ASTM D 1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable – Testing Equipment

Description

4 Classification
4.1 This specification recognizes that polyethylene plastics are identified primarily on the basis of two characteristics, namely, density and flow rate (previously identified as melt index). The former is the criterion for assignment as to type, the latter for designation as to category. Other attributes important to the user for certain applications are covered by three general classes and by specifying in greater detail, by grades, a minimum number of key characteristics covered too broadly or not at all by the type, class, and category designations.
4.1.1 Types:
4.1.1.1 This specification provides for the identification of five types of polyethylene plastics extrusion materials for wire and cable by density in accordance with 10.1 and 12.1.1, and the requirements prescribed in Table 1 and Note 5, Note 6, and

TABLE 1 Classification of Polyethylene Plastics Extrusion Materials for Wire and Cable According to Type

Type	Nominal Density,[A] g/cm^3
0	<0.910
I	0.910 to 0.925
II	>0.925 to 0.940
III	>0.940 to 0.960
IV	>0.960

[A]Uncolored, unfilled material (see Note 12).

NOTE 5—It is recognized that some high-density polyethylene plastics of very high molecular weight may have densities slightly less than 0.960 yet in all other respects they are characteristic of Type IV materials. Similarly, there are other polyethylene plastics of very high molecular weight having densities slightly less than 0.941 which in all other respects are more characteristic of Type III than of Type II materials.

NOTE 6—While the original Type III now has been divided into two ranges of density (Types III and IV), both are still described by the term high density.
4.1.1.2 Material supplied under these types shall be of such nominal density, within the ranges given, as agreed upon between the manufacturer and the purchaser subject to the tolerances specified in 4.1.1.3 (Note 12).
4.1.1.3 In view of production, sampling, and testing variables, a commercial lot or shipment for which a nominal density has been agreed upon between the seller and the purchaser shall be considered as conforming and commercially acceptable when the density value found on a sample from the lot or shipment falls within the tolerance range of ±0.004 of the nominal value.

4.1.1.4 If the nominal value is unknown or unspecified, classification shall be based on the tested value without tolerance consideration.
4.1.2 Classes—Each of the five types is subdivided into four classes according to composition and use as follows:
4.1.2.1 Class A—Natural color only, with or without any antioxidants or other additives in such proportions as agreed upon between the seller and the purchaser.
4.1.2.2 Class B—Colors including white and black, with or without any antioxidants or other additives in such proportions as agreed upon between the manufacturer and the purchaser.
4.1.2.3 Class C—Black (weather-resistant), containing not less than 2 % carbon black of a kind and particle size (Note 7), dispersed by such means and to such degree as necessary to impart weather resistance with or without any antioxidants or other additives in such proportions as agreed upon between the seller and the purchaser.

NOTE 7—Carbon black 35 nm or less in average particle diameter is used as required in black electrical and jacketing materials (Grades E and J) to impart maximum weather resistance.
4.1.2.4 Class D—Colored (UV resistant), including black and white, with antioxidants and UV stabilizers to allow electrical insulation and jackets to meet the requirements outlined in 12.1.12.
NOTE 8—The expected service lifetime of Class D materials is very dependent upon the specific material formulation, including selected colorants. Contact your supplier for additional information regarding this issue.

4.1.3 Categories:
4.1.3.1 The four classes of each type are divided into five categories on the basis of broad ranges of flow rate in accordance with the requirements prescribed in Table 2.
NOTE 9—Some Type II and Type III polyethylene plastics of very high molecular weight cannot be categorized by flow rate. Solution viscosity is recommended as a means of distinguishing such materials.

TABLE 2 Classification of Polyethylene Plastics Extrusion Materials for Wire and Cable According to Category

Category	Nominal Flow Rate, g/10 min (190°C, 2.16 kg load)
1	>25
2	>10 to 25
3	>1.0 to 10
4	>0.4 to 1.0
5	0.4 max

4.1.3.2 Material supplied under these categories shall be of such nominal flow rate, within the ranges given, as agreed upon between the seller and the purchaser subject to the tolerances specified in 4.1.3.3.
4.1.3.3 In view of production, sampling, and testing variables, a commercial lot or shipment for which a nominal flow rate has been agreed upon between the seller and the purchaser shall be considered as conforming and commercially acceptable when the flow rate value found on a sample from the lot or shipment falls within the tolerance range of ±20 % of the nominal flow rate.
4.1.3.4 If the nominal value is unknown or unspecified, classification shall be based on the tested value

without tolerance consideration.
4.1.4 Grades:
4.1.4.1 If further definition is necessary, one of the grades given in Tables 3-5 shall be selected.
NOTE 10—Tables 4 and 5, are included to correspond with the grades specified in Federal Specification L-P-390C.
NOTE 11—The grade shall be associated with the appropriate type, class, and category designations; for example, IA5-E4 or IC5-J3 as required. Other grades may be added as necessary by revision of this specification in established manner. Also, it is anticipated that additional requirements may be added under a given grade designation by future revision to provide more meaningful characterization of the material covered by such designation.
4.1.4.2 If additional requirements specific to the application are necessary, these shall be specified by the purchaser with the agreement of the seller.

5 Basis of Purchase
5.1 The purchase order or inquiry for these materials shall state the specification number, type, class, category, and, if needed, the appropriate grade, for example, D1248–IA5-E4.
5.2 It is acceptable for further definition to be agreed upon between the seller and the purchaser as follows:
5.2.1 Nominal density.
NOTE 12—For Class B, Class C, and Class D material, the nominal density of the base resin will be identified by the manufacturer upon request.
5.2.2 Nominal flow rate.
5.2.3 Antioxidant(s) or Other Additive(s) and Proportions:
5.2.3.1 Class A—As stated in 4.1.2.1,
5.2.3.2 Class B—As stated in 4.1.2.2,
5.2.3.3 Class C—As stated in 4.1.2.3, and
5.2.3.4 Class D—As stated in 4.1.2.4.
5.2.4 Contamination level (see 6.2).
5.2.5 Other supplementary definition, unless grade is sufficient and is identified (see 4.1.4.1 and 4.1.4.2).

TABLE 3 Detail Requirements for Molded Test Specimens

Property and Unit	Grade[A]									
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Tensile stress, min:[B]										
MPa	8	10	10	12	12	17	17	19	19	22
(psi)	(1200)	(1500)	(1500)	(1800)	(1800)	(2400)	(2400)	(2800)	(2800)	(3200)
Elongation, min, %[B]	300	400	400	500	500	400	400	400	400	400
Brittleness temperature, max, °C	–50	–60	–60	–75	–75	–45	–75	–75	–75	–75
Environmental stress-crack resistance,[C,D] min, f_{20} h	. . .	. . .	. . .	48	48	. . .	. . .	48	48	48
Thermal stress-crack resistance, h without cracking, min	. . .	. . .	. . .	. . .	. . .	. . .	. . .	96	96	168
Dissipation factor,[E] max:										
Class A										
Before milling	0.0005	0.0002	0.0005	0.0002	0.0005	0.0002	0.0005	0.0002	0.0005	0.0002
After milling	0.0005	0.0003	0.0005	0.0003	0.0005	0.0003	0.0005	0.0003	0.0005	0.0003
Class B	0.001	0.0005	0.001	0.0005	0.001	0.0005	0.001	0.0005	0.001	0.0005
Class C	0.01	0.005	0.01	0.005	0.01	0.005	0.01	0.005	0.01	0.005
Dielectric constant[E] max increase over nominal[F]:										
Class A	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01
Class B	0.12	0.04	0.12	0.04	0.12	0.04	0.12	0.04	0.12	0.04
Class C	0.52	0.30	0.52	0.30	0.52	0.30	0.50	0.30	0.50	0.30
Volume resistivity, min, Ω-cm:										
Classes A, B	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}
Water immersion stability	[G]	[G]	[G]	[G]	[G]	[G]	[G]	[G]	[G]	[G]

Property and Unit	E11	J1	J3	J4	J5
Tensile stress, min:[B]					
MPa	22	10	12	19	22
(psi)	(3200)	(1500)	(1800)	(2800)	(3200)
Elongation, min, %	400	400	500	400	400
Brittleness temperature, max, °C	–75	–60	–75	–75	–75
Environmental stress-crack resistance,[C,D] min, f_{20} h	48	. . .	24	24	24
Thermal stress-crack resistance, h without cracking, min	168	. . .	. . .	. . .	. . .
Dissipation factor,[E] max:					
Class A					
Before milling	0.0005	. . .	. . .	. . .	. . .
After milling	0.0005	. . .	. . .	. . .	. . .
Class B	0.001	. . .	. . .	. . .	. . .
Class C	0.01	. . .	0.01	0.01	. . .
					. . .
Dielectric constant[E] max increase over nominal[F]:					
Class A	0.05	. . .	. . .	. . .	. . .
Class B	0.12	. . .	. . .	. . .	. . .
Class C	0.50	. . .	0.52	0.52	. . .
Volume resistivity, min, Ω-cm:					
Classes A, B	10^{15}	. . .	. . .	. . .	. . .
Water immersion stability	[G]	. . .	. . .	. . .	. . .

[A] The letters associated with these grades identify areas of potential applicability as indicated below:
E = Electrical Insulation (in some instances these materials also have the potential to serve as jacketing).
J = Jacketing (in some instances these materials also have the potential to serve as primary insulation).
[B] At break.
[C] f_{20} is the time required for failure of 20 % of the samples tested in accordance with Test Method D1693 as further directed by 12.1.6.1-12.1.6.4 of this specification.
[D] Requirements for environmental stress-crack resistance apply only to Class B, Class C, and Class D compounds unless otherwise specified (see 5.2.5).
[E] At any frequency from 1 kHz through 1 MHz (see also 12.1.8.1-12.1.8.3).
[F] Dielectric constant is a function of density; hence, the nominal value will be different for each type. Based on published information, the nominal values for the five types covered by this specification are as follows: Type 0-2.28, Type I-2.28, Type II-2.31, Types III and IV-2.35 (Lanza, V. L., and Herrmann, D. B., *Journal of Polymer Science*, JPSCA, Vol 28, 1958, p. 622). To illustrate the manner in which the maximum limit for the dielectric constant of a particular, grade is determined, assume that a Type I, Class A material is to be supplied under Grade E2, then its maximum limit for dielectric constant will be 2.28 + 0.01 = 2.29.
[G] Dissipation factor and dielectric constant must not exceed the limits specified above after immersion of the test specimens in water as described in 12.1.9. However, because this test is lengthy, it need not be performed on every lot of material. Rather, the material is to be checked initially for compliance with this requirement and, after that, as often as necessary to assure continued compliance. This requirement is not applicable to weather resistant (Class C and Class D) compounds (see Note 12).

5.3 Inspection (see 13.1).

6 Materials and Manufacture

6.1 The extrusion material for wire and cable shall be polyethylene plastic in the form of powder, granules, or pellets.

6.2 The extrusion materials for wire and cable shall be as uniform in composition and size and as free of contamination as can be achieved by good manufacturing practice. If necessary, the acceptable level of contamination shall be agreed upon between the seller and the purchaser.

TABLE 4 Special Grades—Dielectric—Natural and Colors

	Very Low Density, Specification D1248, Type 0	Low Density, Specification D1248, Type I				Medium Density, Specification D1248, Type II		High Density,[A] Specification D1248, Types III & IV				
		Natural	Colors	Natural	Colors	Natural	Colors					
Grade	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11
Tensile Stress, min:[B]												
MPa	6.9	9.7	9.7	9.7	9.7	12.4	12.4	19.3	19.3	24.1	24.1	27.6
(psi)	1000	(1400)	(1400)	(1400)	(1400)	(1800)	(1800)	(2800)	(2800)	(3500)	(3500)	(4000)
Elongation, min, %[B]	500	400	400	400	400	400	400	400	400	400	400	400
Brittleness temperature, max, °C	−60	−60	−55	−60	−55	−60	−55	−55	...	−55	...	...
Dielectric constant, max, 1 MHz	2.28	2.35	2.35	2.35	2.35	2.35	2.35	2.38	2.38	2.38	2.38	2.38
Dissipation factor, max, 1 MHz	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Environmental stress crack resistance, min:												
f_{20}h (100 % Igepal)	...	...	...	24	24	...	...	...	...	...	...	...
f_{20}h (10 % Igepal)	>24	...	...	...	...	...	...	...	...	...	...	...
Thermal stress crack resistance, min, f_{45}h	...	...	...	...	...	...	...	96	...	96	...	...
Milling stability After milling, dissipation factor, max	...	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

[A]Grades D7 through D11 apply to both natural and colors, including black.
[B]At break.

TABLE 5 Special Grades—Weather Resistant—Black

	Very Low Density, Specification D 1248, Type 0	Low Density, Specification D1248, Type 1				Medium Density, Specification D1248, Type II			High Density, Specification D1248, Types III & IV	
Grade	W0	W1	W2	W3	W4	W5	W6	W7	W8	W9
Tensile Stress, min:[A]										
MPa	6.9	9.7	9.7	9.7	9.7	12.4	12.4	12.4	19.3	24.1
(psi)	(1000)	(1400)	(1400)	(1400)	(1400)	(1800)	(1800)	(1800)	(2800)	(3500)
Elongation, min, %[A]	500	400	400	400	400	400	400	400	400	400
Brittleness temperature, max, °C	−60	−50	−50	−50	−50	−50	−50	−50	−55	−55
Dielectric constant, max, 1 MHz	2.28	2.50	2.75	2.75	2.80	2.50	2.75	2.80	2.75	2.75
Dissipation factor, max, 1 MHz	0.0005	0.003	0.007	0.007	0.01	0.003	0.007	0.01	0.005	0.007
Environmental stress crack resistance, min:										
f_{20}h (100 % Igepal)		...	...	24	...	...	...	...	...	...
f_{20}h (10 % Igepal)	>24	...	...	...	24	...	...	...	...	...
Thermal stress crack resistance, min, f_{45}h		...	...	...	...	...	...	...	96	96
Milling stability After milling, dissipation factor, max		0.003	0.007	0.007	0.01	0.003	0.007	0.01	0.005	0.007
Carbon content, range, %	2.0-3.0	0.4-0.6	2.0-3.0	2.0-3.0	2.0-3.0	0.4-0.6	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0
Absorption coefficient, min	320	...	320	320	320	...	320	320	320	320

[A]At break.

6.3 Unless controlled by requirements specified elsewhere (see 4.1.4.1 and 4.1.4.2), the color and translucence of extruded pieces formed under conditions recommended by the manufacturer of the material, shall be comparable within commercial match tolerances to the color and translucence of standard molded or extruded samples of the same thickness supplied in advance by the manufacturer of the material.

7 Physical Requirements

7.1 Test specimens of the material prepared as specified in 10.1, and tested in accordance with 12.1, shall conform to the requirements prescribed by the material designation for type in Table 1, for class in 4.1.2, for category in Table 2, and for grade in Tables 3-5.

8 Sampling

8.1 Sampling shall be statistically adequate to satisfy the requirements of 13.4.

8.2 A batch or lot shall be constituted as a unit of manufacture as prepared for shipment and can consist of a blend of two or more production runs.

9 Testing

9.1 The requirements identified by the material designation and otherwise specified in the purchase order (see 5.1 and 5.2) shall be verified by tests made in accordance with the directions given in 12.1.

12 Test Methods

12.1 Determine the properties enumerated in this specification in accordance with the following test methods:

12.1.1 Density—Test Method D1505 or alternative methods of suitable accuracy, such as Practice D2839 or Methods A or B of Test Methods D792. Make duplicate determinations using two separate portions of the same specimen or from two specimens. The specimen geometry and conditioning requirements shall meet the requirements of the specific method or practice used to determine the density. Any departure from the specified geometry or conditioning shall be reported.

12.1.2 Flow Rate—Test Method D1238, using Condition 190/2.16 unless otherwise directed (Note 13). Make duplicate determinations on the material in the form of powder, granules, or pellets. No conditioning is required.

12.1.3 Carbon Black Content—Test Method D1603 or E1131. If Test Method D1603 is used, it must be known that no inorganic pigments or fillers are present in the material. Make duplicate determinations from a sample of the material in the form of powder, granules, or pellets.

12.1.3.1 If it is known or suspected that the material contains moisture, the sample shall be dried prior to being tested, but otherwise no conditioning is required.

12.1.4 Tensile Stress at Break and Elongation at Break— Test Method D638, except that speed of grip separation shall be 500 mm (20 in.)/min for Types 0 and I and 50 mm (2 in.)/min for Types II, III, and IV. Specimens shall conform to the dimensions given for Type IV in Test Method D638 with their thickness to be 1.9 ± 0.2 mm (0.075 ± 0.008 in.). Specimens shall be either die cut or machined to the specified dimensions. Bench marks or a high range extensometer shall be used for the determination of elongation at break. The initial distance between the bench marks or extensometer grips shall be 25.4 ± 0.4 mm (1.00 ± 0.02 in.). The initial grip separation shall be 63.5 ± 5 mm (2.5 ± 0.2 in.). Test results for specimens that break outside the gage-marks after extensive cold drawing need not be discarded unless the break occurs between the contact surfaces of a grip.

12.1.5 Brittleness Temperature—Procedure A of Test Method D746.

12.1.6 Environmental Stress-Crack Resistance Test—Test Method D1693, with the following provisions:

12.1.6.1 Type 0 materials shall be tested under Condition B, as defined in Table 1 of Test Method D1693.

12.1.6.2 Type I materials shall be tested under Condition A, as defined in Table 1 of Test Method D1693.

12.1.6.3 Unless otherwise specified, test materials of Types II, III, and IV under Condition B, as defined in Table 1 of Test Method D1693.

12.1.6.4 Test Grades E4, E5, E8, E9, E10, E11, and W3 in undiluted Igepal CO-630.5 Test Grades J3, J4, J5, and W4 in a solution of 10 weight % Igepal CO-630 in water.

12.1.7 Thermal Stress-Crack Resistance of Types III and IV Polyethylenes—Test Method D2951.

12.1.8 Dissipation Factor and Dielectric Constant—Test Method D1531 or Test Method D150, with the former to be the referee method. The following additional instructions and the precautions of 12.1.3.1 shall be observed:
12.1.8.1 Milling Stability—This procedure is intended for application to materials to be used for electrical insulation. For such materials, the milling procedure described in 12.1.8.2 can be performed as a preconditioning step prior to the determination of dissipation factor and dielectric constant as provided in 12.1.8. Its purpose is to establish that a suitable antioxidant is present in adequate quantity. After being milled as prescribed, the material shall meet the dielectric requirements prescribed in Table 3.
12.1.8.2 Process approximately 400 g of material for 3 h ± 5 min on a two-roll laboratory mill meeting the requirements prescribed in Practice D3182 at a temperature of 160 ± 5°C with the distance between the rolls so adjusted that the charge maintains a uniform rolling bank. Any other size two-roll laboratory mill is acceptable provided the charge is adequate to maintain a uniform rolling bank on the rolls and to furnish sufficient material for test specimens.
12.1.8.3 Due to the time-consuming nature of this preconditioning procedure, the frequency with which it is applied shall be established by sound statistical quality control practices by the individual manufacturer. However, the specified electrical tests shall be performed on every batch or run, using the normal conditioning procedure (11.1) plus the precautions of 12.1.3.1.
12.1.9 Water Immersion Stability—Immerse the test specimen in distilled water at 23 ± 2°C for 14 days after which remove, wipe dry, and immediately test for dissipation factor and dielectric constant in accordance with 12.1.8.
12.1.10 Volume Resistivity—Test Methods D257, using the electrodes shown in Fig. 4 (Flat Specimen for Measuring Volume and Surface Resistances or Conductances) or Fig. 5 (Tubular Specimen for Measuring Volume and Surface Resistances or Conductances). Conditioning and test conditions shall be as specified in 11.1 and 11.2.
12.1.10.1 Test specimens, particularly those molded of compounds containing carbon black, shall be tested immediately after conditioning and their storage under humid conditions shall be avoided.
12.1.11 Absorption Coeff?cient—Test Method D3349.
12.1.12 Weatherability for Colored Materials (Including White and Black:
12.1.12.1 Carbon Arc—See Appendix X1 for this test.
12.1.12.2 Xenon Arc—The material shall retain a minimum of 50 % of its unexposed elongation after 4000 h (Note 15) of exposure in a xenon-arc apparatus. Prepare the specimens in accordance with Test Methods D2633 for physical tests of insulations and jackets. Perform the tests in accordance with Practices D2565, G151 and G155 using daylight filters (Note 16) and an irradiance of 0.70 ± 0.02 W/(m2 .nm) at 340 nm (see Note 17). The exposure cycle consists of a light cycle of 10 h with 18 minutes water spray on the front surface during each 2 h period followed by a dark period of 2 h with continuous water spray on the back surface. The insulated black panel temperature is 70 ± 2°C with the light on and 55 ± 2°C with the light off. The chamber air temperature is adjusted to 48 ± 2°C during the light cycle and 55 ± 2°C during the dark cycle. The relative humidity requirements are 50 ± 10 % during the light cycle and 95 +5 %/–10 % when the light is off.
NOTE 15—The 4000 h exposure period specified cannot be extrapolated to service life under environmental conditions without data to estimate an acceleration factor for the materials exposed.
NOTE 16—The previous revision of D1248 specified filters that met the requirements of Test Method G155 daylight filters, while reducing the infrared irradiance, resulting in a lower specimen temperature. When testing materials that are temperature sensitive, or when comparing to historical results, similar filters can be used. Consult with the instrument manufacturer for selection of filters that meet this

criterion NOTE 17—Longer periods of exposure will be required for older xenon-arc machines operated at irradiance of 0.35 W/(m2 .nm) at 340 nm.
NOTE 18—The plus/minus (±) tolerances given for irradiance, temperature and relative humidity are the maximum allowable operational fluctuations of the parameter set point value under equilibrium conditions. This does not mean that the value can be set by plus/minus the amount indicated from the value specified. If the deviations are greater than the maximum allowable after the equipment has stabilized, discontinue the test and correct the cause of the problem before continuing.
12.1.12.3 Fluorescent UV Condensation Device—The material shall retain a minimum of 50 % of its unexposed elongation after 4000 h (Note 15) of exposure in a fluorescent UV condensation apparatus operated with fluorescent UVA340 lamps. Prepare the specimens in accordance with Methods D2633 for physical tests of insulations and jackets. Perform the tests in accordance with Practices G151, G154, and D4329 using the following exposure conditions: 20 h exposure to UVA-340 fluorescent lamps with uninsulated black panel temperature maintained at the control point at 70 ± 3°C followed by 4 h darkness with condensation at an uninsulated black panel temperature maintained at the control point at 55 ± 3°C. Irradiance at the control point shall be maintained at 0.70 ± 0.05 W/(m2 .nm) at 340 nm when using the irradiance controlled apparatus.
NOTE 19—The degradation rate of polyethylene has been found to be more variable in the non irradiance controlled device than in the device in which the irradiance is controlled. However, the non irradiance controlled machine can be used for relative weatherability comparison among different materials exposed at the same time.
NOTE 20—Because of differences in emission properties of the radiation sources and test conditions in the xenon arc, fluorescent UV lamp and carbon arc devices, the devices cannot be used interchangeably without supporting data that demonstrates equivalency for the materials tested.
NOTE 21—It should be noted that the irradiation spectra from different sources including carbon arc, xenon arc, and UV fluorescent equipment are not equivalent. Therefore, the effects of the exposures described in 12.1.12.1, 12.1.12.2, and 12.1.12.3 are not equivalent.

[Accelerated Aging UV Testing Chamber]

Category

1. Equipment for Standards
2. Standards