Designation: D 2519 – 02

An American National Standard

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

This standard is issued under the fixed designation D 2519; 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 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 and health practices and determine the applicability of regulatory limitations prior to use.* See Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*

D 115 Test Methods for Testing Solvent Containing Varnishes Used for Electrical Insulation[2]

D 1711 Terminology Relating to Electrical Insulation[2]

D 6054 Practice for Conditioning Electrical Insulating Materials for Testing[3]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *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 See Terminology D 1711 for definitions of other terms relating to electrical insulation.

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

6. Apparatus

6.1 *Tensile Testing Machine*—An adjustable-speed drive and a suitable instrument for measuring force should be used in breaking the specimen. This may be in the form of one of the generally available tensile testing machines, or may be simply an accurate spring gage and a separate adjustable-speed drive.[5] 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 shall consist 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. There shall be no friction contact which will affect this movement. The general shape and the

[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 Varnishes, Powders and Encapsulating Compounds.

Current edition approved Sept. 10, 2002. Published October 2002. Originally published as D 2519 – 66 T. Last previous edition D 2519 – 01.

[2] *Annual Book of ASTM Standards*, Vol 10.01.

[3] *Annual Book of ASTM Standards*, Vol 10.02.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] Spring gages from John Chattilon and Sons, 83-30 Kew Gardens Road, Kew Gardens, NY 11415 or from Hunter Spring Co., One Spring Avenue, Hatfield, PA 19440, or its equivalent, have been found satisfactory for this purpose.

relative position of these parts is shown in Fig. 1. The rollers shall have a diameter of 9.5 mm (0.375 in.) at the center and shall be parallel having a center-to-center distance of 44.5 mm (1.75 in.). The 90° V-block shall have 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 should permit a frictionless connection between the test fixture and the instrument that measures the breaking force. The enclosure should have a suitable location for holding six or more specimens. It should be heated or cooled by a separate source of uniformly circulating hot or cold air. The temperature control system should be 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, should be set to maintain the temperature of the chamber to within ±2°C of the desired temperature after the temperature has stabilized.

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 supplier and user 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. A trailing angle of 1 to 5° from a perpendicular to the mandrel should be maintained. When the wire is cut, the coil must be restrained to avoid rapid spring back.

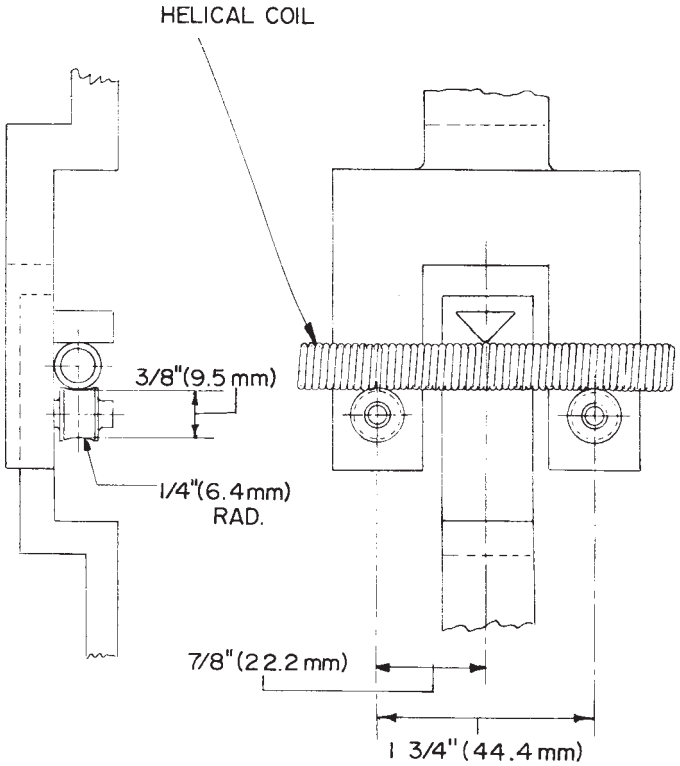

FIG. 1 Test Fixture for Bond Strength Test

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 D 115.

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 the Standard Laboratory Atmosphere in accordance with Practice D 6054. 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 should be broken only once.

9.2 *Number of Specimens*—Test a minimum of five specimens for each condition. One of the original six specimens may be used for adjusting the testing machine.

9.3 *Selection of Test Range*—Select the proper test range which must correspond to the specified rate of loading. The proper test range is the one where the anticipated bond strength will be reached in the middle or upper portion of the test range, whenever possible. For testers with chart recorders it is essential that the test range be selected in such a manner that the event time is greater than the response time of the recorder.

9.4 *Tests at Other than Room Temperature*:

9.4.1 Adjust the temperature control until the temperature of the chamber becomes constant within ±2°C of the specified test temperature.

9.4.2 Place one specimen in the test fixture. Place the remaining specimens in the enclosure. Allow the enclosure to

stabilize for 5 ± 1 min at the test temperature. Break the specimen in the test fixture as described in 9.1-9.3.

9.4.3 Replace broken specimen with an untested specimen from within the enclosure. Allow enclosure to stabilize for approximately 1 min at the test temperature. Break the specimen in the test fixture as described in 9.1-9.3.

9.4.4 Repeat 9.4.3 for the remaining specimens.

10. Report

10.1 Report the following information:

10.1.1 Description of varnish,

10.1.2 Identification of wire used,

10.1.3 Cure time and temperature for each coat and number of dips used to prepare the coils, and

10.1.4 The individual values in newtons (pounds-force) of bond strength and their averages at each test condition.

11. Precision and Bias

11.1 *Precision*—Table 1 lists the results based on a round robin test conducted in accordance with Practice E 691 involving six laboratories and three materials. Each test result was the average of five specimens. Each laboratory obtained two test results for each material.

11.2 *Bias*—This test method has no bias because the value for bond strength of electrical insulating varnishes by the helical coil test is determined solely in terms of this test method.

Combined data from six laboratories:
Mean = 220.6 N (49.6 lbf)
Standard deviation = 41.99 N (±6.96 lbf)
95 % Confidence level = 82.25 N (±13.64 lbf)

12. Keywords

12.1 bond strength; helical coil; varnish

TABLE 1 Results inNewtons

Material	Average	Standard Deviation	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
Solvent Varnish	97.21	13.92	1.75	12.81	4.90	35.87
Unsaturated Polyester	166.76	34.03	6.26	31.59	17.53	88.45
Epoxy	208.43	37.45	10.41	35.48	29.15	99.34