INTERNATIONAL

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Standard Test Method for Thermal Endurance of Rigid Electrical Insulating Materials[1]

This standard is issued under the fixed designation D2304; 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[2] provides procedures for evaluating the thermal endurance of rigid electrical insulating materials. Dielectric strength, flexural strength, or water absorption are determined at room temperature after aging for increasing periods of time in air at selected-elevated temperatures. A thermal-endurance graph is plotted using a selected end point at each aging temperature. A means is described for determining a temperature index by extrapolation of the thermal endurance graph to a selected time.

1.2 This test method is most applicable to rigid electrical insulation such as supports, spacers, voltage barriers, coil forms, terminal boards, circuit boards and enclosures for many types of application where retention of the selected property after heat aging is important.

1.3 When dielectric strength is used as the aging criterion, it is also acceptable to use this test method for some thin sheet (flexible) materials, which become rigid with thermal aging, but is not intended to replace Test Method D1830 for those materials which must retain a degree of flexibility in use.

1.4 This test method is not applicable to ceramics, glass, or similar inorganic materials.

1.5 The values stated in metric units are to be regarded as standard. Other units (in parentheses) are provided for information.

1.6 When determining the thermal endurance of rigid EIM, the basic concepts in this standard follow IEEE 1, IEEE 98, and IEEE 101.

1.7 *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.* A specific warning statement is given in 11.3.4.

1.8 *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]

D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

D229 Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation

D570 Test Method for Water Absorption of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1830 Test Method for Thermal Endurance of Flexible Sheet Materials Used for Electrical Insulation by the Curved Electrode Method

D5423 Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation

2.2 *IEEE:*[4]

No. 1 General Principles Upon Which Temperature Limits Are Based in the Rating of Electric Equipment

No. 98 Guide for the Preparation of Test Procedures for the Thermal Evaluation of Electrical Insulating Materials

No. 101 Guide for the Statistical Analysis of Test Data

3. Terminology

3.1 *Definitions:*

3.1.1 *Arrhenius plot, n*—a graph of the logarithm of thermal life as a function of the reciprocal of absolute temperature.

[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 D09.07 on Electrical Insulating Materials.

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[2] This test method is a revision of a procedure written by the Working Group on Rigid Electrical Insulating Materials of the Subcommittee on Thermal Evaluation, IEEE Electrical Insulation Committee, which was presented as CP 59-113 at the IEEE Winter General Meeting Feb. 1–6, 1959. See references at end of this test method.

[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, 445 Hoes Ln., P.O. Box 1331, Piscataway, NJ 08854-1331.

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

3.1.1.1 *Discussion*—This is normally depicted as the best straight line fit, determined by least squares, of end points obtained at aging temperatures. It is important that the slope, which is the activation energy of the degradation reaction, be approximately constant within the selected temperature range to ensure a valid extrapolation.

3.1.2 *temperature index, n*—a number which permits comparison of the temperature/time characteristics of an electrical insulating material, or a simple combination of materials, based on the temperature in degrees Celsius which is obtained by extrapolating the Arrhenius plot of life versus temperature to a specified time, usually 20 000 h.

3.1.3 *thermal life, n*—the time necessary for a specific property of a material, or a simple combination of materials, to degrade to a defined end point when aged at a specified temperature.

3.1.4 *thermal life curve, n*—a graphical representation of thermal life at a specified aging temperature in which the value of a property of a material, or a simple combination of materials, is measured at room temperature and the values plotted as a function of time.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *rigid electrical insulating material, n*—an electrical insulating material having a minimum flexural modulus of 690 MPa and minimum use thickness of 0.5 mm (0.02 in.). It is generally used as terminal boards, spacers, coil forms, voltage barriers, and circuit boards.

4. Hazards

4.1 *High Voltage:*

4.1.1 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.

4.1.2 Solidly ground all electrically conductive parts which it is possible for a person to contact during the test.

4.1.3 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.

4.1.4 Thoroughly instruct all operators as to the correct procedures for performing tests safely.

4.1.5 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. See 11.3.4.

5. Summary of Test Method

5.1 Test specimens are aged in air at three or preferably four temperatures above the expected use temperature. The aging temperatures are selected so that the thermal life is at least 100 h at the highest aging temperature and 5000 h at the lowest aging temperature. A thermal-life curve is plotted for each aging temperature. The values of thermal life determined from the thermal-life curve are used to plot the thermal-endurance graph. A temperature index is determined from the thermal-endurance graph for each aging criterion used. (It is possible to obtain different values for the thermal index of a material with different aging criteria.)

6. Significance and Use

6.1 Thermal degradation is often a major factor affecting the life of insulating materials and the equipment in which they are used. The temperature index provides a means for comparing the thermal capability of different materials in respect to the degradation of a selected property (the aging criterion). This property needs to directly or indirectly represent functional needs in application. For example, it is possible that a change in dielectric strength will be of direct, functional importance. However, more often it is possible that a decrease in dielectric strength will indirectly indicate the development of undesirable cracking (embrittlement). A decrease in flexural strength has the potential to be of direct importance in some applications, but also has the potential to indirectly indicate a susceptibility to failure in vibration. Often, it is necessary that two or more criteria of failure be used; for example, dielectric strength and flexural strength.

6.2 Other factors, such as vibration, moisture and contaminants, have the potential to cause failure after thermal degradation takes place. In this test method, water absorption provides one means to evaluate such considerations.

6.3 For some applications, the aging criteria in this test method will not be the most suitable. Other criteria, such as elongation at tensile or flexural failure, or resistivity after exposure to high humidity or weight loss, have the potential to serve better. The procedures in this test method have the potential to be used with such aging criteria. It is important to consider both the nature of the material and its application. For example, it is possible that tensile strength will be a poor choice for glass-fiber reinforced laminates, because it is possible that the glass fiber will maintain the tensile strength even when the associated resin is badly deteriorated. In this case, flexural strength is a better criterion of thermal aging.

6.4 When dictated by the needs of the application, it is possible that an aging atmosphere other than air will be needed and used. For example, thermal aging can be conducted in an oxygen-free, nitrogen atmosphere.

7. End Point

7.1 An expression of the thermal life of a material, even for comparative purposes only, inevitably involves the choice of an end point. The end point is one of the following 4 criteria: a fixed magnitude of the property criterion, a percentage reduction from its initial magnitude, the minimum magnitude obtainable with time (that is, when change with time ceases), or a fixed degrading change rate (that is, a fixed value for the negative derivative of property with respect to time).

7.2 Experience has shown that the choice of an end point can affect the comparative thermal life. A choice of end points