Standard Test Methods for Glass-Bonded Mica Used as Electrical Insulation[1]

This standard is issued under the fixed designation D 1039; 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.

ε1 NOTE—The Reference Documents were updated editorially in November 1999.

1. Scope

1.1 These test methods cover the evaluation of the characteristics of glass-bonded, natural, or synthetic mica materials intended for use as electrical insulation.

1.2 Glass bonded mica materials are commercially available in both injection molded and compression molded types. These test methods are applicable to both types except for tensile strength methods. (See Section 41.)

1.3 The test methods appear in the following sections:

Test Method	Section	ASTM Test Method
Arc Resistance	57-59	D 495
Compressive Strength	33-35	D 695
Conditioning	5	D 618
Dielectric Strength	48-51	D 149
Dissipation Factor	43-47	D 150 and D 2149
Heat Distortion Temperature	24-29	D 648
Impact Resistance	36-39	D 256
Modulus of Rupture	30-32	D 790 and C 674
Permittivity	43-47	D 150 and D 2149
Porosity	13-16	D 116
Resistivity, Volume and Surface	52-56	D 257
Rockwell Hardness	10-12	D 785
Specific Gravity	6-9	D 792
Specimens	4	
Tensile Strength	40-42	D 638 and D 651
Terminology	3	D 1711
Thermal Conductivity	17-19	C 177 and E 1225
Thermal Expansion	20-23	E 228 and E 289
Thickness	49 and 54	D 374

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.* See also Sections 45, 49, 54, and 58.

2. Referenced Documents

2.1 *ASTM Standards:*

C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Properties by Means of the Guarded Hot Plate Apparatus[2]

C 674 Test Methods for Flexural Properties of Ceramic Whiteware Materials[3]

D 116 Methods of Testing Vitrified Ceramic Materials for Electrical Applications[3]

D 149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies[4]

D 150 Test Methods for A-C Loss Characteristics and Permittivity Dielectric Constant of Solid Electrical Insulation[4]

D 256 Test Method for Determining the IZOD Pendulum Impact Resistance of Plastics[5]

D 257 Test Methods for D-C Resistance or Conductance of Insulating Materials[4]

D 374 Test Methods for Thickness of Solid Electrical Insulation[4]

D 495 Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation[4]

D 638 Test Method for Tensile Properties of Plastics[5]

D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load[5]

D 651 Test Method for Tensile Strength of Molded Electrical Insulating Materials[4]

D 695 Test Method for Compressive Properties of Rigid Plastics[5]

D 785 Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials[5]

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[5]

D 792 Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement[5]

[1] These test methods are under the jurisdiction of ASTM Committee D-9 on Electrical and Electronic Insulating Materials and are the direct responsibility of Subcommittee D09.19 on Dielectric Sheet and Roll Products.

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[2] *Annual Book of ASTM Standards*, Vol 04.06.

[3] *Annual Book of ASTM Standards*, Vol 15.02.

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

[5] *Annual Book of ASTM Standards*, Vol 08.01.

D 1711 Terminology Relating to Electrical Insulation[4]
D 2149 Test Method for Permittivity (Dielectric Constant) and Dissipation Factor of Solid Ceramic Dielectrics at Frequencies to 10 MHz and Temperature to 500°C[4]
D 6054 Practice for Conditioning Electrical Insulating Materials for Testing[6]
E 228 Test Method for Linear Thermal Expansion of Solid Materials with a Vitreous Silica Dilatometer[7]
E 289 Test Method for Linear Thermal Expansion of Rigid Solids with Interferometry[7]
E 1225 Test Method for Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique[7]

3. Terminology

3.1 For definitions of terms used in this standard see Terminology D 1711.

4. Test Specimens

4.1 Except for thermal expansion and thermal conductivity tests and unless otherwise specified for injection molded materials, the preferred form of specimen is a disk approximately 100 mm diameter and 2.5 to 7.5 mm thickness. Alternatively, injection molded specimens may have the final shape and form of the finished device.

4.2 Except for thermal expansion and thermal conductivity tests and unless otherwise specified for compression molded materials, the preferred form of specimen is a disk 100 to 150 mm diameter, or a square plate 100 to 150 mm on a side, with thickness 2.5 to 7.5 mm. The plate or disk may be molded to size or machined from a compression molded sheet.

4.3 For thermal expansion test specimens use specimens in accordance with Test Method E 228 or Test Method E 289 as appropriate.

4.4 For thermal conductivity specimens use specimens in accordance with Test Method E 1225.

5. Conditioning

5.1 Unless otherwise specified, condition all samples and test specimens in accordance with Procedure A of Practice D 6054, except condition all thicknesses for at least 16 h.

SPECIFIC GRAVITY

6. Significance and Use

6.1 This characteristic is useful for specification purposes and has utility as a quality control parameter.

7. Test Specimens

7.1 From specimens obtained in accordance with Section 4 and conditioned in accordance with Section 5, cut pieces weighing from 5 to 25 g and prepare them in accordance with Test Methods D 792.

8. Procedure and Report

8.1 Determine specific gravity and report the results in accordance with Test Methods D 792.

9. Precision and Bias

9.1 The precision and bias statement of Test Methods D 792 applies to the materials covered in these test methods.

ROCKWELL HARDNESS

10. Significance and Use

10.1 This property is useful as a quality control test and has application for use in specifications.

11. Procedure and Report

11.1 From specimens obtained in accordance with Section 4 and conditioned in accordance with Section 5, determine and report the Rockwell hardness in accordance with Procedure A of Test Method D 785. Use the Rockwell A scale if the hardness is 115 or less, otherwise use the Rockwell E scale.

12. Precision and Bias

12.1 The precision and bias statement of Test Method D 785 applies to the materials covered in these test methods.

POROSITY

13. Significance and Use

13.1 This characteristic serves as a measure of the integrity of the material. The test is useful for quality control and specification purposes.

14. Specimens

14.1 Prepare specimens in accordance with Section 4 and condition them in accordance with Section 5. Then break the material in accordance with the porosity sections of Method B of Methods D 116.

15. Procedure and Report

15.1 Test the glass-bonded mica for porosity and report the results in accordance with Methods D 116.

16. Precision and Bias

16.1 The precision and bias statement of Methods D 116 applies to the materials covered in this standard.

THERMAL CONDUCTIVITY

17. Significance and Use

17.1 Knowledge of this property of glass-bonded mica is important for design of electrical apparatus. The test is useful for quality control and specification purposes.

18. Procedure and Report

18.1 Using specimens obtained in accordance with Section 4, make determinations and report the results for thermal conductivity in accordance with Test Method E 1225.

NOTE 1—If thermal conductivity values are required over a broader temperature range or of a lower order of magnitude than obtainable with

[6] *Annual Book of ASTM Standards*, Vol 10.02.
[7] *Annual Book of ASTM Standards*, Vol 14.02.

Test Method E 1225, Test Method C 177 has been found to be satisfactory for measurement of the thermal conductivity perpendicular to the surface of specimens having large areal dimensions.

19. Precision and Bias

19.1 The precision and bias statement of the referenced test methods apply to the materials covered in these test methods.

THERMAL EXPANSION

20. Significance and Use

20.1 Data on thermal expansion of glass-bonded mica is useful for a designer to match materials in a component so as to minimize mechanical strains caused by temperature variations encountered by the component in service. The data is useful to estimate the amount of strain that may develop in service.

20.2 The interferometric method is better suited for examination of physically small specimens, interfaces, or local areas that are under investigation. The dilatometer method is not as precise or sensitive as the interferometric method but the dilatometer method is useful at higher temperatures and can accommodate larger specimens. The results of the dilatometer method are more representative of large pieces.

21. Procedure

21.1 Using specimens obtained in accordance with Section 4, measure the thermal expansion characteristics of the glass-bonded mica in accordance with either Test Method E 228 or Test Method E 289.

22. Report

22.1 Report the following information:

22.1.1 The identity of the glass-bonded mica,

22.1.2 The method used,

22.1.3 The thermal expansion for the specimen expressed as a change in linear dimensions resulting from a specific change in temperature, and

22.1.4 The temperature range used.

23. Precision and Bias

23.1 The precision and bias statement of the referenced test methods apply to the materials covered in these test methods.

HEAT DISTORTION TEMPERATURE

24. Significance and Use

24.1 This test is useful for the comparison of material from different producers. It may be used as a specification requirement.

25. Apparatus

25.1 A set-up for support and loading of the specimen and a means for measuring the deflection is described in Test Method D 648. Modifications of this set-up in accordance with 25.2 are found satisfactory for use on specimens of glass-bonded mica.

25.2 The materials of construction of the Test Method D 648 apparatus must be capable of withstanding exposure up to 600°C. The oven used for heating of the specimen shall be capable of temperature control within ±5°C throughout the temperature range 300 to 600°C.

26. Test Specimens

26.1 Cut bars of glass-bonded mica approximately 120 by 13 mm with thickness of 3 to 13 mm. Prepare at least two specimens for testing at each load stress mandated by Test Method D 648. Measure each specimen dimension to the nearest 0.02 mm and record these measurements.

27. Procedure

27.1 Determine the heat distortion temperature in accordance with Test Method D 648 except start the test at 300°C. Allow each specimen to reach equilibrium before obtaining the initial readings.

27.2 Increase the temperature 50°C.

27.3 Maintain the increased temperature for 60 ± 5 min before taking readings.

27.4 Continue the 50°C interval increments until the bar deflects 0.25 mm or more. The temperature at which 0.25 mm deflection occurs is the heat distortion temperature.

28. Report

28.1 Report the following information:

28.1.1 The three dimensions of the specimen,

28.1.2 The distance between the supports,

28.1.3 The load and the stress applied to each specimen, and

28.1.4 The heat distortion temperature for each specimen.

29. Precision and Bias

29.1 The precision and bias statement of Test Method D 648 applies to the materials covered in these test methods.

MODULUS OF RUPTURE

30. Significance and Use

30.1 The modulus of rupture is a convenient means for comparing mechanical properties of glass-bonded mica from different producers.

30.2 The method is useful for quality control and specification purposes.

31. Procedure and Report

31.1 Take cylindrical specimens 13 mm in diameter and 150 mm in length and test and report in accordance with Test Methods C 674.

NOTE 2—The specimens should conform to the dimensions suggested in Table 1 of Test Methods D 790 as closely as is practicable.

32. Precision and Bias

32.1 The precision and bias statement of Test Methods C 674 applies to the materials covered in these test methods.

COMPRESSIVE STRENGTH

33. Significance and Use

33.1 The test results have utility for quality control and specification purposes. It is useful in comparison of glass-bonded mica from different producers.

34. Procedure and Report

34.1 Take specimens in accordance with Test Method D 695. Determine and report compressive strength in accordance with Test Method D 695.

35. Precision and Bias

35.1 The precision and bias statement of Test Method D 695 applies to the materials covered in these test methods.

IMPACT RESISTANCE

36. Significance and Use

36.1 The test measures the reaction of the material to a very sudden application of forces on a very concentrated area of a specimen. This reaction is a measure of the brittleness of glass-bonded mica.

36.2 The test result has utility for quality control and specification purposes.

37. Specimens

37.1 Prepare rods 13 ± 1 mm in diameter, conforming to 11.5 of Test Method D 256.

37.2 Condition specimens in accordance with Section 5 of these test methods.

38. Procedure and Report

38.1 Determine impact resistance and report the results in accordance with Test Method D 256 using Method B (the simple beam test).

39. Precision and Bias

39.1 The precision and bias statement of Test Method D 256 applies to the materials covered in these test methods.

TENSILE STRENGTH

40. Significance and Use

40.1 The results of tests for this property are useful for specification and quality control purposes.

41. Procedure and Report

41.1 *For Injection-Type Molded Materials*—Mold test specimens to the form and dimensions of Fig. 2 in Test Method D 651. Condition in accordance with Section 5 of these test methods. Determine tensile strength and report the results in accordance with Test Method D 651.

41.2 *For Compression-Type Molded Materials*—In accordance with Section 5 of these test methods, condition test specimens that conform to the dimensions of Fig. 1 of Test Method D 638. Determine tensile strength and report the results in accordance with Test Method D 638.

42. Precision and Bias

42.1 The precision and bias statement of the referenced test methods apply to the materials covered in these test methods.

RELATIVE PERMITTIVITY AND DISSIPATION FACTOR

43. Significance and Use

43.1 The results of this test have utility for quality control and specification purposes.

43.2 In many cases, the design of efficient electrical apparatus requires knowledge about these characteristics of glass-bonded mica.

43.3 For further information regarding the significance of these properties, see Test Methods D 150.

44. Specimens

44.1 Prepare and condition specimens in accordance with Sections 4 and 5 of these test methods if relative permittivity and dissipation factor at room temperature and 50 % relative humidity are required.

44.2 If these properties are to be evaluated at high humidity, apply silver paint electrodes to the specimens following the concepts of Test Methods D 150, which deal with electrode systems comprised of conducting paint or fired-on silver.

NOTE 3—These electrodes are sufficiently porous to permit diffusion of moisture.

44.3 For high humidity testing, condition specimens in accordance with Procedure C of Practice D 6054, which is 96 h at 90 % relative humidity and 35°C.

44.4 For high temperature testing, prepare specimens having dimensions that are in accordance with Test Method D 2149.

45. Procedure

45.1 **Warning—***Lethal voltages may be present during these tests. It is essential that the test apparatus, and all associated equipment that may be electrically connected to it, be properly designed and installed for safe operation. Solidly ground all electrically conductive parts that any person might come in contact with during the test. Provide means for use at the completion of any test to ground any parts which: were at high voltage during the test; may have acquired an induced charge during the test; may retain a charge even after disconnection of the voltage source. Thoroughly instruct all operators in the proper way to conduct tests safely. When making high voltage tests, particularly in compressed gas or in oil, the energy released at breakdown may be sufficient to result in fire, explosion, or rupture of the test chamber. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury.*

45.2 Specify on the material specification or the purchase order the temperature, humidity, voltage frequency, the voltage stress, and any other requirements for the tests.

45.3 If not otherwise specified, measure dissipation factor and relative permittivity at the standard conditions of Procedure A of Practice D 6054, using a frequency of 48 to 62 Hz and any voltage stress not greater than 1 kV/mm. Use any of the apparatus described in Test Methods D 150.

45.4 If measurements over a range of high temperature are required, perform the tests in accordance with Test Method

D 2149. Unless otherwise specified, make the measurements at a minimum of 4 temperatures within the range specified and use 48 to 62 Hz and an applied voltage stress below 1 kV/mm.

46. Report

46.1 Report the following information:

46.1.1 The complete identification of the material tested,

46.1.2 The test temperature,

46.1.3 The specimen thickness,

46.1.4 The relative humidity used,

46.1.5 The frequency of the applied voltage,

46.1.6 The voltage stress used,

46.1.7 The relative permittivity,

46.1.8 The dissipation factor,

46.1.9 The apparatus of Test Methods D 150 used, and

46.1.10 The method of Test Methods D 2149 used if applicable.

47. Precision and Bias

47.1 This test method has been in use for many years, but no statement for precision has been made and no activity is planned to develop such a statement.

47.2 A statement of bias is not possible due to the lack of a standard reference material.

DIELECTRIC STRENGTH

48. Significance and Use

48.1 The results of this test are useful for comparing different glass-bonded mica materials and for quality control of different lots.

48.2 The values obtained usually will have little relation to the dielectric strength realized in service.

48.3 Dielectric strength data may serve as a guide for estimating the electrical safety factor of a glass-bonded mica part for a given application. However, mechanical requirements are often far more important in determining the needed thickness of dielectric than are the values determined from this test.

49. Procedure

49.1 **Warning—***Lethal voltages may be present during these tests. It is essential that the test apparatus, and all associated equipment that may be electrically connected to it, be properly designed and installed for safe operation. Solidly ground all electrically conductive parts that any person might come in contact with during the test. Provide means for use at the completion of any test to ground any parts which: were at high voltage during the test; may have acquired an induced charge during the test; may retain a charge even after disconnection of the voltage source. Thoroughly instruct all operators in the proper way to conduct tests safety. When making high voltage tests, particularly in compressed gas or in oil, the energy released at breakdown may be sufficient to result in fire, explosion, or rupture of the test chamber. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury.*

49.2 Take five specimens in accordance with Section 4, condition them in accordance with Section 5, and determine the dielectric strength in accordance with Test Method D 149 using the following:

49.2.1 Short time test,

49.2.2 Voltage rate of rise of 1 kV/s,

49.2.3 Type 2 electrodes from Table 1 of Test Method D 149,

49.2.4 Test at room temperature with the specimen submerged in oil, and

49.2.5 Use alternating voltage at 48 to 62 Hz.

49.3 Measure the thickness using a machinist's micrometer that meets the requirements of Apparatus B of Test Methods D 374.

49.4 Record the breakdown voltage and the thickness of each specimen.

49.5 Calculate the average dielectric strength of the five specimens in accordance with the calculation section of Test Method D 149.

50. Report

50.1 Report the results in accordance with Test Method D 149.

51. Precision and Bias

51.1 This test method has been in use for many years, but no statement for precision has been made and no activity is planned to develop such a statement.

51.2 A statement of bias is not possible due to the lack of a standard reference material.

RESISTIVITY

52. Significance and Use

52.1 The results of this test have utility for comparison of materials. The results are used for quality control and specification purposes.

52.2 Knowledge of this characteristic is often helpful in designing electrical apparatus, particularly apparatus for operation at direct voltages.

53. Conditioning

53.1 Condition the test specimens (see Section 4 of these test methods) in accordance with Procedure A of Practice D 6054 if tests are to be made at the standard laboratory atmosphere of Practice D 6054.

NOTE 4—The volume resistivity of some glass-bonded mica materials at the standard laboratory atmosphere conditions is extremely high. In fact, the values may exceed the capability of some of the apparatus described in Test Methods D 257. In such cases it is preferable to make measurements at a higher temperature or under the conditions of Procedure C of Practice D 6054.

53.2 Condition the test specimens in accordance with Procedure C of Practice D 6054 if the tests are specified to be made at high relative humidity.

53.3 If testing is required at specified test temperatures above 100°C, the following instructions apply:

53.3.1 Condition specimens as in 53.1,

53.3.2 Transfer the specimens, preferably immediately but in less than 30 min, to an atmosphere maintained at the test temperature specified, and

53.3.3 Make the tests within 5 h of the transfer or at the time of attainment of thermal equilibrium, whichever occurs first.

54. Procedure

54.1 **Warning—***Lethal voltages may be present during these tests. It is essential that the test apparatus, and all associated equipment that may be electrically connected to it, be properly designed and installed for safe operation. Solidly ground all electrically conductive parts that any person might come in contact with during the test. Provide means for use at the completion of any test to ground any parts which: were at high voltage during the test; may have acquired an induced charge during the test; may retain a charge even after disconnection of the voltage source. Thoroughly instruct all operators in the proper way to conduct tests safety. When making high voltage tests, particularly in compressed gas or in oil, the energy released at breakdown may be sufficient to result in fire, explosion, or rupture of the test chamber. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury*.

54.2 Determine the volume or the surface resistance of the specimen in accordance with Test Methods D 257 except as follows:

54.2.1 Use a direct voltage of 100 ± 2 or 500± 2 V;

54.2.2 For volume resistance tests use an electrification time of 60 ± 1 s. For surface resistance tests, use electrification times of both 10 and 60 ± 1 s.

54.2.3 Use conductive silver painted electrodes in accordance with Fig. 4 of Test Methods D 257.

54.2.4 For volume resistivity, measure specimen thickness using a machinist's micrometer in accordance with Apparatus B of Test Methods D 374.

54.3 Test at least three specimens.

54.4 Record the thickness and the volume resistance for each specimen.

54.5 Record the surface resistance for each specimen.

54.6 Calculate the resistivity, either surface or volume, in accordance with Test Methods D 257.

55. Report

55.1 Report the following information:

55.1.1 The complete identification of the material tested,

55.1.2 The volume resistivity using ohm cm units,

55.1.3 The surface resistivity using units of ohms (per square),

55.1.4 The temperature at which the test was made,

55.1.5 The relativity humidity,

55.1.6 The type of apparatus of Test Methods D 257 used, and

55.1.7 The voltage applied and the electrification time used.

56. Precision and Bias

56.1 This test method has been in use for many years, but no information has been presented to ASTM upon which to base a statement of precision. No activity has been planned to develop such information.

56.2 A statement of bias is not possible due to the lack of a standard reference material.

ARC RESISTANCE

57. Significance and Use

57.1 See Test Method D 495.

58. Procedure and Report

58.1 **Warning—***Lethal voltages may be present during these tests. It is essential that the test apparatus, and all associated equipment that may be electrically connected to it, be properly designed and installed for safe operation. Solidly ground all electrically conductive parts that any person might come in contact with during the test. Provide means for use at the completion of any test to ground any parts which: were at high voltage during the test; may have acquired an induced charge during the test; may retain a charge even after disconnection of the voltage source. Thoroughly instruct all operators in the proper way to conduct tests safety. When making high voltage tests, particularly in compressed gas or in oil, the energy released at breakdown may be sufficient to result in fire, explosion, or rupture of the test chamber. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury*

58.2 Using specimens in accordance with Section 4, measure the arc resistance in accordance with Test Method D 495. Report the results in accordance with Test Method D 495.

59. Precision and Bias

59.1 The precision and bias statement of Test Method D 495 applies to the materials covered in these test methods.

60. Keywords

60.1 arc resistance; compressive strength; dielectric strength; dilatometry; dissipation factor; glass-bonded mica; heat distortion; impact resistance; interferometry; linear thermal expansion; mica; modulus of rupture; permittivity; porosity; resistivity; Rockwell hardness; specific gravity; synthetic mica; tensile strength; thermal conductivity