Designation: D 1389 – 07

An American National Standard

Standard Test Method for Proof-Voltage Testing of Thin Solid Electrical Insulating Materials[1]

This standard is issued under the fixed designation D 1389; 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 a general procedure for proof-voltage testing of thin solid electrical insulating materials at commercial power frequencies. It is intended to apply principally to flat materials but is applicable, with modification, to any form that permits continuously passing the material between suitable electrodes.[2,3]

1.2 On extremely thin materials (usually less than 0.05 mm (0.002 in.)), the test results may be influenced more by mechanical damage caused by conditions of test than by dielectric defects. Consequently, this test method is not recommended for use with extremely thin materials, unless prior determination has established that the test results are not influenced by mechanical damage.

1.3 While the equipment and procedures described in this test method relate specifically to tests made with power frequency ac voltages, similar equipment and procedures are used for proof-voltage tests using dc voltages. To the extent that it applies to dc tests, this test method can serve as a guide for persons making such tests. However, only tests made with power frequency ac voltages can be said to be in accordance with this test method.

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.* For specific hazard statements, see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

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

D 1711 Terminology Relating to Electrical Insulation

3. Terminology

3.1 *Definitions:* For other definitions relating to electrical insulating materials, refer to Terminology D 1711.

3.1.1 *proof voltage test*, *n*—a procedure during which a specified voltage is applied for a specified time between electrodes separated by a specimen located between the electrodes to determine whether or not a specific current is exceeded at that voltage.

3.1.1.1 *Discussion*—If fixed electrodes are used, the voltage is held for a specified time. If a large area (for example, a roll containing sheet or film material) is being tested using roller, brush, or blade electrodes, a velocity of material travel must be specified.

4. Summary of Test Method

4.1 In this test method, sheet insulating material is passed at a specified speed between roller electrodes with a specified ac voltage applied, so that all, or nearly all, of the area of the material is subjected to the specified voltage. The number of electrical breakdowns and their locations are determined.

4.2 The applied proof voltage may be selected as a percentage of the dielectric breakdown voltage, as determined in accordance with Test Method D 149, or as a multiple of the breakdown voltage for an air gap of equal thickness.

4.3 Unless the material being tested is known to have high resistance to partial discharges, the proof voltage is ordinarily selected to be below the visible corona level. If it is necessary to test at a voltage at which visible corona will be present, the

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

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[2] Bartnikas, R., Chapter 3, "High Voltage Measurements," *Electrical Properties of Solid Insulating Materials, Measurement Techniques*, Vol. IIB, *Engineering Dielectrics*, R. Bartnikas, Editor, *ASTM STP 926*, ASTM, Philadelphia, 1987.

[3] Nelson, J. K., Chapter 5, "Dielectric Breakdown of Solids," *Electrical Properties of Solid Insulating Materials: Molecular Structure and Electrical Behavior*, Vol. IIA, *Engineering Dielectrics*, R. Bartnikas and R. M. Eichorn, Editors, *ASTM STP 783*, ASTM, Philadelphia, 1983.

[4] 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.

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

degradation of the material resulting from exposure to corona should be weighed against the advantages of testing at the higher voltage level.

4.4 Two values for the rate of movement of the material between the electrodes are given to facilitate handling of different types of materials. The results obtained using the different speeds are not equivalent.

5. Significance and Use

5.1 Occasional dielectric defects may be found in commercially available and acceptable thin electric insulating materials. More often than not, these materials are used in multiple layers. The probability that occasional dielectric weak spots will coincide from layer to layer is very small but increases with the frequency of occurrence of these defects. The proof-voltage test serves to indicate the frequency of occurrence of dielectric defects and facilitates the isolation of areas where the defects are excessive.

5.2 Some uses of thin electrical insulating materials require the complete absence of any dielectric defects. The proof-voltage test serves to locate dielectric defects, making possible repair or replacement of the area involved as may be desirable.

5.3 In the absence of detected faults, this test method is nondestructive to the material being evaluated, except as discussed in 1.2 and 4.3.

5.4 A critical part of the apparatus and procedure is the sensitivity and speed of response of the fault detection device. The latter is usually a circuit breaker. Depending upon the characteristics of this latter component, it is very likely that the results obtained using different sets of apparatus will exhibit significant variability.

5.5 It is essential that the fault detector respond only to fault currents and that fault currents above a pre-defined value always result in a fault detector response. The design, adjustment, and operation of the apparatus must avoid both erroneous functioning and any erroneous nonfunctioning of the fault detector that might be the result of charging currents, imbalance of impedance, or component malfunction.

5.6 The proof-voltage test has been used as a manufacturing control test and as an acceptance test to guarantee a minimum level of dielectric defects.

5.7 If this test method is used as an acceptance test, take care that the factors discussed in 5.4 and 5.5 have been considered, and if more than one set of apparatus is to be used, that comparable results are obtained from them.

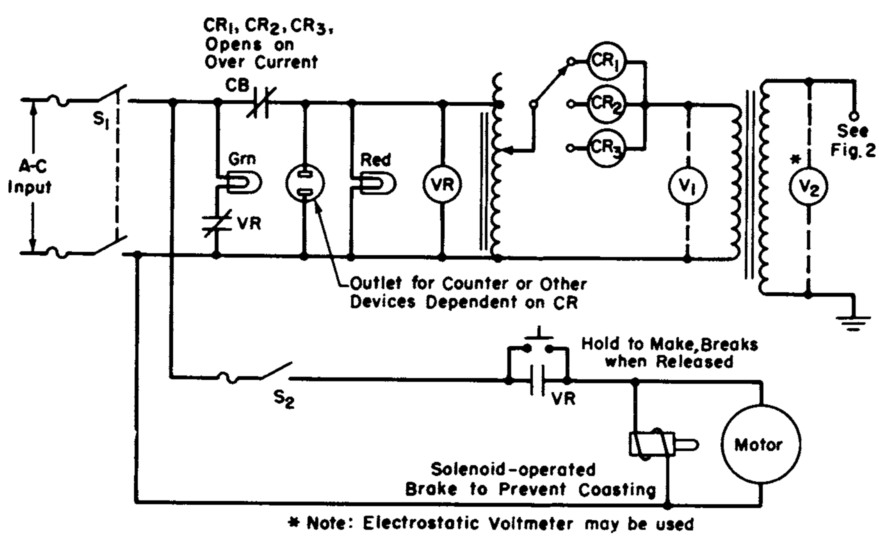
6. Apparatus

6.1 *General Requirements*—The test voltage must conform to the requirements of Test Method D 149, relative to its variation from nominal value, wave-shape, and accuracy and method of measurement. As related to this specific test method, some design details that are useful are described in 6.2-6.5, and in Fig. 1.

6.2 *System Considerations*—Departure from a sinusoidal wave form can arise either at the voltage source or in the load circuit. Excessive distortion due to load current can usually be avoided if the overall impedance drop through the apparatus at rated current and voltage is less than 10 % of the rated voltage, and provided the ratio of test voltage to rated voltage is not too small. The lower limit of this ratio can be determined by test. Use an apparatus of such size and design that fault currents at breakdown produce visually observable ruptures. The magnitude of the fault current required will depend on the material being tested.

6.3 *Transformer*—The desired test voltage is readily obtained from a step-up transformer energized from an adjustable voltage source. The transformer must be of such size and design that its continuous duty rating is consistent with the requirements as specified in 6.1. Standard 5 kVA or larger distribution transformers 14400/13200 to 120/240 or 240/480 V with less than 5 % impedance drop are readily available and their use is suggested.

6.4 *Fault Detector*—Provide fault detection with an automatic circuit-breaking device having non-automatic reset. In order to provide detection of the smallest defects, to prevent pitting of the electrodes, and to provide maximum protection of



Symbols: CB-Circuit Breaker: CR-Current Relay; VR-Voltage Relay.

FIG. 1 Elementary Schematic Diagram of Typical Electrical Test Apparatus

the other electrical elements, the fault detector should be as sensitive and as fast-acting as possible. On the other hand, the task of visually locating dielectric punctures in some types of materials may be difficult if the fault current is interrupted too quickly. Therefore, the current setting and the response time of the fault detector must be related to the material being tested. CR_1, CR_2, and CR_3, shown in Fig. 1, can be separate fixed devices having differing characteristics, or can be a single device which can be set to different current and time values as needed. The circuit breaker (CB) of Fig. 1 should have a response time appropriate to the material being tested.

6.5 *Voltage Control*—To control voltage use any of the following: (*1*) variable-ratio auto-transformer, (*2*) generator-field regulation, or (*3*) induction regulator. Give preference to the variable-ratio auto-transformer or generator-field regulation. Use a voltage control design and the associated transformer so that the requirements of 6.1 are met.

6.6 *Voltmeter*—Use instruments that meet the requirements specified in Test Method D 149 to continuously measure the voltage applied during the test.

6.7 *Electrodes*:

6.7.1 The upper electrode of Fig. 2 is a hollow metal cylinder, 38 mm (1.5 in.) to 50 mm (2.0 in.) in diameter, of such length that as much of the width of the material is covered as is feasible without obtaining flash-over, and weighing no more than 2.5 g/mm (0.14 lb/in.) plus 225 g (0.5 lb). The ends are rounded to a radius of at least 13 mm (0.5 in.).

6.7.2 The lower electrode of Fig. 2 is constructed of a suitable metal, 150 mm (6 in.) in diameter, and is coupled to the drive. Round the ends of the lower electrode to a radius of at least 13 mm (0.5 in.), if that electrode does not extend at least 50 mm (2 in.) beyond both edges of the material being tested.

6.7.3 Both of the electrodes are circular and straight to within 0.025 mm (0.001 in.), and have a smooth satin or mirror finish. No sharp surface irregularities having a radial dimension greater than 0.10 times the thickness of the material being tested are permitted.

6.8 *Test Assembly*:

6.8.1 The test assembly, Fig. 2, consists of the upper and lower cylindrical electrodes mounted in suitable apparatus with provision being made for a drive to move the material at the specified speed.

6.8.2 It is desirable to mount the upper electrode for convenient removal so that electrodes of various lengths can be used to test materials of different widths. The upper electrode rests on the material to be tested, and is free to rotate about its axis and move only in a plane perpendicular to the plane of the material being tested.

6.8.3 The lower electrode is grounded and a protective cage at ground potential is provided over the upper electrode.

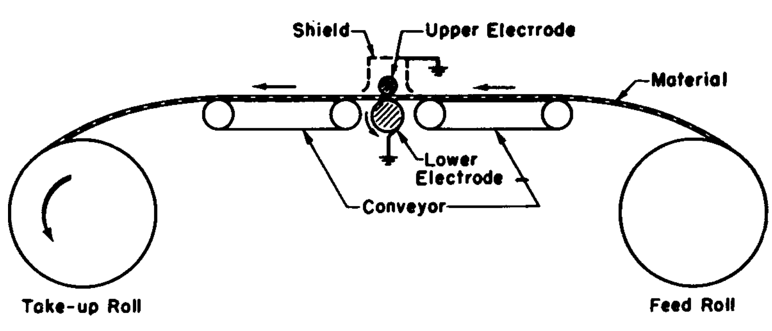
NOTE 1—Special electrode and test assemblies are necessary to test some types of materials. For materials which are relatively nonuniform in thickness it is desirable to use segmented electrodes of special construction. Formed parts such as channels can be tested by constructing electrodes whose geometry is compatible with the shape of the formed material. For extremely thin materials it is desirable to keep the material stationary and explore it by a traveling electrode. In all these cases make reference to test methods for the specific material.

6.8.4 Mount the upper and lower electrodes so that the axis of neither electrode deviates more than 0.25 mm (0.010 in.) from a vertical plane through the axis of the other at any point within the width of its working surface, and the axis of each electrode never deviates more than 0.1 degree of being perpendicular to the direction of motion of the material being tested.

6.8.5 For the testing of cut sheet materials, provide a suitable conveyor, drive coupled, to support and move the material mounted in front of and behind and as close to the electrodes as is feasible, in a horizontal plane just slightly below the plane of intersection of the upper and lower electrodes, as shown in Fig. 2.

6.8.6 Where the material to be tested is in roll form, provide a feed and take-up roll. Use a diameter of the take-up roll appropriate to the material being tested, generally no smaller than the core diameter of the feed roll, and driven in such a manner (for example, circumferential or slipping clutch drive) as to maintain the specified linear velocity of material passing between the electrodes. Do not drive the feed roll. To prevent coasting at certain feed roll speeds, provide a web tension regulator for the feed roll, or an idler roll ahead of the feed roll. In any case, use only as much tension on the test material as is necessary to prevent coasting. Maintain the height of both feed and take-up rolls so as not to cause lifting of the upper electrode with a resultant air gap between the test material and the lower electrode.

6.8.7 Electrically interlock the drive with the fault detector so that the drive stops positively upon dielectric rupture of the material under test, but with provisions made so that the drive is independently operable when needed.



NOTE—Arrows indicate "driven" and direction.

FIG. 2 Typical Elementary Test Assembly for Use With Sheet and Roll-Form Materials

7. Hazards

7.1 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.

8. Procedure

8.1 Place the material in the apparatus and adjust the necessary drives, clutches, and web tension regulators.

8.2 Energize the electrodes within 5 % of the specified ac proof test voltage for the material being tested.

8.3 Pass the material between the electrodes at a speed of either 2.3 m/min (7.5 ft/min) or 7.6 m/min (25 ft/mm).

8.4 Record the number of dielectric faults detected, and if so specified, mark the location of each fault. If specified for material supplied in rolls, record the distance from one of the ends to each fault.

9. Report

9.1 Unless otherwise specified, report the following:

9.1.1 Magnitude and frequency of the proof voltage,

9.1.2 Current and time characteristics of the fault detector,

9.1.3 Speed of the material passing between the electrodes,

9.1.4 Description of the material (name, grade, manufacturer, thickness, width, and so forth),

9.1.5 Electrode system used, if other than that specified in this test method,

9.1.6 Proof test results obtained, and

9.1.7 Dielectric failures per unit area tested.

10. Precision and Bias

10.1 No statement is made about either the precision or bias of this test method since the result merely states whether there is conformance to the criteria for acceptability.

10.2 As mentioned in Section 5, the results obtained from tests on a given sample of material are dependent upon a number of factors, especially the sensitivity and speed of response of the fault detector and the velocity of movement of material between the electrodes. Do not directly compare results obtained on different sets of apparatus or at different times on the same apparatus unless these factors have been determined to be constant.

11. Keywords

11.1 proof-voltage testing; thin solid insulating materials

SUMMARY OF CHANGES

Committee D09 has identified the location of selected changes to this test method since the last issue, D 1389 – 06, that may impact the use of this test method. (Approved May 1, 2007)

(*1*) Revised 3.1.1.

Committee D09 has identified the location of selected changes to this test method since the last issue, D 1389 – 97a(2004), that may impact the use of this test method. (Approved October 15, 2006)

(*1*) Revised the text throughout to remove non-mandatory language and to make editorial corrections.