Designation: ~~D3145 – 18~~ D3145 – 20

Standard Test Method for Thermal Endurance of Electrical Insulating Varnishes by ~~the~~ Helical Coil Method[1]

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 (ε) 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see Section 7.

1.4 *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]

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

2.2 *International Electrotechnical Commission ~~Publications:~~ Publication:*[3]

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

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[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 D09.01 on Electrical Insulating Products.

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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 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. Terminology

~~3.1 *Definitions*~~

~~3.1.1 For definitions of terms used in the test method, refer to Terminology D1711.~~

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

3.1.2.1 *Discussion—*
There are two types of electrical insulating varnish: solvent-containing and solventless. The solvent-containing varnish is a solution, dispersion, or emulsion of a polymer or mixture of polymers in a volatile, nonreactable liquid. The solventless type is a liquid resin system free of volatile, nonreactable solvents.

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.

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, and so forth.

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 and 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.

6.2 *Test Fixture,* see Test Method D2519.

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~~25 °C higher than the estimated temperature index. Separate exposure temperatures from each other by at least ~~10°C,~~10 °C, preferably ~~20°C.~~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) are well established. 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 three coils in each set vertically in each oven.

10.2 Periodically remove one set of coils and condition 2 h at 23 ± ~~2°C~~2 °C and less than 55 % RH. Measure flexural strength at room temperature in accordance with Test Method D2519.

10.3 The length of the exposure period and the number of coils tested per cycle will depend on the deterioration rate at each exposure temperature. The exposure period will be longer at the start, shorter as the deterioration rate increases.

10.4 Continue the test until the breaking strength reaches less than ~~22 N (5 lbf).~~ 5 lbf (22 N). The end point is that point where the curve intersects the ~~22-N (5-lbf)~~5-lbf (22 N) line, or other specified value.

11. Calculation

11.1 Plot the breaking strength value after each exposure period versus time in hours on a three-decade semilog paper with time as the ordinate.

TABLE 1 Suggested Exposure Temperatures and Cycle Durations[A]

Cycle Duration, day	Temperatures Corresponding to the Estimated Temperature Index Range, °C[B,C]													
	Class 105			Class 130		Class 155			Class 180		Class 200		Class 220	
	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to 189	190 to 199	200 to 209	210 to 219	220 to 229	230 to 239
1	170	180	190	200	210	220	230	240	250	260	270	280	290	300
2	160	170	180	190	200	210	220	230	240	250	260	270	280	290
4	150	160	170	180	190	200	210	220	230	240	250	260	270	280
7	140	150	160	170	180	190	200	210	220	230	240	250	260	270
14	130	140	150	160	170	180	190	200	210	220	230	240	250	260
28	120	130	140	150	160	170	180	190	200	210	220	230	240	250
49	110	120	130	140	150	160	170	180	190	200	210	220	230	240

[A] Taken from IEC Publication 60216-1.
[B] Exposure temperatures above and below those given are to be selected by experimentation.
[C] Range to which the temperature is assumed to correspond to an extrapolated ~~20 000 h~~ 20 000 h time to failure.