



# Standard Specification for Crosslinked Polyethylene Insulation for Wire and Cable Rated 2001 to 35 000 V<sup>1</sup>

This standard is issued under the fixed designation D2656; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This specification covers a crosslinked polyethylene insulation for electrical wires and cables for conductor sizes 8 AWG (8.37 mm<sup>2</sup>) and larger. The base polymer of this insulation consists substantially of polyethylene.

1.2 This type of insulation is suitable for use on power cables in wet and dry locations at conductor temperatures not exceeding 90 °C for continuous operation, 130 °C for emergency overload conditions, and 250 °C for short-circuit conditions. It is considered suitable for all sizes and voltage classifications of single- and multiple-conductor power cables at voltage ratings of 2001 to 35 000 V phase-to-phase at the 100 % insulation level and at voltage ratings of 2001 to 25 000 V at the 133 % insulation level as listed in Table 1C of Test Methods D470.

1.3 Materials covered by this specification are not sunlight- and weather-resistant unless they are carbon black pigmented or contain an additive system designed for this protection.

1.4 In many instances the insulation cannot be tested unless it has been formed around a conductor. Therefore, tests are done on insulated wire in this standard solely to determine the relevant property of the insulation and not to test the conductor or completed cable.

1.5 Whenever two sets of values are presented, in different units, the values in the first set are the standard, while those in parentheses are for information only.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

D470 Test Methods for Crosslinked Insulations and Jackets for Wire and Cable

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D09.18 on Solid Insulations, Non-Metallic Shieldings and Coverings for Electrical and Telecommunication Wires and Cables.

Current edition approved Nov. 1, 2013. Published November 2013. Originally approved in 1967. Last previous edition approved in 2006 as D2656 – 06. DOI: 10.1520/D2656-13.

<sup>2</sup> 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.

D1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

D1711 Terminology Relating to Electrical Insulation

D2765 Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics

### 2.2 ICEA Standard:

ICEA T-28-562 Test Method for Measurement of Hot Creep of Polymeric Insulation<sup>3</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 For definitions of terms used in this specification refer to Terminology D1711.

## 4. Physical Properties

4.1 The requirements for the insulation are listed in Table 1.

## 5. Electrical Requirements

5.1 *Order of Testing*—Perform the partial-discharge, ac voltage, insulation resistance, and dc voltage tests in that order when any of these tests are specified. The sequence for other testing is not specified.

5.2 *Partial Discharge (Corona) Extinction Voltage*—Each length of completed power cable with shielded conductors shall comply with the minimum level specified in Table 2. Conduct the tests in accordance with Test Methods D470.

5.3 *AC Voltage Test*—Subject the wires and cables to an ac test voltage for a period of 5 min. Unless otherwise specified, omit this test if the dc voltage test described in 5.5 is to be performed. Test at a voltage of 125 V/mil (5 kV/mm) based on the specified nominal thickness of insulation for the rated circuit voltage, phase to phase. Conduct the test in accordance with Test Methods D470.

5.4 *Insulation Resistance*—The insulated conductor shall have an insulation resistance equal to or greater than that corresponding to a constant of 20 000 at 60 °F (15.6 °C). When the temperature of the water in which the insulation is tested differs from 60 °F, apply a correction factor. Table 2 of

<sup>3</sup> Available from The Insulated Cable Engineers Association, Inc. (ICEA), P.O. Box 1568, Carrollton, GA 30112, http://www.icea.net.

\*A Summary of Changes section appears at the end of this standard

**TABLE 1 Physical Properties for Crosslinked Polyethylene Insulation**

Unaged Requirements:	
Tensile strength, min, psi (MPa)	1800 (12.4)
Elongation at rupture, min %	250
Aged Requirements:	
After Air Oven Test at 121 ± 1 °C for 168 h:	
Tensile strength, min, % of unaged value	75
Elongation at rupture, min, % of unaged value	75
Heat Distortion:	
At 121 ± 1 °C, max, % of unaged value:	
4/0 Awg (107 mm <sup>2</sup> ) and smaller (insulation on cable)	30
Larger than 4/0 Awg (107 mm <sup>2</sup> ) (buffed sample of insulation)	15
Percent Hot Creep, max	
Filled <sup>A</sup>	100
Unfilled <sup>B</sup>	175
Percent Hot Set, max	
Filled <sup>A</sup>	5
Unfilled <sup>B</sup>	10

<sup>A</sup>Filled indicates a crosslinked polyethylene insulation that contains 10 % or greater carbon black and/or mineral fillers.

<sup>B</sup>Unfilled indicates a crosslinked polyethylene insulation that contains less than 10 % carbon black and/or mineral fillers.

**TABLE 2 Partial Discharge (Corona) Extinction Voltage Requirements**

Rated Circuit Voltage Phase to Phase, V	Minimum Level, kV	
	Grounded Neutral	Ungrounded Neutral
	Shielded	
2 001 to 5 000	4	5 <sup>A</sup>
5 001 to 8 000	6	8
8 001 to 15 000	11	15
15 001 to 25 000	19	26
25 001 to 28 000	21	
28 001 to 35 000	26	

<sup>A</sup> Unless otherwise indicated the cable shall be rated grounded neutral.

Test Methods **D470** contains the correction factors. Each insulation manufacturer can furnish the 1 °F coefficient for the insulation material by using the procedure given in Test Methods **D470**. Multiply the measured value by the correction factor to obtain the insulation-resistance value corrected to 60 °F.

5.4.1 Where a nonconducting separator is applied between the conductor and insulation or where an insulated conductor is covered with a nonmetallic jacket so that the insulation resistance can be measured only on the completed assembly, the required insulation resistance shall be at least 60 % of that required for the primary insulation based on the nominal thickness of that insulation.

5.5 *DC Voltage Test*—After the insulation resistance test has been completed, subject wires and cables rated 5001 V and above to a dc voltage test for a period of 15 min. Use a dc voltage three times the ac voltage based on the specified nominal thickness of insulation for the rated circuit voltage, phase to phase. Conduct the tests in accordance with Test Methods **D470**.

5.5.1 Upon completion of the insulation resistance test, each nonshielded insulated conductor rated up to 5000 V shall withstand for 5 min a dc test voltage that is three times the ac

test voltage specified in **5.3**. Unless otherwise specified, omit this test if the ac voltage test described in **5.3** has been performed.

5.6 *Accelerated Water Absorption Requirements*—The insulation shall meet the requirements of **Table 3** when tested in accordance with the Accelerated Water Absorption Tests in Test Methods **D470**. Conduct the Electrical Method Test at 60 Hz with the water temperature at 75 ± 1 °C.

5.7 *Permittivity and Dissipation Factor*—This test applies to insulation rated 5001 V and above. Measure the permittivity and dissipation factor on suitable 60-Hz equipment after the test specimen has been immersed in water at room temperature for at least 24 h. Make the measurements at a voltage corresponding to an average stress of 40 V/mil (1.6 kV/mm), based upon the specified nominal thickness of insulation for the rated circuit voltage, phase to phase. The insulation shall meet the following requirements:

Permittivity at room temperature, max	3.5
Dissipation factor at room temperature, max,	0.020

5.8 *U-Bend Discharge*—Perform this test only on single-conductor nonshielded cables rated 2001 through 5000 V. At the end of the test period no cable dielectric failures or cracks in the cable surface are permitted. Conduct the test in accordance with Test Methods **D470**.

5.9 *Surface Resistivity*—Perform this test only on single-conductor nonshielded cables rated 2001 through 5000 V. The surface resistivity shall exceed 200 000 MΩ. Conduct the test in accordance with Test Methods **D470**.

## 6. Heat Distortion

6.1 The requirements for heat distortion are given in **Table 1** of this Specification. The test is conducted in accordance with Test Methods **D470**.

## 7. Percent Hot Creep and Percent Hot Set

7.1 Determine the percent hot creep for 15 min at 150 °C (302 °F) as follows: Meet the filled or unfilled values specified in **Table 1**. Conduct this test in accordance with Practice ICEA T-28-562.

7.2 Determine the percent hot set for 5 min at 150 °C (302 °F) as follows: Meet the filled or unfilled values specified in **Table 1**. Conduct this test in accordance with Practice ICEA T-28-562.

7.3 In case of dispute, the solvent extraction test in Test Methods **D2765** is to be the referee method. The extractables, after a drying time of 20 h, shall be no more than 30 percent.

**TABLE 3 Accelerated Water Absorption Test Requirements**

Electrical Method:	
Permittivity after one day, max	3.5
Increase in capacitance, max, %:	
From 1 to 14 days	3.0
From 7 to 14 days	1.5
Stability factor after 14 days, max	1.0
Alternative to stability factor:	
Stability factor difference, 1 to 14 days, max	0.5

## **8. Test Applicable for Sunlight and Weather Resistant Materials**

8.1 For insulations requiring sunlight- and weather-resistance testing, test in accordance with “Weatherability for Colored Materials (including white and black)” in Specification **D1248**. Prepare the specimens in accordance with Test Methods **D470** for physical tests of insulations and jackets.

## **9. Sampling**

9.1 Unless otherwise specified, sample the insulation in accordance with Test Methods **D470**.

## **10. Test Methods**

10.1 Unless otherwise specified, test the insulation in accordance with Test Methods **D470**.

## **11. Keywords**

11.1 ac voltage; crosslinked polyethylene; dc voltage; heat distortion; hot creep; hot set; insulation resistance; water absorption; weather resistant

## **SUMMARY OF CHANGES**

Committee D09 has identified the location of selected changes to this specification since the last issue, D2656 – 06, that may impact the use of this specification. (Approved Nov. 1, 2013)

(I) Revised Section **3**.

*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org). Permission rights to photocopy the standard may also be secured from the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, Tel: (978) 646-2600; <http://www.copyright.com/>*