5.4.1 Both black and color conduits, shall have sufficient formulations of carbon black (2% minimum as defined in Specification D3350) or UV color additives that are properly dispersed either by pre-compounding or compounding during extrusion of the conduit. The additive levels shall be sufficient to protect the conduit from UV degradation during shipping and storage outdoors uncovered for a minimum of 1 year.

6. Requirements

6.1 *Workmanship*—Each conduit layer 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 materials or other surface defects.

6.2 *Dimensions and Tolerances:*

6.2.1 *Outside Diameters*—The outside diameters and tolerances shall be as shown in Table 2 for SDR and Schedule sizes covered by this specification, when measured in accordance with Test Method D2122.

6.2.2 *Wall Thickness*—The wall thicknesses and tolerances shall be as shown in Fig. 3 and Table 4 for the SDR and Schedule sizes respectively, and shall be measured in accordance with Test Method D2122.

6.2.3 *Special Sizes*—When mutually agreed to between the manufacturer and the purchaser, other trade sizes and wall types shall be acceptable provided they adhere to the dimensional tolerances. The tolerance for outside diameter shall be ± 5% of the nominal outside diameter. The lowest minimum wall thickness for any conduit diameter shall be 0.062 in. (1.57 mm). Tolerances for wall thicknesses shall be a set minimum of +12% or less but not less than 0.020 in.

6.3 *Ovality:*

TABLE 2 Outside Diameter and Tolerance for PE Conduit, SDR and Schedule Diameters

Nominal Size in.	Outside Diameter		Tolerance	
	in.	mm	in.	mm
½ (12.7)	0.840	(21.3)	±0.004	(± 0.1)
¾ (19.1)	1.050	(26.7)	±0.005	(± 0.1)
1 (25.4)	1.315	(33.4)	±0.007	(±0.2)
1¼ (31.8)	1.660	(42.2)	±0.008	(±0.2)
1½ (38.1)	1.900	(48.3)	±0.010	(±0.2)
2 (50.8)	2.375	(60.3)	±0.012	(±0.3)
2½ (63.5)	2.875	(73.0)	±0.014	(±0.4)
3 (76.2)	3.500	(88.9)	±0.018	(±0.4)

[9] DIRECTIVE 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

TABLE 3 SDR's 15.5, 13.5 and 11 Minimum Walls and Nominal ID's

Nominal Size	SDR 15.5		SDR 13.5		SDR 11	
in. (mm)	Minimum Wall[A]	Nominal ID[B]	Minimum Wall[A]	Nominal ID[B]	Minimum Wall[A]	Nominal ID[B]
½ (12.7)	0.062 (1.6)	0.696 (17.7)	0.062 (1.6)	0.696 (18.0)	0.076 (1.9)	0.679 (17.3)
¾ (19.1)	0.068 (1.7)	0.894 (22.7)	0.078 (1.9)	0.885 (22.5)	0.095 (2.4)	0.849 (21.6)
1 (25.4)	0.085 (2.2)	1.125 (28.6)	0.097 (2.5)	1.109 (28.2)	0.120 (3.1)	1.061 (27.0)
1¼ (31.8)	0.107 (2.7)	1.426 (36.2)	0.123 (3.1)	1.399 (35.5)	0.151 (3.8)	1.340 (34.0)
1½ (38.1)	0.123 (3.1)	1.634 (41.5)	0.141 (3.6)	1.601 (40.7)	0.173 (4.4)	1.533 (38.9)
2 (50.8)	0.153 (3.9)	2.051 (52.1)	0.176 (4.5)	2.002 (50.9)	0.216 (5.5)	1.917 (48.7)
2½ (63.5)	0.185 (4.7)	2.483 (63.1)	0.213 (5.4)	2.423 (61.5)	0.261 (6.6)	2.322 (59.0)
3 (76.2)	0.226 (5.7)	3.021 (76.7)	0.259 (6.6)	2.951 (75.0)	0.318 (8.1)	2.826 (71.8)

[A] Minimum wall is calculated by dividing the average OD by the standard dimension ration (SDR) but shall not be less than 0.062 in. and the maximum wall is determined by adding the allowable wall tolerance of +0.020 in. or +12% of the wall thickness, whichever is greater.
[B] The nominal inside diameter is calculated by the following method, (average OD) – ((min wall + ½ Tolerance)*2).

TABLE 4 Schedules 40 and 80 Minimum Walls and Nominal ID's

Nominal Size in.	Schedule 40		Schedule 80	
in. (mm)	Minimum Wall[A]	Nominal ID[B]	Minimum Wall[A]	Nominal ID[B]
½ (12.7)	0.109 (2.8)	0.602 (15.3)	0.147 (3.7)	0.526 (13.4)
¾ (19.1)	0.113 (2.9)	0.804 (20.4)	0.154 (3.9)	0.722 (18.3)
1 (25.4)	0.133 (3.4)	1.029 (26.1)	0.179 (4.6)	0.936 (23.8)
1¼ (31.8)	0.140 (3.6)	1.360 (34.5)	0.191 (4.9)	1.255 (31.9)
1½ (38.1)	0.145 (3.7)	1.590 (40.4)	0.200 (5.1)	1.476 (37.5)
2 (50.8)	0.154 (3.9)	2.047 (52.0)	0.218 (5.5)	1.913 (48.6)
2½ (63.5)	0.203 (5.2)	2.445 (62.1)	0.276 (7.0)	2.290 (58.2)
3 (76.2)	0.216 (5.5)	3.042 (77.3)	0.300 (7.6)	2.864 (72.8)

[A] Minimum wall is replicated from F2160, Table 9.
[B] Nominal inside diameter is calculated by the following method, (average OD) – ((min wall + ½ Tolerance)*2)

TABLE 5 Suggested Reel Drum, Coil ID Sizes

Nominal Size	Outside Diameter in.	Outside Diameter (mm)	Minimum Reel Drum/Coil ID in.	Minimum Reel Drum/Coil ID (mm)
½ (12.7)	0.840	(21.3)	15	(384.0)
¾ (19.1)	1.050	(26.7)	19	(480.6)
1 (25.4)	1.315	(33.4)	24	(601.6)
1¼ (31.8)	1.660	(42.2)	30	(759.0)
1½ (38.1)	1.900	(48.3)	35	(869.0)
2 (50.8)	2.375	(60.3)	43	(1086.2)
2½ (63.5)	2.875	(73.0)	52	(1315.8)
3 (76.2)	3.500	(88.9)	64	(1600.6)

6.3.1 There are different causes of ovality for HDPE conduit, the first is processing which can be controlled and shall be less than 5% and measured as follows:

6.3.1.1 *Apparatus*—A micrometer or vernier caliper accurate to within ±0.001 in (± 0.02 mm).

6.3.1.2 *Procedure*—take a series of outside diameter (OD) measurements at closely spaced intervals around the circumference, prior to coiling, to ensure that the minimum and maximum diameters have been determined for the following calculation.

6.3.1.3 *Calculation*—Calculate the percent Ovality as follows:

$$\%\text{ovality} = \frac{(\text{maximum OD} - \text{minimum OD})}{(\text{maximum OD} + \text{minimum OD})} \times 200 \quad (1)$$

6.3.2 The second factor influencing ovality is the result of bending the conduit as it is coiled onto reels or as coils. This condition can be minimized by properly cooling the conduit to ambient temperature prior to coiling and by selecting the proper reel drum size. The suggested minimum drum size shall be 18 times the OD of the conduit, rounded to the nearest in. (mm) as shown in Table 5.

6.3.2.1 A third cause of ovality is deformations due to packaging requirements, as such the end sections, when within five (5) ft. of either end of coiled conduit should not be used.

6.3.2.2 Ovality is a packaging condition that occurs when a HDPE conduit is wound into a coil configuration causing the conduit to flatten as it is coiled. The amount of ovality is largely influenced by diameter and bending radius, becoming more oval as the diameter increases or radius decreases. Ovality can be corrected either when clamps designed for rounding are applied, like those used in butt fusion equipment, or by pulling the conduit through re-rounding equipment during installation.

6.4 *Friction Reduction and Prevention of Cable Adhesion:*

6.4.1 The manufacturer shall implement process controls to assure the cable(s) being installed shall not adhere to the conduit during extrusion and shall move freely within the conduit.

6.4.2 Internal lubrication or a coextruded lubrication layer on the inner wall of the conduit for reducing friction and preventing cable bonding during extrusion shall be permitted.

6.4.3 Liquid type lubricants, that are to be applied during extrusion, shall be tested as specified in 9.4.

6.4.4 Lubrication applied during manufacture of the CIC shall not adversely affect the removal or replacement of cables in the future.

7. Physical Properties

7.1 *Pipe Stiffness*—is the force per unit length of the test specimen, extruded from resin having a minimum flexural modulus of 80,000 psi, loaded at a prescribed rate of 0.5 in./min, at a prescribed percentage deflection of 5%. The test measures the conduit's resistance to ring deflection as it is being compressed between two steel plates. More details describing pipe stiffness as a quality test can be found in Test Method D2412.

7.2 The parallel plate method described above, empirically determines pipe stiffness where as an alternative "calculated" method uses the materials modulus and SDR (Standard Dimension Ratio).

7.2.1 Table 6 below, provides the minimum calculated loads based on the flexural modulus and relative dimension ratios for each wall type listed in this specification.