Designation: D2519 – 19a

Standard Test Method for Bond Strength of Electrical Insulating Varnishes by the Helical Coil Test[1]

This standard is issued under the fixed designation D2519; 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 determination of the bond strength of an electrical insulating varnish when applied to a helical coil. The helical coil can be made from bare aluminum or copper wire or from film or fiber-insulated magnet wire. Helical coils made from bare aluminum or bare copper wire will yield values of bond strength for the varnish when applied to bare metal conductors. The use of film or fiber-insulated magnet wire will show values for that particular combination of insulation and varnish.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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.* 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]

D115 Test Methods for Testing Solvent Containing Varnishes Used for Electrical Insulation

D1711 Terminology Relating to Electrical Insulation

D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)[3]

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method refer to Terminology D1711.

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *event time*—the time between initial application of a physical or electrical stress and failure of the specimen under test.

3.2.2 *response time*—the time required for an indicating or recording device to react to change in stress on a specimen under test.

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 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.

4. Summary of Test Method

4.1 Flexural strength tests are made on varnish-treated helical coils to determine the force required to break the coil under specified conditions.

5. Significance and Use

5.1 Values obtained by flexural tests can provide information with regard to the bond strength of the particular varnish,

[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.

Current edition approved Nov. 1, 2019. Published November 2019. Originally approved in 1966. Last previous edition approved in 2019 as D2519 – 19. DOI: 10.1520/D2519-19A.

[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] The last approved version of this historical standard is referenced on www.astm.org.

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

in combination with a particular wire, when measured under conditions described in this test method.

6. Apparatus

6.1 *Tensile Testing Machine*—Use an adjustable-speed drive and a suitable instrument for measuring force to break the specimen. Available tensile testing machines or an accurate spring gauge and a separate adjustable-speed drive are suitable. To cover the range of load strength values which are commonly encountered it is recommended that a multirange tester be used.

6.1.1 It has been found that gages rated 5, 25, 150, and 500 N (1, 5, 30, and 100 lbf) are adequate to cover the range of varnishes.

6.2 *Test Fixture*—The test fixture consists of two rollers, attached to a common frame, and a 90° V-block. One part, either the rollers or the V-block, is held stationary while the other part is moved. No friction contact which will affect this movement is allowed. The general shape and the relative position of these parts are shown in Fig. 1. The rollers have a diameter of 9.5 mm (0.375 in.) at the center and are parallel having a center-to-center distance of 44.5 mm (1.75 in.). The 90° V-block has a radius at the apex of 0.8 mm (0.03 in.).

6.3 *Test Fixture Enclosure*—For tests at other than room temperature, use an insulated heat-resistant enclosure, designed to fit around the test fixture and connected to the tension testing machine. This enclosure permits a frictionless connection between the test fixture and the instrument that measures the breaking force. The enclosure is designed with a suitable location for holding six or more specimens. It is heated or cooled by a separate source of uniformly circulating hot or cold air. The temperature control system is capable of returning the test specimens and the chamber to the test temperature in less than 10 min. A thermostatic control, with the measuring thermocouple located within 25 mm (1.0 in.) of the center of the coil being tested, is set to maintain the temperature of the chamber to within ±2°C of the desired temperature after the temperature has stabilized.

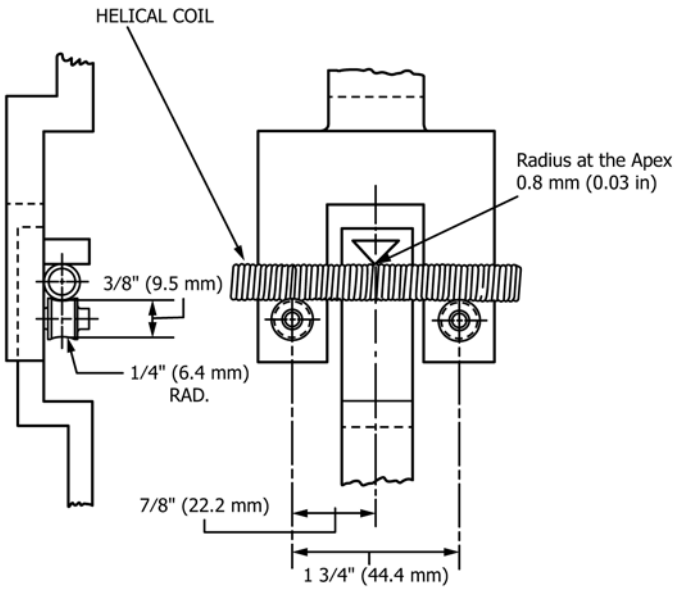

FIG. 1 Test Fixture for Bond Strength Test

7. Safety Precautions

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

8. Test Specimens

8.1 The test specimens are 75 mm (3 in.) long coils of No. 18 AWG wire, cut from a helix of convenient length which has been wound without space between turns on a 6 mm (0.25 in.) diameter mandrel. Bend the last loop on each end of the coil to approximately 90° to the coil to provide a means of support. Treat the coil with the varnish to be tested. Make the helical coils as agreed to by interested parties from one of the following:

8.1.1 Bare aluminum wire,

8.1.2 Bare copper wire,

8.1.3 Film-coated magnet wire, or

8.1.4 Fiber-insulated magnet wire.

NOTE 1—A practical method of winding a tight helical coil is to guide the wire from the rotating reel between folds of a clean cloth onto the rotating mandrel using moderate hand tension. Maintain a trailing angle of 1 to 5° from a perpendicular to the mandrel. When the wire is cut, the coil must be restrained to avoid rapid spring back.

8.2 Prepare six or more specimens for each condition to be investigated.

8.3 Adjust the viscosity of the varnish to be tested, by trial, to produce a dry film build of 0.043 to 0.053 mm (0.0017 to 0.0021 in.) on a metal panel double coated in accordance with Test Methods D115.

8.4 Use solventless varnish in the “as received” condition.

8.5 Immerse coils made from bare wire in a solvent of 50 % toluene and 50 % denatured alcohol by weight for 30 min. Remove and dry for 15 min at 100°C before treating with varnish. Do not clean coils made from insulated wire before treating with varnish.

8.6 Attach several coils to a rack and immerse vertically in the varnish until bubbling stops. Withdraw them at 100 ± 5 mm⁄min (4 ± 0.2 in.⁄min) and allow them to drain 10 to 30 min at 23 ± 2°C and less than 55 % RH. Place the coils in an oven in the same position as dipped at the temperature and for the time specified by the manufacturer. For solvent containing varnishes, reverse dip and bake the coils, following the above procedure.

9. Procedure

9.1 *Rate of Loading*—Adjust the testing machine to a crosshead speed of 50 mm/min (2 in./min).

9.1.1 Position the coils in the test fixture with the center of the coils below the V-block. Each coil is broken only once.

9.2 *Number of Specimens*—Test a minimum of five specimens for each condition. It is allowable to use one of the original six specimens for adjusting the testing machine.