Designation: D 1082 – 00

An American National Standard

Standard Test Method for Dissipation Factor and Permittivity (Dielectric Constant) of Mica[1]

This standard is issued under the fixed designation D 1082; 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 This test method covers the determination of the dissipation factor and the relative permittivity of natural block mica having thicknesses between 0.007 and 0.030 in. (0.18 and 0.77 mm) and mica films or capacitor splits between 0.0008 and 0.004 in. (0.02 and 0.10 mm) in thickness.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information purposes only.

1.3 *This standard does not purport to address all of the safety problems, 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.* A specific warning statement is given in Section 7 and Note 5.

NOTE 1—Procedures for the measurement of dissipation factor and permittivity are given in IEC Publication 60371-2, but the details of the procedure are somewhat different from those specified in this test method.

2. Referenced Documents

2.1 *ASTM Standards:*

D 150 Test Methods for A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials[2]

D 374 Test Methods for Thickness of Solid Electrical Insulation[2]

D 748 Specification for Natural Block Mica and Mica Films Suitable for Use in Fixed Mica-Dielectric Capacitors[2]

D 1711 Terminology Relating to Electrical Insulation[2]

2.2 *IEC Publication:*

Publication 60371-2 Specification for insulating materials based on mica—Part 2: Methods of test[3]

3. Summary of Test Method

3.1 Any of the techniques and apparatus set forth in Test Method D 150 may be used for measuring dissipation factor and relative permittivity of block mica or film. Select an appropriate electrode system from those given in Section 5.

3.2 If a relative order of magnitude of dissipation factor is desired, the use of Method A in the Appendix of Specification D 748 is satisfactory.

4. Significance and Use

4.1 The dissipation factor of natural muscovite mica, as determined by this test method, is of practical importance as a measure of the electrical energy lost as heat in the mica serving as the dielectric substance of capacitors, or in other applications in which the electric field is applied perpendicular to the plane of cleavage. The dissipation factor is particularly important in applications using mica at radio frequencies and in some less extensive audio frequency applications. This test method is suitable for specification acceptance and dielectric-loss control tests (See the Significance and Use of Test Methods D 150).

4.2 *Relative Permittivity (Dielectric Constant)*—The permittivity of natural muscovite mica is a measure of its relative ability to store electrostatic energy. Since the relative permittivity perpendicular to the cleavage plane is fairly uniform, regardless of origin, its practical significance is mainly for identification purposes, special uses, research, and design. If a loss index is desired, the value of the permittivity must be known (see the Significance and Use of Test Methods D 150).

5. Apparatus

5.1 For a general description of apparatus suitable for measuring dissipation factor and relative permittivity, refer to Test Methods D 150.

5.2 Select a suitable electrode arrangement from the following:

5.2.1 *Steel Electrodes*—Three electrodes made of stainless steel or nickel-plated tool steel will be required. The electrodes shall be cylindrical in shape and of a diameter sufficient to provide the minimum specified capacitance (Note 2). The upper and lower electrodes shall have a minimum axial length of ½ in. (12.7 mm) and the center electrode shall have a

---

[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 D09.19 on Dielectric Sheet and Roll Products.

Current edition approved Apr. 10, 2000. Published June 2000. Originally published as D 1082 – 49 T. Last previous edition D 1082 – 87 (1993)$^{\epsilon 1}$.

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

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

maximum length of ¼ in. (6.35 mm). A low-resistance contact and conductor to the electrode is essential for dissipation factor measurements in the order of 0.0001. The upper and lower electrodes shall be electrically connected together, thus forming a two-terminal capacitor, with the center electrode serving as the active or measuring terminal. The surfaces of the electrodes adjacent to the specimen shall be ground and polished optically flat, and shall be parallel to each other. The upper electrode shall be provided with a recess for a steel ball, so that the applied pressure will be uniformly distributed. The electrodes shall be carefully and accurately aligned without scratching the surface of the mica specimen. It is recommended that a slotted V-shaped jig be provided to aid with the aligning of the electrodes.

NOTE 2—Steel electrodes having diameters of ¾ , 1, 1¼ , and 1½ in. (19, 25, 32, and 38 mm) have been found satisfactory for practical thicknesses of mica specimens.

5.2.2 *Mercury Electrodes*—Three hollow, stainless steel or nickel-plated cold-rolled steel electrodes mounted with the axis horizontal so that the test specimens are in a vertical plane, will be required as shown in Fig. 1. The electrode assembly shall be cylindrical in shape and of the same outside diameter, which shall be large enough to provide the minimum specified capacitance (Note 3). Two adjustable electrodes having axial lengths of approximately ¾ in. (19 mm), provided with suitable cavities, shall be mounted on screws in a solid stainless steel or nickel-plated cold-rolled steel rectangular yoke. A center, or fixed, electrode consisting of a hollow ring approximately ⅜ in. (9.5 mm) in length shall be mounted at the center of the steel yoke on a support of insulating material such as polystyrene, hard rubber, low-loss ceramic, or quartz. All electrodes shall taper from the inside to rather sharp edges approximately 1⁄64 in. (0.4 mm) in width.

5.2.2.1 The two outer electrodes shall be provided with a rubber tube attached to ⅛-in. (3.2-mm) steel tubes located at the bottom of each electrode. Small vent holes shall be provided in the top of the outer electrodes to permit the escape of entrapped air as the mercury rises. The center electrode shall be filled through a ⅛-in. steel tube projecting approximately ⅛ in. above the top of the electrode and extending three fourths of the way down inside the steel ring. Vent holes shall be provided on either side of the projecting steel tube to permit entrapped air to escape as the mercury rises. With the test specimens clamped in position, the electrodes shall be in good alignment. As in the case of the flat, steel electrodes, a two-terminal capacitor is formed with the center electrode serving as the active or measuring terminal with the outer electrodes that are connected together by the steel yoke at the ground.

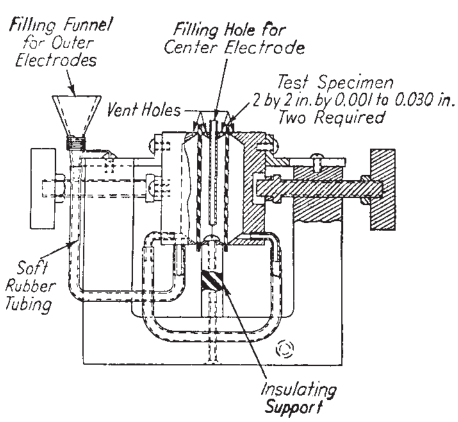

FIG. 1 Mercury Electrode Test Assembly

NOTE 3—Mercury electrodes having diameters of 1¾ in. (44.5 mm) have been found satisfactory for mica specimens 2 by 2 in. by 0.001 to 0.030 in. (51 by 51 mm by 0.025 to 0.76 mm).

NOTE 4—Conducting paint electrodes can be substituted for mercury electrodes.

5.2.3 *Lead-Foil Electrodes*—The use of lead-foil electrodes 0.0005 in. (0.013 mm) in thickness and 2.0 in. (51 mm) in diameter is satisfactory for block mica 0.015 to 0.030 in. (0.38 to 0.76 mm) in thickness. (See also metal-foil electrodes described in the Section of Test Methods D-150 under Electrode Systems).

5.3 The apparatus for the rapid, direct-reading method is set forth in Appendix of Specification D 748. This technique is for use only where classification of relative magnitude of dissipation factor (or its reciprocal Q value) of block mica or films is desired.

5.4 Thickness-measuring apparatus shall conform to the requirements set forth in Test Method A of Test Methods D 374 which describes a machinist's micrometer caliper with a ratchet or friction thimble.

6. Specimen Preparation and Conditioning

6.1 The dielectric properties of mica are affected by temperature, humidity, pressure, etc. Therefore, preparation and conditioning of the specimen shall be made in the following manner:

6.1.1 With the exception of the specimens used in 5.4, thoroughly and carefully clean the surfaces of the specimen with a camel's-hair brush dipped in petroleum ether or vapor degrease using trichloroethylene. Subsequent to the cleaning, exercise care not to contaminate the surfaces in handling.

NOTE 5—**Warning:** Petroleum ether and trichlorethylene may be hazardous. Use adequately ventilated work areas and observe all procedures for the safe handling of these liquids. Keep away from open flames.

6.1.2 After cleaning, place each specimen in an air oven maintained at 105 to 110°C, for a period of 1 h. Upon removal from the oven, immediately store the specimen in a desiccator until ready for the test.

6.2 Prepare two similar test specimens of approximately equal and uniform thickness for each measurement when using steel or mercury electrodes (see Section 5).

6.3 Only one test specimen is needed for testing with lead-foil electrodes.

6.4 Obtain specimens from the same block or splitting when two specimens are used. Each specimen shall have a sufficient area and thickness to give a total capacitance of not less than 200 pF. Test a sufficient number of specimens to obtain representative data.

7. Procedure

7.1 When steel, mercury, or lead-foil electrodes are used, determine the dissipation factor and relative permittivity of the mica in accordance with Test Methods D 150 except for size and type of electrode.

7.2 **Warning—***Mercury metal vapor poisoning has long been recognized as a hazard in industry. The exposure limits are set by governmental agencies and are usually based upon recommendations made by the American Conference of Governmental Industrial Hygienists.*[4] *The concentration of mercury vapor over spills from broken thermometers, barometers, and other instruments using mercury can easily exceed these exposure limits. Mercury, being a liquid with high surface tension and quite heavy, will disperse into small droplets and seep into cracks and crevices in the floor. This increased area of exposure adds significantly to the mercury vapor concentration in air. The use of a commercially available emergency spill kit is recommended whenever a spill occurs. Mercury vapor concentration is easily monitored using commercially available sniffers. Make spot checks periodically around operations where mercury is exposed to the atmosphere. Make thorough checks after spills.*

7.3 Certain types of micas are affected by pressure; therefore, when flat, steel electrodes are used, apply a sufficient range of pressures (Note 6) so that curves of pressure in pounds-force per square inch versus dissipation factor and relative permittivity may be plotted.

NOTE 6—Pressures in the order of 100 to 10 000 psi may be readily obtained by the use of an automobile-type hydraulic jack equipped with a pressure gauge.

7.4 Mercury and lead-foil electrodes give capacitance values comparable with those obtained at the highest pressures when using flat, steel electrodes (Note 7). Use clean mercury that has a bright surface that is free of scum. Observe health hazard precautions when using mercury, particularly at elevated temperatures.

NOTE 7—In order to satisfactorily compare the dissipation factor and relative permittivity of various specimens of mica, it may be necessary to investigate such properties over a wide frequency range. However, it is recommended that at least one measurement be made at 1000 kHz and a temperature of 25 ± 5°C, at a pressure of 1000 psi if flat steel electrodes are used.

[4] American Conference of Governmental Industrial Hygienists, Building Number D-7, 6500 Glenway Avenue, Cincinnati, OH 45211.

8. Calculation

8.1 Since two specimens are used in each measurement when using steel or mercury electrodes, use the equivalent "parallel thickness" in calculating the relative permittivity as follows:

$$T_e = 1/[(1/t_1) + (1/t_2)] \quad (1)$$

where:

T_e = equivalent parallel thickness,
t_1 = thickness of the upper specimen, and
t_2 = thickness of the lower specimen.

9. Report

9.1 Report the following information:

9.1.1 Identification of the mica tested,

9.1.2 The date of testing,

9.1.3 The test conditions, including frequency of the applied voltage, specimen temperature during testing, voltage stress on the specimen, relative humidity during testing, type, and size of electrodes used.

9.1.4 The applied pressure if flat steel electrodes are used,

9.1.5 Capacitance of each specimen,

9.1.6 The "parallel thickness" of each specimen,

9.1.7 A plot of dissipation factor versus pressure if flat, steel electrodes are used,

9.1.8 A plot of permittivity versus pressure if flat, steel electrodes are used,

9.1.9 The value of the dissipation factor and the relative permittivity for each specimen,

9.1.10 The method of measurement from Test Methods D 150, if applicable, and

9.1.11 The method used if techniques from Specification D 748 were used.

10. Precision and Bias

10.1 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.

10.2 *Bias*—This test method has no bias because the values for dissipation factor and capacitance are determined solely in terms of this test method.

11. Keywords

11.1 dissipation factor; mica; permittivity