Designation: D349 – 13

Standard Test Methods for Laminated Round Rods Used for Electrical Insulation[1]

This standard is issued under the fixed designation D349; 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 These test methods cover the procedures for testing rigid round rods used in electrical insulation. These round rods include many types made from fibrous sheets of basic materials, such as cellulose, glass, or nylon in the form of paper, woven fabrics, or mats, bonded together by natural or synthetic resins, or by adhesives. Such round rods include vulcanized fiber and thermosetting laminates as well as round rods made from cast, molded, or extruded natural or synthetic resins, with or without fillers or reinforcing materials.

1.2 The procedures appear in the following sections:

	Section
Compressive strength (axial)	20 – 25
Density	28 – 30
Dielectric strength	31 – 39
Flexural strength	13 – 19
Tensile strength	7 – 12
Water absorption	26-27

1.3 The values stated in inch-pound units are to be regarded as the standard.

1.4 *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 warning statement see 36.2.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

D570 Test Method for Water Absorption of Plastics

D668 Test Methods of Measuring Dimensions of Rigid Rods and Tubes Used for Electrical Insulation

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D1711 Terminology Relating to Electrical Insulation

D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)[3]

3. Terminology

3.1 *Definitions*—Use Terminology D1711 for definitions of terms used in these test methods and associated with electrical or electronic insulation materials.

4. Selection of Test Specimens

4.1 Specimens for tests shall be selected from portions of material that are free of obvious defects unless the purpose of the test is to evaluate the effect of these defects.

5. Conditioning

5.1 In order to eliminate the effects of previous history of humidity exposure and to obtain reproducible results (Note 1), in all cases of dispute give the test specimens of laminated rods a conditioning treatment for physical test as follows:

5.1.1 *Tensile, Flexural, and Compressive Strengths, and Density*—Prior to test, condition the machined specimens in accordance with Procedure B of Practice D6054. All specimens shall be tested at room temperature maintained at 23 ± 5 °C.

NOTE 1—The following are potential reasons to undertake conditioning of specimens: (*a*) for the purpose of bringing the material into equilibrium with normal or average room conditions of 23 °C and 50 % relative humidity; (*b*) simply to obtain reproducible results, irrespective of previous history of exposure; or (*c*) to subject the material to abnormal conditions of temperature or humidity in order to predict its service behavior.

The conditions given here to obtain reproducible results will give physical values which could be somewhat higher or somewhat lower than values under equilibrium at normal conditions, depending upon the particular material and test. To ensure substantial equilibrium under normal conditions of humidity and temperature, however, will require from 20 to 100 days or more depending upon thickness and type of material and its previous history. Consequently, conditioning for reproducibility must of necessity be used for general purchase specifications and product control tests.

[1] These test methods are under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and are the direct responsibility of Subcommittee D09.07 on Flexible and Rigid Insulating Materials.

Current edition approved Nov. 1, 2013. Published November 2013. Originally approved in 1932. Last previous edition approved in 2007 as D349 – 07. DOI: 10.1520/D0349-13.

[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**

6. Dimensional Measurements

6.1 Make dimensional measurements of rods in accordance with Test Methods D668.

TENSILE STRENGTH

7. Significance and Use

7.1 This test method is designed to provide data for the control and specification of materials and for characterization purposes in research and development of new materials. It is possible that the tensile properties will vary with the size of specimens and the speed of testing. Consequently, these factors along with others noted herein must be controlled where precise comparative results are desired.

8. Apparatus

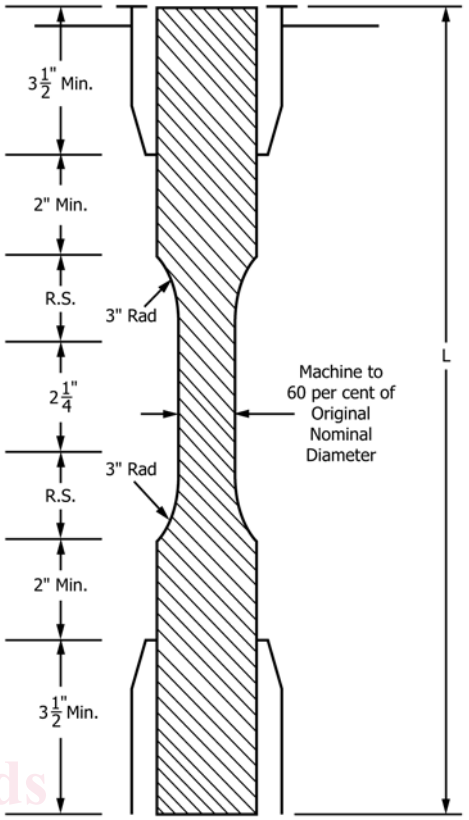
8.1 Any testing machine is acceptable for use provided it is accurate to 1 % of the lowest breaking force to be applied. Use jaws which tighten under load, such as wedge grip jaws, with the specimen properly aligned.

9. Test Specimens

9.1 Prepare the test specimen as shown in Fig. 1. The length, *L*, is as shown in Table 1. Machine a groove around the specimen at the center of its length so that the diameter of the machined portion is 60 % of the original nominal diameter. This groove consists of a straight section 2 ¼ in. (57 mm) in length with a radius of 3 in. (76 mm) at each end joining it to the outside diameter.

10. Procedure

10.1 Adjust the crosshead speed of the testing machine not to exceed 0.050 in. (1.27 mm)/min when running idle and test five specimens.



Metric Equivalents

in.	mm
2	50.8
2¼	57.1
3	76.2
3½	88.9

FIG. 1 Diagram Showing Location of Rod Tension Test Specimen in Testing Machine

11. Report

11.1 Report the following information:

11.1.1 The average diameter of the specimen, expressed to the nearest 0.001 in. (0.0254 mm), determined from at least two measurements 90° apart,

11.1.2 The average diameter of the reduced section, expressed to the nearest 0.001 in. (0.025 mm), determined from at least two measurements 90° apart,

11.1.3 Crosshead speed in inches per minute (or millimetres).

11.1.4 The breaking load of each specimen in pounds-force (or newtons),

11.1.5 The tensile strength of each specimen in pounds-force per square inch, (or pascals), and

11.1.6 The room temperature in degrees Celsius.

12. Precision and Bias

12.1 *Precision*—This test method has been in use for many years, but no statement of precision has been available and no activity is planned to develop such a statement.

12.2 *Bias*—A statement of bias is not applicable in view of the lack of a standard reference material for this property.

FLEXURAL STRENGTH

13. Significance and Use

13.1 Flexural strength data are useful for the control and specification of materials and to provide guidance in the design of electrical equipment. Flexural properties have the potential to vary with the size of the specimens and the speed of testing. Consequently, these factors, together with others noted herein, must be controlled where precise comparative results are desired.

14. Apparatus

14.1 Any testing machine is acceptable for use provided it is accurate to 1 % of the lowest breaking force to be applied.

15. Test Specimens

15.1 Prepare the test specimen with a diameter equal to that of the rod and a length eight times the diameter, plus 1 in. (25.4 mm) for rods under ½ in. (12.7 mm) in diameter. For rods over ½ in. and up to 2 in. (50.8 mm) in diameter, machine specimens to a diameter of ½ in. and cut to a length of 6 in. (152.4 mm).

TABLE 1 Dimensions of Rod Specimens

Nominal Diameter, in. (mm)	Length of Radial Sections 2 RS, in. (mm)	Total Calculated Minimum Length of Specimen, in. (mm)	Standard Length, *L*, of Specimen to be Used for 3 ½ in. (88.9 mm) Jaws[A]
⅛ (3.2)	0.773 (19.63)	14.02 (35.61)	15 (381.0)
3⁄16 (4.8)	0.946 (24.03)	14.20 (36.06)	15 (381.0)
¼ (6.4)	1.091 (27.71)	14.34 (36.42)	15 (381.0)
⅜ (9.5)	1.333 (33.86)	14.58 (37.03)	15 (381.0)
½ (12.7)	1.563 (38.01)	14.79 (37.56)	15.75 (400.0)
⅝ (15.9)	1.714 (43.56)	14.96 (37.99)	15.75 (400.0)
¾ (19.0)	1.813 (46.05)	15.12 (38.40)	15.75 (400.0)
⅞ (22.1)	2.019 (51.28)	15.27 (38.78)	15.75 (400.0)
1 (25.4)	2.154 (54.71)	15.40 (39.11)	16.5 (414.0)
1¼ (31.8)	2.398 (60.90)	15.65 (39.75)	16.5 (414.0)
1½ (38.0)	2.615 (66.42)	15.87 (40.31)	16.5 (414.0)
1¾ (44.5)	2.812 (70.41)	16.06 (40.79)	16.5 (414.0)
2 (50.8)	2.993 (76.02)	16.24 (41.25)	17 (432.0)

[A] For other jaws greater than 3 ½ in. (88.9 mm), the standard length shall be increased by twice the length of the jaw minus 7 in. (177.8 mm). The standard length permits a slippage of approximately ¼ to ½ in. (6.35 to 12.7 mm) in each jaw while maintaining maximum length of jaw grip.

15.2 When the rod being tested is not circumferentially isotropic, prepare specimens for testing in both of the principal directions, and identify them as to directionality. This particularly includes rods machined from stripmolded or sheet stock.

16. Procedure

16.1 Test five specimens for each laminate orientation, each as a simple beam loaded at the center. The distance between the supports shall be eight times the diameter of the rod. The supports shall have contact edges rounded to a radius of ⅛ in. (3.2 mm). Adjust the crosshead speed of the testing machine not to exceed an idle speed of 0.050 in./min (1.27 mm/min) and apply the load through a steel block having a semi-circular contact edge of the same radius as the rod, with edges rounded to a radius of ⅛ in. (3.2 mm).

17. Calculation

17.1 Calculate the maximum fiber stress, S, as follows:

$$S = 8\,WL/\pi d^{3} \tag{1}$$

where:

W = breaking load, lbf (N),
L = distance between supports, in. (mm), and
d = diameter, in (mm).

18. Report

18.1 Report the following information:

18.1.1 The diameter of the specimen expressed to the nearest 0.001 in. (0.0254 mm), determined from at least two measurements 90° apart,

18.1.2 Crosshead speed in inches per minute (or millimetres),

18.1.3 The breaking load of each specimen in pounds-force (or newtons),

18.1.4 The maximum fiber stress S, in pounds-force per square inch (pascals), and

18.1.5 The direction of loading relative to the direction of the laminate if the rods are ground from strip-molded stock, sheet stock, and vulcanized fiber.

19. Precision and Bias

19.1 *Precision*—This test method has been in use for many years, but no statement of precision has been available and no activity is planned to develop such a statement.

19.2 *Bias*—A statement of bias is not applicable in view of the lack of a standard reference material for this property.

COMPRESSIVE STRENGTH (AXIAL)

20. Significance and Use

20.1 Compression tests, properly interpreted, provide reasonably accurate information with regard to the compressive properties of rigid round rods when employed under conditions approximating those under which the tests are made. The compressive strength values have the potential to vary with the size of the rigid round rod, and with temperature and atmospheric conditions. Compression tests provide data potentially useful for research and development, engineering design, quality control, and acceptance or rejection under specifications.

21. Apparatus

21.1 Any testing machine is acceptable for use provided it is accurate to 1 % of the lowest breaking force to be applied. One end of the specimen shall bear upon an accurately centered spherical bearing block, located, whenever practicable, at the top. The metal bearing plates shall be directly in contact with the ends of the test specimen.

22. Test Specimens

22.1 Unless otherwise specified in the test method or specification for that material, test the samples as received. For rods ⅛ to 1 in. (3.2 to 25.4 mm) in diameter, prepare the test specimen with a diameter equal to the diameter of the rod, and length conforming to the following requirements:

Diameter, in. (mm)	Length, in. (mm)	Slenderness Ratio
⅛ to ¼ (3.2 to 6.4) incl	½ (12.7)	16 to 8
Over ¼ to ½ (6.4 to 12.7) incl	1 (25.4)	16 to 8
Over ½ to 1 (12.7 to 25.4) incl	2 (50.8)	16 to 8