



Designation: **D 2656 – 9500**

An American National Standard

Standard Specification for Crosslinked Polyethylene Insulation for Wire and Cable Rated 2001 to 35 000 V¹

This standard is issued under the fixed designation D 2656; 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 a crosslinked polyethylene insulation for electrical wires and cables ~~in~~ for conductor sizes 8 AWG (8.37 mm²) 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 D 470.

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 va~~ insulation cannot be tested unless it has been formed around a conductor. Therefore, tests are done on insulated wire in this stanedard solely to determine th-e relevant property of the insulation and not to test the conductor or completed cable.

1.5 ~~Wheniever two sets of values are presented, in different units, the standard, except values in cases where SI units the first set are more appropriate. The values stated~~ the standard, while those in parentheses are for information only.

2. Referenced Documents

2.1 ASTM Standards:

¹ This specification is under the jurisdiction of ASTM Committee ~~D-9~~ D09 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D 09.18 on Solid Insulations, Non-Metallic Shieldings, and Coverings for Electrical and Telecommunications Wires and Cables.

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

D 257 Test Methods for DC Resistance or Conductance of Insulating Materials²

D 470 Test Methods for Crosslinked Insulations and Jackets for Wire and Cable²

~~D-1499 Practice 1248 Specification for Operating Light and Water Exposure Apparatus (Carbon-Arc Type) Polyethylene Extrusion Materials for Exposure of Plastics Wire and Cable³~~

~~D-2765 Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics⁴ 1711 Terminology Relating to Electrical Insulation²~~

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

³ *Annual Book of ASTM Standards*, Vol 08.01.

~~D-5071 Practice 2765 Test Methods for Operating Xenon ARC-Type Exposure Apparatus With Water for Exposure Determination of Photodegradable Plastics⁴~~

Annual Book of ASTM Standards, Vol 08.03.

⁴ Available from Insulated Cable Engineers Association, P.O. Box 440, South Yarmouth, MA 02664, or Global Engineering Documents, 15 Inverness Way, East Englewood CO 80112.

~~G 23 Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With Gel Content and Without Water for Exposure Swell Ratio of Nonmetallic Materials⁴~~

~~G 26 Practice for Operating Light-Exposure Apparatus (Xenon Arc Type) With and Without Water for Exposure of Nonmetallic Materials⁶ Crosslinked Ethylene Plastics⁴~~

2.2 *ICEA Standard:*

⁴ *Annual Book of ASTM Standards, Vol 08.02.*

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in this specification refer to Terminology D 1711.

3.2 Definitions of Terms Specific to This Standard:

3.1.1 ~~aged, a~~

3.2.1 ~~aging (act of), n—exposed of materials to an environment air at 121°C for an interval of time. 168 h.~~

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 ~~rated for service at 2001 V and above with shielded conductors~~ shall comply with the minimum level specified in Table 2. Conduct the tests in accordance with Test Methods D 470.

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 D 470.

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 Test Methods D 470 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 D 470. 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 D 470.

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 D 470. 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

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 ²) and smaller (insulation on cable)	30
Larger than 4/0 Awg (107 mm ²) (buffed sample of insulation)	15
Percent Hot Creep	
Filled	100
Unfilled	175
Percent Hot Set	
Filled	5
Unfilled	10

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 ^A
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	

^A Unless otherwise indicated the cable shall be rated grounded neutral.

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

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 D 470.

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 D 470.

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 D 470.

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 D 2765 is to be the referee method. The extractables, after a drying time of 20 h, shall be no more than 30 percent.

8. Test Applicable for Sunlight and Weather Resistant Materials

~~8.1 The insulation shall retain a minimum of 80 % of its unaged tensile strength~~

~~8.1 For insulations requiring sunlight- and elongation after 720 h of exposure weather-resistance testing, test in a dual carbon-arc apparatus, or 500 h of exposure accordance with “Weatherability for Colored Materials (including white and black)” in a Xenon-arc apparatus. Specification D 1248. Prepare the specimens in accordance with Test Methods D 470 for physical tests of insulations and jackets. Perform the Carbon-arc apparatus test in accordance with Practice D 1499 using Method 1 of Practice G 23. Perform the Xenon-arc apparatus test in accordance with Practice D 5071 using Test Method A of Practice G 26. jackets.~~

9. Sampling

9.1 Unless otherwise specified, sample the insulation in accordance with Test Methods D 470.

10. Test Methods

10.1 Unless otherwise specified, test the insulation in accordance with Test Methods D 470.

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

- (1) Added new sections 1.4, 1.5, 3, 7.3, 8.1, and 11.
- (2) General editorial changes.

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