Designation: D 3151 – 88 (Reapproved 1998)

An American National Standard

Standard Test Method for Thermal Failure of Solid Electrical Insulating Materials Under Electric Stress[1]

This standard is issued under the fixed designation D 3151; 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 the thermal failure of solid electrical insulating materials subjected to electric stress at commercial power frequencies. This test method has been developed for testing materials such as certain glasses and ceramics, that exhibit large increases in dielectric loss with increasing temperature.

1.2 *This standard does not purport to address all of the safety problems, 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.* A specific hazard statement is given in 10.1.

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 374 Test Methods for Thickness of Solid Electrical Insulation[2]

D 1711 Terminology Relating to Electrical Insulation[2]

E 145 Specification for Gravity-Convection and Forced-Ventilation Ovens[3]

2.2 *Other Standards:*

IEEE Standard No. 4 Measurements of Voltage in Dielectric Tests[4]

3. Terminology

3.1 *Definition:*

3.1.1 *dielectric breakdown voltage*—see Terminology D 1711.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *thermal dielectric breakdown, n*—an increase in the dissipation factor or conductance in the test material which leads to failure by thermal runaway. The time to failure and the voltage stress at which thermal breakdown occurs is influenced by the ambient test temperature, the test voltage, the dimensions of the test specimen, the specific heat of the material, and its thermal conductivity.

3.2.2 *thermal dielectric breakdown voltage*, *n*—the voltage at which thermal dielectric breakdown takes place at a specified ambient temperature and thermal transfer condition.

3.2.3 *thermal runaway*, *n*—a mode of response exhibited by certain materials which, when subjected to electric stress exceeding a critical value, undergo a rise in temperature which itself increases the conductance of the material, further increasing the temperature, and so on in a self-escalating manner.

4. Significance and Use

4.1 This test method is intended to supplement the standard dielectric strength test procedure (Test Method D 149) for tests at elevated temperatures, particularly of glasses and ceramics. The method determines at elevated temperature the potential difference at which the current becomes so great due to increased conductance that dielectric heating causes the temperature in the material to rise and ultimately cause thermal electric breakdown to occur.

4.2 This test method is intended for use as a control and acceptance test. It may be used also in the partial evaluation of materials for specific end uses and as a means for detecting changes in materials due to specific deteriorating causes. A more complete discussion of the significance of thermal dielectric breakdown tests is given in Annex A1.

5. Apparatus

5.1 *High-Voltage Test Equipment*—Suitable equipment is described in Test Method D 149. The transformer rating should be adequate to maintain a sine wave at full-load current. Higher ratings than specified in Test Method D 149 are usually required.

5.2 *Voltmeter*—The voltage shall be measured in accordance with IEEE Standard No. 4. The response time of the voltmeter shall be such that its time lag does not introduce an

[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.

Current edition approved Aug. 26, 1988. Published October 1988. Originally published as D 3151–73. Last previous edition D 3151–79.

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

[3] *Annual Book of ASTM Standards,* Vol 14.02.

[4] Available from the Institute of Electrical and Electronics Engineers, Inc., 345 E. 47th St., New York, NY 10017.

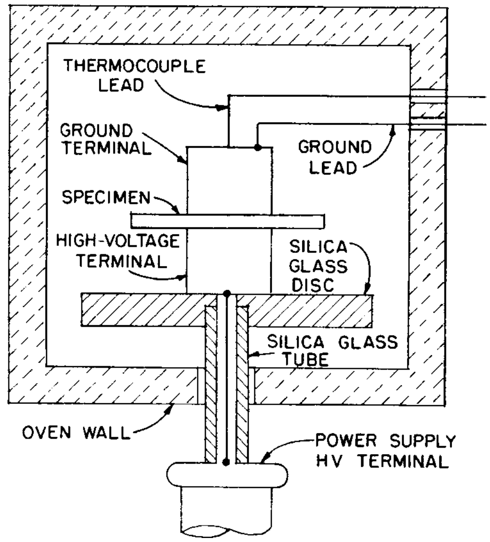

FIG. 1 General Arrangement in Test Chamber

error greater than 1% of full scale at the 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 5%.

5.3 *Test Area*, containing the test chamber and high-voltage transformer shall be contained in a suitably grounded metal enclosure with a door provided with an interlock that interrupts the high voltage when opened.

5.4 *Test Chamber*:

5.4.1 The test chamber shall consist of an electrically heated furnace and an auxiliary temperature controller. A high-temperature gravity-convection oven with controller conforming to Specification E 145, Type 1, is suitable.

5.4.2 The size of the chamber shall be such that the highest test voltage anticipated, when applied to the test electrodes, will not flash over to the walls of the chamber at the highest temperature.

5.4.3 The chamber shall be provided with holes for three leads. A ceramic or fused-silica glass tube capable of withstanding the anticipated test voltage shall be inserted through one hole in the floor. The high-voltage lead shall be brought through this insulating tube. The ground lead and the thermocouple lead shall be brought through holes in the walls.

NOTE 1—Some investigators have found that a conductive coating on the inside surface of the insulating tube reduces corona.

5.4.4 A ceramic or fused-silica glass disk with a hole for the insulating tube of 5.4.3 to fit through should be placed at the bottom of the test chamber to prevent the high-voltage (bottom) electrode from shorting to the bottom of the chamber.

NOTE 2—Unless the disk fits the tube very closely, or is cemented to it, voltage breakdown may take place along the interface between the disk and the tube. For this reason, it may be necessary in some cases to use a one-piece insulator with an integral flange, or other appropriate shape to prevent breakdown in this location.

5.4.5 The glass tube and disk should be fastened to supports outside the furnace and should not touch the inside walls or other parts of the furnace.

5.4.6 Fig. 1 shows the general arrangment of the items cited in 5.4.3-5.4.5.

5.5 *Temperature Recorder*—Temperature of the specimen shall be measured with a No. 40 Awg (0.080-mm) Chromel-Alumel thermocouple. The thermocouple shall be connected to an adjustable-zero, multirange temperature recorder.

6. Surrounding Medium

6.1 In general it is preferable to test materials in the medium in which they are to be used. However in this test the surrounding medium is usually restricted to air or other gas or liquid that is stable at the test temperature.

7. Electrodes

7.1 The specimens shall have circular gold electrodes 31.75 $\pm$ 3.05 mm (1.25 $\pm$ 0.12 in.) in diameter applied to the center of each face. The gold may be applied with a brush or silk screen, and then fired in a furnace.[5]

7.2 Electrical contact to the gold electrodes on the specimen shall be made by means of two gold-plated hollow stainless steel cylinders having the same diameter as the gold electrodes as shown in Fig. 2.

7.3 The high-voltage connection shall be made to the bottom electrode. The top electrode shall be grounded.

8. Test Specimens

8.1 The test specimens shall be representative of the materials to be tested. Sufficient material shall be available to permit making ten tests.

[5] Gold electrodes that have been found satisfactory for this purpose when applied in accordance with the manufacturer's recommendations are:

(1) Liquid Bright Gold No. MM, Engelhard Industries, Inc., Hanovia Liquid Gold Div., East Newark, NJ and

(2) Vacuum-evaporated gold with suitable masks during application. (**Caution**—Significant errors may be produced if the thermocouple removes electrode material.)