Designation: D 3755 – 97

An American National Standard

Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials Under Direct-Voltage Stress[1]

This standard is issued under the fixed designation D 3755; 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 test method covers the determination of dielectric breakdown voltage and dielectric strength of solid electrical insulating materials under direct-voltage stress.

1.2 Since some materials require special treatment, reference should also be made to ASTM specifications or to the test method directly applicable to the material to be tested. See Test Method D 149 for the determination of dielectric strength of electrical insulating materials at commercial power frequencies.

1.3 This test method is similar to IEC Publication 243-2. All procedures in this test method are included in IEC 243-2. Differences between this test method and IEC 243-2 are largely editorial.

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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific precaution statements are given in Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*

D 149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies[2]

D 176 Test Methods for Solid Filling and Treating Compounds Used for Electrical Insulation[2]

D 877 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes[3]

D 1711 Terminology Relating to Electrical Insulation[2]

D 2436 Specification for Forced-Convection Laboratory Ovens for Electrical Insulation[2]

D 3487 Specification for Mineral Insulating Oil Used in Electrical Apparatus[3]

2.2 *ANSI Standard:[4]*

ANSI C68.1 Techniques for Dielectric Tests, IEEE Standard No. 4.

2.3 *IEC Standard:*

IEC 243-2 Methods of test for electric strength of solid insulating materials—Part 2: Additional requirements for tests using direct voltage[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *dielectric breakdown voltage*, *n*—Refer to Terminology D 1711.

3.1.2 *dielectric strength*, *n*—Refer to Terminology D 1711.

3.1.3 *flashover*, *n*—Refer to Terminology D 1711.

4. Summary of Test Method

4.1 The specimen, held in a properly designed electrode system, is electrically stressed by the application of an increasing direct voltage until internal breakdown occurs. The test voltage is applied at a uniform rate of increase. The direct voltage is obtained from a high-voltage supply of adequate current capacity and regulation, reasonably ripple-free, with facilities for measuring and controlling the output voltage.

5. Significance and Use

5.1 This test method is intended for use as a control and acceptance test for direct-voltage applications. It may be used also in the partial evaluation of material for specific end uses and as a means for detecting changes in material due to specific deteriorating causes.

5.2 Experience indicates that the breakdown value obtained with direct voltage usually will be approximately 2 to 4 times the rms value of the 60-Hz alternating-voltage breakdown.

5.3 For a nonhomogeneous test specimen, the distribution of voltage stress within the specimen is determined by impedance (largely capacitive) with alternating voltage. With an increasing direct voltage, the voltage distribution may be still

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[1] This test method is under the jurisdiction of ASTM Committee D-9 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D09.12 on Electrical Tests.

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

[3] *Annual Book of ASTM Standards*, Vol 10.03.

[4] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

largely capacitive, but depends partly on the rate of voltage increase. After steady application of direct voltage the voltage division across the test specimen is determined by resistance. The choice of direct or alternating voltage depends upon the purpose for which the breakdown test is to be used, and to some extent, on the intended application of the material.

5.4 A more complete discussion of the significance of dielectric breakdown tests is given in Appendix X1 of this method and of Test Method D 149. Those appendix sections of Test Method D 149 that refer to alternating voltage are not applicable to the direct-voltage method.

6. Apparatus

6.1 *Basic Direct-Voltage Power Supplies*, or dielectric test sets of various voltage ratings, that can operate with one of the two output terminals grounded, are commonly available commercially. Such apparatus customarily includes the necessary voltage-control, voltage-measuring, and circuitinterrupting equipment. A provision for retaining the breakdown voltage reading after breakdown is desirable.

6.1.1 For a direct voltage derived from a rectified and filtered power frequency source, ripple on the output voltage generally should be less than 1 %. The criterion is met if the time constant of the circuit is at least 0.4 s. The time constant is product of the filter capacitance plus the specimen capacitance in microfarads, and the specimen insulation resistance (in megohms) corresponding to the parallel combination of the voltmeter circuit resistance and the specimen resistance.

6.2 *Voltage Control*, that will enable the test voltage to be increased at a linear rate. Preference should be given to a variable-speed motor-driven voltage control over a manual control. The rate-of-rise of test voltage shall not vary more than ±20 % from the specified rate at any point.

6.3 *Voltmeter*, to measure the voltage directly applied to the electrode system. The response of the voltmeter shall be such that its time lag shall not introduce an error greater than 1 % of full scale at any rate-of-rise used. The overall accuracy of the voltmeter and the voltage-measuring device used shall be such that the measurement error will not exceed ±2 % of full scale and be in accordance with ANSI C68.1.

6.4 *Electrodes*:

6.4.1 For those cases when the insulating material is in the form of flat sheet or tape, or is of the nature of a semisolid (for example, grease potting material, etc.) the electrodes may be selected from those listed in Table 2 of Test Method D 149. The electrode contact pressure shall be adequate to obtain good electrical contact.

6.4.2 Where excellent electrode contact is considered important, use paint or vaporized metal electrodes. Such electrodes may also be used when specimen geometry prevents the use of rigid, solid metal electodes. The results obtained with painted or sprayed electrodes may not be comparable with those obtained using other types of electrodes.

6.5 *Test Chamber*—For tests under other than ambient conditions, the specimen must be placed in a suitable environmental chamber of adequate size. For tests at elevated temperatures, an oven that meets the requirements of Specification D 2436 may be convenient. The test chamber must be equipped with safety devices (Section 7).

6.6 *Ground Switch*—The power supply shall be equipped with a grounding switch that is gravity operated and designed to close in less than 0.5 s. The grounding switch shall connect the high-voltage output terminal of the power supply and ground terminal through a low resistance when the input supply power is removed or the test chamber door is opened.

7. Safety Precautions

7.1 **Warning**— *Lethal voltages are a potential hazard during the performance of this test. It is essential that the test apparatus, and all associated equipment electrically connected to it, be properly designed and installed for safe operation. Solidly ground all electrically conductive parts which it is possible for a person to contact during the test. Provide means for use at the completion of any test to ground any parts which were at high voltage during the test or have the potential for acquiring an induced charge during the test or retaining a charge even after disconnection of the voltage source. Thoroughly instruct all operators as to the correct procedures for performing tests safely. When making high voltage tests, particularly in compressed gas or in oil, it is possible for the energy released at breakdown to be sufficient to result in fire, explosion, or rupture of the test chamber. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury. If the potential for fire exists, have fire suppression equipment available.*

7.2 When a direct-voltage test has been applied to the test specimen, both the specimen and power supply can remain charged after the test voltage source has been de-energized. This may present a hazard to test personnel. Direct-voltage testing may be more hazardous than testing with alternating voltage, where the charge on the specimen is rapidly dissipated in the low-impedance winding of the test transformer after the test is de-energized.

7.3 The test specimen and high-voltage output of the power supply must be enclosed in a grounded metallic screen. Access to the test enclosure must be dependent upon prior grounding of the power supply and test specimen through a low resistance as referred to in 6.6.

7.4 A manual grounding stick must be used to completely discharge the test specimen and power supply after the test and prior to handling them. The grounding stick should be left in contact with the test specimen and high-voltage transformer terminals for as long as feasible.

7.5 **Warning**—Ozone is a physiologically hazardous gas at elevated concentrations. Levels of acceptable industrial exposure have been established by the American Conference of Government and Industrial Hygienists.[5] Ozone has a distinctive odor that is initially discernible at low concentrations, but temporary loss of the sense of smell can occur. It is likely to be present wherever voltages exist that are sufficient to cause partial or complete discharges in air or other atmospheres containing oxygen. When the odor of ozone is persistently present or when ozone generating conditions continue, the

[5] American Conference of Governmental Industrial Hygienists, Building D-7, 6500 Glenway Drive, Cincinnati, OH 45211.