Designation: D2307 – 21

Standard Test Method for Thermal Endurance of Film-Insulated Round Magnet Wire[1]

This standard is issued under the fixed designation D2307; 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 determination of the thermal endurance of film-insulated round magnet wire in air at atmospheric pressure. It is not applicable to magnet wire with fibrous insulation, such as cotton or glass.

1.2 This test method covers the evaluation of thermal endurance by observing changes in response to ac proof voltage tests. The evaluation of thermal endurance by observing changes in other properties of magnet wire insulation requires the use of different test methods.

1.3 It is possible that exposure of some types of film insulated wire to heat in gaseous or liquid environments in the absence of air will give thermal endurance values different from those obtained in air. Consider this possibility when interpreting the results obtained by heating in air with respect to applications where the wire will not be exposed to air in service.

1.4 It is possible that electric stress applied for extended periods at a level exceeding or even approaching the discharge inception voltage will change significantly the thermal endurance of film insulated wires. Under such electric stress conditions, it is possible that comparisons between materials will also differ from those developed using this method.

1.5 This test method is similar to IEC 60172. Differences exist regarding specimen preparation.

1.6 The values stated in inch-pound units are to be regarded as the standard. The SI units in parentheses are provided for information only and are not considered standard.

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.*

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:*[2]

D1676 Test Methods for Film-Insulated Magnet Wire

D1711 Terminology Relating to Electrical Insulation

D3251 Test Method for Thermal Endurance Characteristics of Electrical Insulating Varnishes Applied Over Film-Insulated Magnet Wire

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

2.2 *Other Standards:*

IEC 60172 Test Procedure For The Determination Of The Temperature Index Of Enamelled Winding Wires[3]

IEEE 101 Guide for the Statistical Analysis of Thermal Life Test Data[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *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.

3.1.2 *thermal endurance, n*—an expression for the stability of an electrical insulating material, or a simple combination of materials, when maintained at elevated temperatures for extended periods of time.

3.2 *Definitions of Terms Specific to This Standard:*

[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 D09.17 on Fire and Thermal Properties.

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[2] 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.

[3] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, 1st floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, https://www.iec.ch.

[4] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., Piscataway, NJ 08854-4141, http://www.ieee.org.

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

FIG. 1 Device for Preparing Twisted Pair Specimens, Motorized Unit

3.2.1 *specimen failure time, n*—the hours at the exposure temperature that have resulted in a specimen failing the proof test (see 9.1).

3.2.2 *thermal endurance cycle, n*—one oven exposure period followed by a proof voltage test.

3.2.3 *time to failure, n*—the log average hours calculated for a set of specimens, calculated from the individual specimen failure times at an exposure temperature (see 9.2).

3.3 For definitions of terms related to electrical insulation, see Terminology D1711.

4. Summary of Test Method

4.1 This test method specifies the preparation of specimens, the exposure of these specimens at elevated temperatures, and the periodic testing of the specimens by applying a preselected proof voltage.

4.2 The cyclic exposure to temperature is repeated until a sufficient number of specimens have failed to meet the proof test, and the time to failure is calculated in accordance with Section 9. The test is carried out at three or more temperatures. A regression line is calculated in accordance with Section 10, and the time to failure values plotted on thermal endurance graph paper (see Fig. 6) as a function of the exposure temperature.

5. Significance and Use

5.1 This test method is useful in determining the thermal endurance characteristics and thermal indices of film-insulated round magnet wire in air (see 1.3). This test method is used as a screening test before making tests of more complex systems or functional evaluation. It is also used where complete functional systems testing is not feasible.

5.2 Experience has shown that film-insulated wire and electrical insulating varnishes or resins can affect one another during the thermal exposure process. Test Method D3251 provides indications on the thermal endurance for a combination of insulating varnish or resin and film insulated wire. It is possible that interaction between varnish or resin and film insulation will increase or decrease the relative thermal life of the varnish and film insulated wire combination compared with the life of the film insulated wire tested without varnish.

5.3 The conductor type or the surface condition of the conductor will affect the thermal endurance of film-insulated magnet wire. This test method is used to determine the thermal endurance characteristics of film insulation on various kinds of conductors. The use of sizes other than those specified in 7.1.1 is permissible but is not recommended for determining thermal endurance characteristics.

5.4 The temperature index determined by this test method is a nominal or relative value expressed in degrees Celsius at 20 000 h. It is to be used for comparison purposes only and is not intended to represent the temperature at which the film insulated wire could be operated.

5.5 There are many factors that influence the results obtained with this test method. Among the more obvious are the following:

5.5.1 Wire size and film thickness.

5.5.2 Moisture conditions during proof voltage tests.

5.5.3 Oven construction:

5.5.3.1 Velocity of air.

5.5.3.2 Amount of replacement air.

5.5.3.3 Elimination of products of decomposition during thermal exposure.

5.5.3.4 Oven loading.

5.5.3.5 Accuracy with which the oven maintains temperature.

5.5.4 In most laboratories, the number of thermal endurance ovens is limited and, therefore, many different sets of specimens are thermally exposed in the same oven. All specimens are not necessarily removed each time the oven is opened. This extra temperature cycling will possibly have a degrading influence.

5.5.5 Care with which specimens are handled, especially during latter cycles when the insulation becomes brittle.

5.5.6 Vibration of specimens will have a degrading effect during the later thermal endurance cycles.

5.5.7 Electrical characteristics of dielectric test instrument. Refer to 8.4 and 8.5.

5.5.8 Environmental factors such as moisture, chemical contamination, and mechanical stresses, or vibration are factors that will possibly result in failure after the film insulated wire has been weakened by thermal deterioration and are more appropriately evaluated in insulation system tests.