



# Standard Test Method for Thermal Endurance of Electrical Insulating Varnishes by the Helical Coil Method<sup>1</sup>

This standard is issued under the fixed designation D3145; 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 ( $\epsilon$ ) 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 covers the determination of the thermal endurance of electrical insulating varnishes alone or in combinations with magnet wire insulation. Changes in the helical coil bond strength are used as the test criteria. The coils are made from bare aluminum or copper wire, or from film- or fiber-insulated magnet wire.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

NOTE 1—There is no similar or equivalent IEC standard.

1.3 *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 a specific precautionary statement, see Section 7.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

[D618 Practice for Conditioning Plastics for Testing](#)

[D1711 Terminology Relating to Electrical Insulation](#)

[D1932 Test Method for Thermal Endurance of Flexible Electrical Insulating Varnishes](#)

[D2307 Test Method for Thermal Endurance of Film-Insulated Round Magnet Wire](#)

[D2519 Test Method for Bond Strength of Electrical Insulating Varnishes by the Helical Coil Test](#)

[D3251 Test Method for Thermal Endurance Characteristics of Electrical Insulating Varnishes Applied Over Film-Insulated Magnet Wire](#)

~~[D3850 Test Method for Rapid Thermal Degradation of Solid Electrical Insulating Materials By Thermogravimetric Method \(TGA\)](#)~~

[D5423 Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation](#)

~~[D6054 Practice for Conditioning Electrical Insulating Materials for Testing \(Withdrawn 2012\)](#)~~<sup>3</sup>

### 2.2 International Electrotechnical Commission Publications:<sup>3</sup>

[IEC 60216-1 Guide for the Determination of Thermal Endurance Properties of Electrical Insulation Materials \(Part 1\)](#)

## 3. Terminology

### 3.1 Definitions

3.1.1 For definitions of terms used in the test method, refer to Terminology [D1711](#).

### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *bond strength, n*—a measure of the force required to separate surfaces which have been bonded together.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee [D09](#) on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee [D09.01](#) on Electrical Insulating Varnishes, Powders and Encapsulating Compounds.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

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

3.2.2 *magnet wire, n*—a metal electrical conductor, covered with electrical insulation, for use in the assembly of electrical inductive apparatus such as coils for motors, transformers, generators, relays, magnets, etc.

#### 3.2.2.1 Discussion—

The electrical insulation is usually composed of a film covering formed from a magnet wire enamel applied over a bare conductor. In some specific applications, fibrous coverings, either taped or linear filament served, are also used as electrical insulation.

3.2.3 *varnish, electrical insulating, n*— a liquid resin system that is applied to and cured on electrical components providing electrical, mechanical and environmental protection.

#### 3.2.3.1 Discussion—

There are two types of electrical insulating varnishes—solvent-containing and solventless. Solvent-containing types are solutions, dispersions or emulsions of a polymer or a mixture of polymers in a volatile, nonreactable liquid. Solventless types are liquid resin systems free of volatile, nonreactable solvents.

### 4. Summary of Test Method

4.1 Flexural strength of the helical coils is measured periodically after exposure to several exposure temperatures. The time to reach an arbitrarily selected value of bond strength at each exposure temperature is determined. The logarithms of these times in hours are plotted as a function of the reciprocal temperature (1/K) to give an Arrhenius plot.

### 5. Significance and Use

5.1 This test method is used to determine the effect of exposure to elevated temperatures on the bond strength of combinations of magnet wire insulations and electrical insulating varnishes. The results are used as a guide for the comparison and selection of varnishes and combinations of varnishes and magnet wire insulation for specific applications. Test Methods [D1932](#), ~~[D3251](#)~~, and ~~[D3850](#)~~[D3251](#) describe additional tests for determining the thermal endurance of insulating varnishes. A comprehensive evaluation of thermal characteristics includes a comparison of the thermal endurance determined in these different ways.

5.2 This test method is useful for research and product qualifications purposes.

### 6. Apparatus

6.1 *Testing Machine*, see Test Method [D2519](#). [ASTM D3145-13](#)

6.2 *Test Fixture*, see Test Method [D2519](#). [standards/sist/4a4bfd7e-7e67-45eb-93cb-e53f78b30d6a/astm-d3145-13](#)

6.3 *Ovens*, see Specification [D5423](#), Type II.

### 7. Hazards

7.1 It is unsafe to use varnish at temperatures above flash point without adequate ventilation, especially if the possibility exists that flames or sparks are present. Store varnish in sealed containers.

### 8. Test Specimen

8.1 Prepare 60 or more specimens for each exposure temperature, following the procedure specified in Test Method [D2519](#).

### 9. Selection of Test Temperatures

9.1 Expose the material to at least three temperatures. Choose the lowest temperature such that it is not more than 25°C higher than the estimated temperature index. Separate exposure temperatures from each other by at least 10°C, preferably 20°C.

9.2 Select exposure temperatures in accordance with those shown in [Table 1](#) as indicated by the anticipated temperature index of the material under test. It is recommended that exploratory tests be first made at the highest temperature to obtain data establishing the 100 h minimum endpoint time requirement, and that this be used as a guide for the selection of the lower test temperatures.

9.3 Choose the exposure temperature so that any essentially linear portions of the Arrhenius plot (log of time to failure versus the reciprocal of the absolute temperature) is well established; that is, confirm the suspicion of significant nonlinearity by test at one or more additional temperatures. Generally the additional temperatures are lower than the ones previously tested.

### 10. Procedure

10.1 Suspend at least 20 sets of coils containing at least 3 coils in each set vertically in each oven.