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# Standard Specification for Crosslinkable Ethylene Plastics[1]

This standard is issued under the fixed designation D 2647; 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.

ε[1] NOTE—Sections 2 and 3 were corrected editorially in November 2000.

## 1. Scope

1.1 This specification covers a general classification system for crosslinkable ethylene plastics compounds (Note 1). The requirements specified herein are not necessarily applicable for use as criteria in determining suitability for the end use of a fabricated product.

NOTE 1—It is to be noted that this specification describes materials that are available commercially in their uncrosslinked form. Therefore, they are crosslinkable compounds despite the fact that measurement of the parameters used for their classification and specification will usually be carried out after curing has been effected.

1.2 Two types of compounds are covered, namely, mechanical types in which mechanical strength properties are of prime importance in applications, and electrical types in which electrical insulating or conducting properties also are of prime importance in applications.

1.3 The parameters used to classify and specify the mechanical types are ultimate elongation, elongation retention after aging, apparent modulus of rigidity, and brittleness temperature.

1.4 The parameters used to classify and specify the electrical types are ultimate elongation, elongation retention after aging, apparent modulus of rigidity, brittleness temperature, dielectric constant, dissipation factor, and volume resistivity.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 The following safety hazards caveat pertains only to the test methods portion, Section 7, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 2—There is no similiar or equivalent ISO standard.

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 150 Test Methods for A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation[2]

D 257 Test Methods for D-C Resistance or Conductance of Insulating Materials[2]

D 573 Test Method for Rubber—Deterioration in an Air Oven[3]

D 618 Practice for Conditioning Plastics for Testing[4]

D 638 Test Method for Tensile Properties of Plastics[4]

D 746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact[4]

D 883 Terminology Relating to Plastics[4]

D 991 Test Method for Rubber Property—Volume Resistivity of Electrically Conductive and Antistatic Products[3]

D 1043 Test Method for Stiffness Properties of Plastics as a Function of Temperature by Means of a Torsion Test[4]

D 1898 Practice for Sampling of Plastics[5]

D 2765 Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics[6]

D 3892 Practice for Packaging/Packing of Plastics[6]

IEEE/ASTM SI-10 Standard for Use of the International System of Units (SI): (The Modernized Metric System)[7]

2.2 *Military Standard:*

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes [8](Obsoleted 1995)

## 3. Terminology

3.1 *Definitions:* For definitions of plastics terms used in this specification, see Terminology D 883.

[1] This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.12 on Olefin Plastics.

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[2] *Annual Book of ASTM Standards,* Vol 10.01.

[3] *Annual Book of ASTM Standards,* Vol 09.01.

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

[5] Discontinued: see 1997*Annual Book of ASTM Standards,* Vol 08.01.

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

[7] *Annual Book of ASTM Standards,* Vol 14.04.

[8] Available from Defense Automation and Production Service, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

3.2 *Abbreviations:*Units, Symbols, and Abbreviations—For units, symbols, and abbreviations used in this specification see IEEE/ASTM SI-10.

## 4. Classification

4.1 *Classification System*—Table 1 and Table 2 provide a classification system for these compounds so that the relations among them may be delineated and those that are commercially available may be specified readily. It is not the intent to indicate that all the combinations of properties possible are represented by commercial products or that they are technically possible at the present state of knowledge.

4.2 *Types*—This specification covers two general types of compounds: *Type I*—Mechanical types (Table 1), and *Type II*—Electrical types (Table 2).

4.3 *Grades*—This specification covers as many grades of compounds as may be selected from the possible combinations of requirements in Table 1 and Table 2. A grade is designated by first indicating the type (I or II) followed by cell numbers for each property in the order in which they are listed in the tables. Where there is no interest in a property, a "0" is entered in place of a cell number.

## 5. General Requirements

5.1 The compound shall be in powder, pellet or granular form, as agreed upon between the seller and the purchaser.

5.2 The compound, after crosslinking, shall conform to the requirements given in Table 1 or Table 2, whichever is applicable, for the type and grade specified when tested in accordance with the procedures given in Sections 6, 7, and 8.

## 6. Sampling

6.1 Unless otherwise agreed between the seller and the purchaser, the material shall be sampled in accordance with the general and specific sampling procedures of Practice D 1898. Adequate statistical sampling prior to packaging shall be considered an acceptable alternative.

## 7. Specimen Preparation

7.1 Unless otherwise agreed upon between the seller and the purchaser, the test specimens shall be formed and cured in accordance with the compound manufacturer's recommendations.

## 8. Test Methods

8.1 *Conditioning*—Condition the test specimen at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D 618, for those tests where conditioning is required and in all cases of disagreement.

8.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this specification.

8.3 *Ultimate Elongation*—Test Method D 638, using three Type IV specimens tested at 500 mm/min (20.0 in./min). If any value differs significantly from the other two, two additional samples shall be tested, making a total of five specimens.

8.4 *Elongation Retention After Aging*— Age three or five test specimens in accordance with the number evaluated in 8.3, conforming to Type IV of Test Method D 638, in a circulating air oven at either 121 ± 2°C (250 ± 3.6°F) or 150 ± 2°C (302 ± 3.6°F) in accordance with Test Method D 573, so that the hot air circulates freely around each specimen for 7 days (168 h). After 7 days, recondition the test specimens and measure the ultimate elongation in accordance with 8.3. Average the results and designate as *A*. Calculate the percentage elongation retention, as follows:

$$\text{Elongation retention, \%} = (A/I) \times 100 \quad (1)$$

where:

I = original elongation from 8.3.

8.5 *Apparent Modulus of Rigidity*—Condition and test specimens in accordance with Sections 8 and 8.2 and measure in accordance with Test Method D 1043.

8.6 *Brittleness Temperature*—Test Method D 746.

8.7 *Dielectric Constant*—Test Method D 150, at 1000 Hz (cycles per second) and 23 ± 1°C (73.4 ± 1.8°F).

8.8 *Dissipation Factor*—Test Methods D 150 at 1000 Hz and 23 ± 1°C (73.4 ± 1.8°F).

8.9 *Volume Resistivity*—Test Methods D 257. For precise evaluation of specimens below $10^6$ Ω·cm, use Test Method D 991 as an alternative.

8.10 *Degree of Crosslinking*—Test Methods D 2765, with Method A to be used for referee tests.

**TABLE 1 Type I, Mechanical Compound Requirements**

| Designation Order No. | Property | Cell Limits | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| 1 | Ultimate elongation, % | unspecified | <25 | 25 to 150 | 151 to 250 | 251 to 450 | >450 |
| 2 | Minimum of 75 % retention of elongation after aging at the specified temperature for 168 h, °C (°F) | unspecified | 121 (250) | 150 (302) | | | |
| 3 | Apparent modulus of rigidity, MPa (psi) | unspecified | <70 (10 000) | 70 to 275 (10 000 to 40 000) | >275 (40 000) | | |
| 4 | Brittleness temperature, °C (°F) | unspecified | <−75 (−103) | −54 (−65) to −75 (−103) | −40 (−40) to −53 (−63) | −29 (−20) to −39 (−38) | |
| 5 | Percent extract (measure of degree of cross-linking) | unspecified | <10 | <20 | <30 | ≥30 | |

**TABLE 2 Type II, Electrical Compound Requirements**

| Designation Order No. | Property | Cell Limits | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| 1 | Ultimate elongation, % | unspecified | <25 | 25 to 150 | 151 to 250 | 251 to 450 | >450 |
| 2 | Minimum of 75 % retention of elongation after aging at the specified temperature for 168 h, °C (°F) | unspecified | 121 (250) | 150 (302) | | | |
| 3 | Apparent modulus of rigidity, MPa (psi) | unspecified | <70 (10 000) | 70 to 275 (10 000 to 40 000) | >275 (40 000) | | |
| 4 | Brittleness temperature,° C (°F) | unspecified | <−75 (−103) | −54 (−65) to −75 (−103) | −40 (−40) to −53 (−63) | −29 (−20) to −39 (−38) | |
| 5 | Percent extract (measure of degree of cross-linking) | unspecified | <10 | <20 | <30 | ≥30 | |
| 6 | Dielectric constant | unspecified | 2.50 max | 3.50 max | 6.00 max | 8.00 max | >8.00 |
| 7 | Dissipation factor | unspecified | 0.001 max | 0.005 max | 0.01 max | 0.1 max | >0.1 |
| 8 | Volume resistivity, Ω·cm | unspecified | $>10^{15}$ | $10^{12}$ to $10^{15}$ | $10^{4}$ to $10^{12}$ | $<10^{4}$ | |

## 9. Inspection

9.1 Inspection of the materials shall be agreed upon between the purchaser and the supplier as part of the purchase contract.

## 10. Packaging and Marking

10.1 *Packaging*—The material shall be packaged in standard commercial containers, so constructed as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery, unless otherwise specified in the contract or order.

10.2 *Marking*—Unless otherwise agreed between the seller and the purchaser, shipping containers shall be marked with the name of the material and its supplier, type and grade designation, and the quantity contained.

10.3 All packing, packaging, and marking provisions of Practice D 3892 shall apply to this specification.

## 11. Keywords

11.1 crosslinkable; crosslinked; ethylene plastics; insoluble fraction; volume resistivity

## QUALITY ASSURANCE PROVISIONS FOR GOVERNMENT/MILITARY PROCUREMENT

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

S1. When specified in the contract or purchase order, sampling for inspection and testing shall be carried out in accordance with the recommendations of Practice D 1898.

S2. Selection of Acceptable Quality Level (AQL) and of Inspection Level (IL) shall be made, with consideration of the specific use requirements. This is discussed in the Means and Standard Deviations and Comparison of Sampling Plans sections of the above document, with reference to Military Standard MIL-STD-105.

S3. In the absence of contrary requirements, the following values shall apply:

| | IL | AQL |
|---|---|---|
| Defects of appearance and workmanship | II | 2.5 |
| Defects of preparation for delivery | S-2 | 2.5 |
| Test (products) | S-1 | 1.5 |
| Testing (polymer, unfabricated) | S-1[A] | — |

[A] Samples shall be drawn from the required number of units, and pooled for preparation of molded samples for mechanical properties evaluation.