Designation: D229 – 13

Standard Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation[1]

This standard is issued under the fixed designation D229; 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 These test methods cover procedures for testing rigid electrical insulation normally manufactured in flat sheet or plate form. They are generally used as terminal boards, spacers, voltage barriers, and circuit boards.

1.2 Use Test Methods D619 (withdrawn) or Specification D710 for tests applying to vulcanized fibre.

1.3 Some of the test methods contained in this standard are similar to those contained in IEC 60893-2, which applies to rigid industrial laminated sheets based on thermosetting resins for electrical purposes.

1.4 The test methods appear in the following sections:

Test	Sections	ASTM Test Method
Acetone extractable matter	83 to 84	D494
Arc resistance	47	D495
Ash	56 to 60	...
Bonding strength	49 to 54	...
Burning rate and flame resistance	61 to 75	...
Compressive strength	25	D695
Conditioning	4	D6054
Dissipation factor	34 to 40	D669
Dielectric strength	28 to 33	D149
Expansion (linear thermal)	76	D696
Flexural properties	12 to 24	D790
Hardness (Rockwell)	55	D785
Insulation resistance and resistivity	41 to 46	D257
Permittivity	34 to 40	D150
Resistance to impact	26	D256
Tensile properties	7 to 11	D638
Thickness	5 to 6	D374
Tracking resistance	48	D2132
Warp or twist	77 to 82	...
Water absorption	27	D570

1.5 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.

1.6 This is a fire-test-response standard. See Sections 61 through 75, which are the procedures for burning rate and flame resistance.

1.7 *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.* Specific precautionary statements are given in 31.1 and 1.8.

1.8 *This standard measures and describes the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.*

1.9 *Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.*

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

D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation

D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

D257 Test Methods for DC Resistance or Conductance of Insulating Materials

D374 Test Methods for Thickness of Solid Electrical Insulation (Withdrawn 2013)[3]

D494 Test Method for Acetone Extraction of Phenolic Molded or Laminated Products

D495 Test Method for High-Voltage, Low-Current, Dry Arc

[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 1925. Last previous edition approved in 2009 as D229 – 09b. DOI: 10.1520/D0229-13.

[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**

Resistance of Solid Electrical Insulation
D570 Test Method for Water Absorption of Plastics
D617 Test Method for Punching Quality of Phenolic Laminated Sheets (Withdrawn 2003)[3]
D619 Test Methods for Vulcanized Fibre Used for Electrical Insulation
D638 Test Method for Tensile Properties of Plastics
D669 Test Method for Dissipation Factor and Permittivity Parallel with Laminations of Laminated Sheet and Plate Materials (Withdrawn 2012)[3]
D695 Test Method for Compressive Properties of Rigid Plastics
D696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between −30°C and 30°C with a Vitreous Silica Dilatometer
D710 Specification for Vulcanized Fibre Sheets, Rods, and Tubes Used for Electrical Insulation
D785 Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D883 Terminology Relating to Plastics
D1674 Test Method for Testing Polymerizable Embedding Compounds Used for Electrical Insulation (Withdrawn 1990)[3]
D1711 Terminology Relating to Electrical Insulation
D1825 Practice for Etching and Cleaning Copper-Clad Electrical Insulating Materials and Thermosetting Laminates for Electrical Testing (Withdrawn 2012)[3]
D2132 Test Method for Dust-and-Fog Tracking and Erosion Resistance of Electrical Insulating Materials
D2303 Test Methods for Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials
D3487 Specification for Mineral Insulating Oil Used in Electrical Apparatus
D5032 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Glycerin Solutions
D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)[3]
E176 Terminology of Fire Standards
E197 Specification for Enclosures and Servicing Units for Tests Above and Below Room Temperature (Withdrawn 1981)[3]

2.2 *IEC Standard:*
IEC 60893–2 Specification for Rigid Industrial Laminated Sheets Based on Thermosetting Resins for Electrical Purpose, Methods of Tests[4]

2.3 *International Organization for Standardization (ISO) Standard:*
ISO 13943 Fire Safety: Vocabulary[5]

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

[5] Available from International Organization for Standardization, P.O. Box 56, CH-1211, Geneva 20, Switzerland or from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3. Terminology

3.1 *Definitions*—Rigid electrical insulating materials are defined in these test methods in accordance with Terminology D883. The terminology applied to materials in these test methods shall be in accordance with the terms appearing in Terminologies D883 and D1711. Use Terminology E176 and ISO 13943 for definitions of terms used in this test method and associated with fire issues. Where differences exist in definitions, those contained in Terminology E176 shall be used.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 In referring to the cutting, application, and loading of the specimens, the following terms apply:

3.2.1.1 *crosswise (CW), adj*—in the direction of the sheet at 90° to the lengthwise direction. This is normally the weakest direction in flexure. For some materials, including the raw materials used for manufacture of materials considered herein, this direction may be designated as the cross-machine direction or the weft direction.

3.2.1.2 *edgewise loading, n*—mechanical force applied in the plane of the original sheet or plate.

3.2.1.3 *flatwise loading, n*—mechanical force applied normal to the surfaces of the original sheet or plate.

3.2.1.4 *lengthwise (LW), adj*—in the direction of the sheet which is strongest in flexure. For some materials, including the raw materials used for the manufacture of materials considered herein, this direction may be designated as the machine direction or the warp direction.

3.2.2 In referring to bonding strength, the following term applies:

3.2.2.1 *bonding strength, n*—the force required to split a prescribed specimen under the test conditions specified herein.

4. Conditioning

4.1 The properties of the materials described in these test methods are affected by the temperature and moisture exposure of the materials to a greater or lesser extent, depending on the particular material and the specific property. Control of temperature and humidity exposure is undertaken to: (*1*) obtain satisfactory test precision, or (*2*) study the behavior of the material as influenced by specific temperature and humidity conditions.

4.2 Unless otherwise specified in these test methods or by a specific ASTM material specification, or unless material behavior at a specific exposure is desired, condition test specimens in accordance with Procedure A of Practice D6054 and test in the Standard Laboratory Atmosphere (23 ± 1.1 °C, 50 ± 2 % relative humidity).

THICKNESS

5. Apparatus and Procedure

5.1 Measure thickness in accordance with Test Methods D374.

5.2 On test specimens, the use of a machinist's micrometer as specified in Method B is satisfactory for the determination of thickness for all of the test methods that follow. Where it is convenient, use the deadweight dial micrometer, Method C.

5.3 On large sheets, use Method B. Choose a micrometer with a yoke of sufficient size and rigidity to permit accurate measurements in the center of the sheet.

6. Precision and Bias

6.1 Results of comparative tests in several factories, measuring 36-in. (914-mm) square sheets by a variety of such devices, indicate that the trade is able to measure sheets 1/32 and 1/8 in. (1 and 3 mm) in thickness to accuracy of 0.0015 in. (0.0381 mm). (In the tests, σ, of 0.0005 in. (0.0127 mm) was obtained.)

6.2 This test method has no bias because the value for breaking strength is determined solely in terms of this test method itself.

TENSILE PROPERTIES

7. Test Specimens

7.1 Machine the test specimens from sample material to conform to the dimensions of sheet and plate materials in Fig. 1.

7.2 Prepare four LW and four CW specimens.

8. Rate of Loading

8.1 The materials covered by these test methods generally exhibit high elastic modulus. Use any crosshead speed provided that the load and strain indicators are capable of accurate measurement at the speed used, except use 0.05 in./min (1 mm/min) in matters of dispute.

9. Procedure

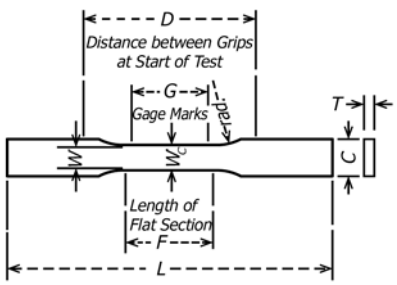
9.1 Measure the tensile strength and elastic modulus in accordance with Test Method D638 except as modified in the following paragraphs.

9.2 Measure the width and thickness of the specimen to the nearest 0.001 in. (0.025 mm) at several points along the length of the flat section, which is indicated as Dimension F in Fig. 1. Record the minimum values of cross-sectional area so determined.

9.3 Place the specimen in the grips of the testing machine, taking care to align the long axis of the specimen and the grips with an imaginary line joining the points of attachment of the grips to the machine. Allow 0.25 in. (6.3 mm) between the ends of the gripping surfaces and the shoulders of the fillet of the flat test specimen; thus, it is important that the ends of the gripping surfaces be the indicated distance apart, as shown in Fig. 1, at the start of the test. Tighten the grips evenly and firmly to the degree necessary to prevent slippage of the specimen during the test, but not to the point where the specimen would be crushed.

9.4 *Tensile Strength*—Set the rate of loading. Load the specimen at the indicated rate until the specimen ruptures. Record the maximum load (usually the load at rupture).

9.5 *Elastic Modulus*—When elastic modulus is desired, use a load-extension recorder with appropriate extension transmitter and proceed as in 9.3. Attach the extension transmitter, and proceed as in 9.4.



Dimension	Nominal Thickness, *T*										Tolerance	
	¼ in. (6 mm) or Under				Over ¼ in. (6 mm) to ½ in. (13 mm), incl				Over ½ in. (13 mm) to 1 in. (25 mm), incl[A]			
	Type I		Type II[B]		Type I		Type II[B]		Type I			
	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.
C—Width over-all	19.05	0.750	19.05	0.750	28.57	1.125	28.57	1.125	38.10	1.500	±0.40 −0.00	+ 0.016 −0.000
W—Width of flat section	12.70	0.500	6.35	0.250	19.05	0.750	9.52	0.375	25.40	1.000	+ 0.12	+ 0.005
F—Length of flat section	57.1	2.25	57.1	2.250	57.1	2.25	57.1	2.25	57.1	2.25	±0.40	±0.016
G—Gauge length[C]	50.8	2.00	50.8	2.00	50.8	2.00	50.8	2.00	50.8	2.00	±0.40	±0.016
D—Distance between grips	114	4½	133	5¼	114	4½	133	5¼	133	5¼	±3	±⅛
L—Length over-all	216	8½	238	9⅜	248	9¾	257	10⅛	305	12	min	min
Rad.—Radius of fillet	76	3	76	3	76	3	76	3	76	3	min	min

[A] For sheets of a nominal thickness over 1 in. (25.4 mm) machine the specimens to 1 in. (25.4 mm) ± 0.010 in. (0.25 mm) in thickness. For thickness between 1 in. (25.4 mm) and 2 in. (51 mm), machine approximately equal amounts from each surface. For thicker sheets, machine both surfaces and note the location of the specimen with reference to the original thickness.
[B] Use the type II specimen for material from which the Type I specimen does not give satisfactory failures in the gauge length, such as for resin-impregnated compressed laminated wood.
[C] Test marks only.

FIG. 1 Tension Test Specimen for Sheet and Plate Insulating Materials