Designation: D877/D877M – 19

Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes[1]

This standard is issued under the fixed designation D877/D877M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method describes two procedures, A and B, for determining the electrical breakdown voltage of insulating liquid specimens. The breakdown test uses ac voltage in the power-frequency range from 45 to 65 Hz.

1.2 This test method is used to determine the electrical discharge voltage of in-use electrical liquids. It is no longer applicable to new insulating liquids upon receipt, in which case Test Method D1816 shall be used.

NOTE 1—It is understood that long-term histories for this test method exist, but this test method is no longer considered applicable as numerous deficits exist that affect its usefulness. It is recommended to move all new and in-service electrical discharge voltage testing of electrical insulating liquids to Test Method D1816.

1.3 *Limitations of the Procedures:*

1.3.1 The sensitivity of this test method to the general population of contaminants present in a liquid sample decreases as applied test voltages used in this test method become greater than approximately 25 kV rms.

1.3.2 If the concentration of water in the sample at room temperature is less than 60 % of saturation, the sensitivity of this test method to the presence of water is decreased. For further information refer to RR:D27-1006.[2]

1.3.3 The suitability for this test method has not been determined for a liquid's viscosity higher than 900 cSt at 40 °C.

1.4 *Procedure Applications*

1.4.1 *Procedure A:*

1.4.1.1 Procedure A is used to determine the breakdown voltage of liquids in which any insoluble breakdown products easily settle during the interval between the required repeated breakdown tests. These liquids include petroleum oils, hydrocarbons, natural and synthetic esters, and askarels (PCB) used as insulating and cooling liquids in transformers, cables, and similar apparatus.

1.4.1.2 Procedure A may be used to obtain the dielectric breakdown of silicone fluid as specified in Test Methods D2225, provided the discharge energy into the sample is less than 20 mJ (milli joule) per breakdown for five consecutive breakdowns.

1.4.2 *Procedure B:*

1.4.2.1 This procedure is used to determine the breakdown voltage of liquids in which any insoluble breakdown products do not completely settle from the space between the disks during the 1-min interval required in Procedure A. Procedure B, modified in accordance with Section 17 of Test Methods D2225, is acceptable for testing silicone dielectric liquids if the requirements of 1.4.1.2 can not be achieved.

1.4.2.2 Procedure B should also be applied for the determination of the breakdown voltage of liquid samples containing insoluble materials that settle from the specimen during testing. These may include samples taken from circuit breakers, load tap changers, and other liquids heavily contaminated with insoluble particulate material. These examples represent samples that may have large differences between replicate tests. The use of Procedure B will result in a more accurate value of breakdown voltage when testing such liquids.

1.4.2.3 Use Procedure B to establish the breakdown voltage of an insulating liquid where an ASTM specification does not exist or when developing a value for an ASTM guide or standard. Procedure A may be used once the single operator precision of 13.1 has been demonstrated.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

[1] This test method is under the jurisdiction of ASTM Committee D27 on Electrical Insulating Liquids and Gases and is the direct responsibility of Subcommittee D27.05 on Electrical Test.

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[2] RR:D27-1006, Round-Robin Data Using Modified VDE Electrode Cell for Dielectric Strength Tests on Oil, is available from ASTM Headquarters.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D923 Practices for Sampling Electrical Insulating Liquids

D1816 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes

D2225 Test Methods for Silicone Fluids Used for Electrical Insulation

D2864 Terminology Relating to Electrical Insulating Liquids and Gases

2.2 *IEEE Standards:*[4]

Standard 4, IEEE Standard Techniques for High-Voltage Testing

C57.106 Guide for Acceptance and Maintenance of Insulating Oil in Equipment

3. Significance and Use

3.1 The dielectric breakdown voltage is a measure of the ability of an insulating liquid to withstand electrical stress. The power-frequency breakdown voltage of a liquid is reduced by the presence of contaminants such as cellulosic fibers, conducting particles, dirt, and water. A low result in this test method indicates the presence of significant concentrations of one or more of these contaminants in the liquid tested. See Appendix X1.

3.2 A high breakdown voltage measured in this test method does not necessarily indicate that the amount of the contaminants present in a liquid from which the sample was taken is sufficiently low for the sampled liquid to be acceptable in all electrical equipment. Test Method D877 is not sensitive to low levels of these contaminants. Breakdown in this test method is dominated by events occurring at the electrode edges. The voltage stress distribution between the parallel disk electrodes used in this test method are quasi-uniform and there is substantial stress concentration at the sharp edges of the flat disk faces.

3.3 This test method may be used for evaluation of insulating liquids in equipment that is designed to be filled with unprocessed liquids as delivered by a vendor.

3.4 This test method is not recommended for evaluation of the breakdown voltage of liquids used in equipment that requires the application of vacuum and filtering of the oil before being placed into service. Test Method D1816 should be used to determine the breakdown voltage of filtered and degassed liquids.

3.5 This test method is used in laboratory or field tests. For field breakdown results to be comparable to laboratory results, all criteria including room temperature (20 to 30 °C) must be met.

4. Electrical Apparatus

4.1 In addition to this section, use IEEE Standard 4 to determine other requirements necessary for conducting test methods and making measurements using alternating voltages. Procedures to ensure accuracy should follow the requirements of IEEE Standard 4. Calibration(s) shall be traceable to national standards and should be conducted annually or more often.

4.1.1 *Test Voltage*—The test voltage shall be an alternating voltage having a frequency in the range from 45 to 65 Hz, normally referred to as power-frequency voltage. The voltage waveshape should approximate a sinusoid with both half cycles closely alike, and it should have a ratio of peak-to-rms values equal to the square root of 2 within ±5 %.

4.1.2 *Generation of the Test Voltage*— The test voltage is generally supplied by a transformer or resonant circuit. The voltage in the test circuit should be stable enough to be practically unaffected by varying current flowing in the capacitive and resistive paths of the test circuit. Nondisruptive discharges in the test circuit should not reduce the test voltage to such an extent, and for such a time, that the disruptive discharge (breakdown) voltage of the test specimen is significantly affected. In the case of a transformer, the short-circuit current delivered by the transformer should be sufficient to maintain the test voltage within 3 % during transient current pulses or discharges, and a short circuit current of 0.1 A may suffice.

4.1.3 *Disruptive Voltage Measurement*— Design the measurement circuit so the voltage recorded at the breakdown is the maximum voltage across the test specimen immediately prior to the disruptive breakdown with an error no greater than 3 %.

4.2 *Circuit-Interrupting Equipment*— Design the circuit used to interrupt the disruptive discharge through the specimen to operate when the voltage across the specimen has collapsed to less than 100 V. It is recommended that the circuit design limit the disruptive current duration and magnitude to low values that will minimize damage to the disks and limit formation of non-soluble materials resulting from the breakdown, but consistent with the requirements of 4.1.1.

4.3 *Voltage Control Equipment*—Use a rate of voltage rise of 3 kV/s. The tolerance of the rate of rise should be 5 % for any new equipment. Automatic equipment should be used to control the voltage rate of rise because of the difficulty of maintaining a uniform voltage rise manually. The equipment should produce a straight-line voltage-time curve over the operating range of the equipment. Calibrate and label automatic controls in terms of rate-of-rise.

4.4 *Measuring Systems*—The voltage shall be measured by a method that fulfills the requirements of IEEE Standard No. 4, giving rms values.

[3] 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.

[4] Available from The Institute of Electrical and Electronics Engineers, Inc., PO Box 1331, Piscataway, NJ 08855.