Designation: D1677 – 02 (Reapproved 2011)

# Standard Methods for Sampling and Testing Untreated Mica Paper Used for Electrical Insulation[1]

This standard is issued under the fixed designation D1677; 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 methods cover procedures for sampling and testing untreated mica paper to be used as an electrical insulator or as a constituent of a composite material used for electrical insulating purposes.

1.2 The procedures[2] appear in the following order:

| Procedures | Sections | ASTM Method References |
|---|---|---|
| Apparent Density | 12 | ... |
| Aqueous Extract Conductivity | 32 and 33 | D202 |
| Conditioning | 4 | D685 |
| Dielectric Strength | 16 – 19 | D149 |
| Impregnation Time | 20 – 24 | D202 |
| Moisture Content | 26 – 28 | D644 |
| Roll Quality | 25 | ... |
| Sampling | 3 | ... |
| Tensile Strength | 13 – 15 | D828 |
| Thickness | 6 – 10 | D374 |
| Weight | 11 | D646 |
| Weight Variability | 29 – 31 | ... |

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 whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[3]

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

D202 Test Methods for Sampling and Testing Untreated Paper Used for Electrical Insulation

D374 Test Methods for Thickness of Solid Electrical Insulation (Withdrawn 2013)[4]

D644 Test Method for Moisture Content of Paper and Paperboard by Oven Drying (Withdrawn 2010)[4]

D646 Test Method for Mass Per Unit Area of Paper and Paperboard of Aramid Papers (Basis Weight)

D685 Practice for Conditioning Paper and Paper Products for Testing

D828 Test Method for Tensile Properties of Paper and Paperboard Using Constant-Rate-of-Elongation Apparatus (Withdrawn 2009)[4]

D1711 Terminology Relating to Electrical Insulation

## 3. Sampling

3.1 Sample in accordance with the requirements set forth in Test Methods D202.

3.2 Make the tests for physical properties on each sample insofar as the specimens are of sufficient width.

3.3 Untreated mica papers are, in general, quite fragile and friable. At all times during the operations of sampling, conditioning, specimen preparation, and testing, great care must be taken to prevent flexing and tearing, and to minimize abrasion of particles from the surfaces. The test values may be significantly and adversely affected if these precautions are not taken.

## 4. Conditioning

4.1 Condition samples in accordance with Practice D685, except that samples should remain in the conditioned air for not less than 16 h prior to the tests.

4.2 The following physical tests shall be made in the conditioned atmosphere: thickness, weight, tensile strength, dielectric strength, and impregnation.

## 5. Precision and Bias

5.1 Due to the range of types and grades, and nonuniform nature of commercially available mica papers, no statement

[1] These methods are under the jurisdiction of ASTM Committee D09 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] The test methods for other properties will be added in accordance with standard ASTM procedures as their need becomes generally desirable.

[3] 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.

[4] The last approved version of this historical standard is referenced on www.astm.org.

can be made about the precision of these methods when used on these materials. Neither can a statement about bias be made because of the unavailability of standard reference materials. Nevertheless, these methods serve to distinguish basic, relative differences in properties, and variations in quality among mica papers used in electrical insulation.

## THICKNESS AND THICKNESS VARIATION

### 6. Terminology Definition

6.1 *thickness,n—of an electrical insulating material,* the perpendicular distance between the two surfaces of interest, determined in accordance with a standard method.

### 7. Significance and Use

7.1 Accurate determination of thickness is important for identification purposes. Thickness is related to weight and must be known in order to calculate apparent density and the dielectric strength.

7.2 Thickness variation affects the quality of roll winding and is useful in judging the uniformity of mica paper particularly with respect to dielectric breakdown voltage, impregnation time, and thickness of the end product.

### 8. Test Specimens

8.1 Take test specimens from the original samples obtained in accordance with Section 3 and conditioned as prescribed in Section 4, and tested under the same conditions.

8.2 For all thicknesses of mica paper, the specimen shall be a single sheet.

### 9. Procedure

9.1 Determine the thickness in accordance with Test Methods D374. The preferred method shall be Method D with a drop rate of 12 ± 4 mil/s and a dwell time of 3 ± 1 s for thickness of 0.002 to 0.006 in. and 6 ± 2 s for + 0.006 in. Method C of Test Methods D374 is an acceptable alternative.

9.2 Take at least five measurements of thickness at regular intervals across the entire width of each specimen, preferably in a line that is at right angles to the machine direction.

### 10. Report

10.1 Report in accordance with Test Methods D202 and include:

10.1.1 Average, minimum, and maximum thickness.

## WEIGHT

### 11. Procedure

11.1 Determine the weight in accordance with Test Method D646, except sample the material in accordance with Section 3, condition as prescribed in Section 4, and test under the same conditions. Report the results as weight in grams per square metre.

## APPARENT DENSITY

### 12. Procedure

12.1 Determine the apparent density from the thickness (Sections 8 – 10), and the weight (Section 11). Make the thickness and weight determinations on the same sample. Calculate the apparent density as follows:

$$D = A/B \quad (1)$$

where:

$A$ = basis weight, kg/m$^2$,
$B$ = thickness, µm, and
$D$ = apparent density, g/cm$^3$.

## TENSILE STRENGTH

### 13. Significance and Use

13.1 The results of the test are suitable for acceptance and product control. They are also a means of measuring the ability of mica paper to withstand the tensile stresses encountered in application processes.

### 14. Procedure

14.1 Determine the tensile strength in accordance with Test Methods D202, except for specimen width and test span. Sample the material in accordance with Section 3 and condition in accordance with Section 4 and test under the same conditions. The specimen shall be 1 to 3 in. (25 to 77 mm) wide. The distance between the jaws shall be 5 in. (127 mm).

NOTE 1—If excessive fractures occur in or at the edge of either jaw, a cushion of soft kraft paper or other material may be used between the jaws of the clamps and the specimen.

### 15. Report

15.1 Report the following information:

15.1.1 The thickness of test specimen, and

15.1.2 The average, minimum and maximum tensile strength in pounds-force per inch of width (or newtons per metre of width).

## DIELECTRIC STRENGTH

### 16. Nomenclature

16.1 *dielectric strength*—Refer to Terminology D1711.

### 17. Significance and Use

17.1 For mica paper to be used in the untreated state, this test gives some indication of the electrical strength. For mica paper to be subsequently treated, this test has value as a quality control test.

### 18. Procedure

18.1 Determine the dielectric strength in accordance with Test Method D149, except sample the material in accordance with Section 3 and condition in accordance with Section 4, and test under the same conditions. Make tests in air using 2-in. (50.8-mm) electrodes and the short-time (continuous-rise) method. Determine the average dielectric strength on the basis of ten dielectric breakdowns.

### 19. Report

19.1 Report the following information:

19.1.1 Average thickness of the specimen,

19.1.2 Average, high, and low breakdown voltage, and

19.1.3 Average dielectric strength in volts per mil (or kilovolts per millimetre).

## IMPREGNATION TIME

### 20. Definition

20.1 *impregnation time, n—of paper,* the time in seconds required for a liquid of specified composition and viscosity to penetrate completely from one face of a sheet of paper to the other, under certain prescribed conditions.

### 21. Significance and Use

21.1 Impregnation time influences the speed and quality of resin impregnation of the mica paper.

### 22. Test Specimens

22.1 Take test specimens from the original samples obtained in accordance with Section 3 and conditioned as prescribed in Section 4, and test under the same conditions. Test specimens shall be 3 in. (76 mm) square.

### 23. Procedure

23.1 Determine the impregnation time in accordance with Impregnation Time of Test Methods D202, except as follows:

23.1.1 Use a test solution that is approximately 60 parts castor oil and 40 parts toluene, adjusted to a specific gravity of 0.917 ± 0.001 at 77°F (25°C).

NOTE 2—Use cold pressed castor oil (USP Grade No. 1).

23.1.2 Insert a glass plate between the mica paper and the paper clamp.

23.1.3 The end point is that time at which the paper is completely penetrated at a uniform rate of wet out. Particles which require substantially longer to wet out will not influence the determination. Make sure that the penetrated area is 95 to 100 % of the surface. This will vary with the type of mica paper. First make trial tests observing the characteristics of the end point.

### 24. Report

24.1 Report the following information:

24.1.1 Thickness of the specimen, and

24.1.2 Average of five readings.

## ROLL QUALITY

### 25. Report

25.1 Mica paper is chiefly supplied in continuous lengths in roll form. Because roll quality determines handling properties of the mica paper when it is unwound on combining or impregnating equipment, the following conditions shall be observed and reported if they are found to occur in the roll, and to what degree:

25.1.1 Sticking of layers to each other,

25.1.2 Loose mica platelets,

25.1.3 Delamination, separation, or cracking of the mica paper (that is, examine the mica paper for delamination, separation, or cracking when it is unwound and bent back on itself (reverse direction) over a 3-in. diameter mandrel and when it is cut across full width of the roll),

25.1.4 Uneven winding tension, loosely wound ends, bagging,

25.1.5 Telescoping or coning, indexing of edges,

25.1.6 Position of the center of the mica paper with respect to the center of the core on which the mica paper is wound (that is, does the center of the mica paper coincide with the center of the core or is it offset),

25.1.7 Shape of roll, for example, degrees of roundness,

25.1.8 Crushed roll ends which cause tearing when the material is unrolled,

25.1.9 Nonlinear edges in which the edge follows a long sine wave, and

25.1.10 Any other unusual conditions.

## MOISTURE CONTENT

### 26. Significance and Use

26.1 Excessive moisture content will cause raw mica paper to weaken significantly with lengthwise or crosswise tearing, or both, resulting when it is unwound. It may also cause polar impregnants, or impregnants that are dissolved in polar solvents, to impregnate to a higher degree, or at a faster rate, or both, than is desired. It may also contribute to blistering of the mica paper when these impregnants are dried with heat. It may, in addition, cause contiguous layers of raw mica paper in the roll to stick to each other, making unwinding difficult or impossible. Excessive moisture will also weaken and soften the cardboard core upon which the mica paper is customarily rolled. Low-moisture contents are generally not as deleterious in effect, although they can conceivably cause excessive stiffness in thick mica papers.

### 27. Procedure

27.1 Determine the moisture content in accordance with Test Method D644, except sample the material in accordance with Section 3. The samples should not be preconditioned.

### 28. Report

28.1 Report the average, minimum, and maximum moisture content for all samples tested.

## WEIGHT VARIABILITY

### 29. Significance and Use

29.1 The degree of variability of basis weight (mass per unit area) from point to point on a sheet has an effect on the physical and electrical properties of which the sheet is a component.

29.2 In general the variability is greater across the width of the sheet than along its length. For this reason, specimens for the determination of weight variability must represent the entire width of the material being sampled.

### 30. Procedure

30.1 Sample in accordance with Section 3. The sample must represent the entire width of the sheet being evaluated.

30.2 Carefully cut ten specimens (see 3.3). The specimens may be either circular or rectangular, and they shall be as nearly identical in size as possible. The area of each specimen shall be between 10 and 20 in.$^2$ (0.0065 and 0.0130 mm$^2$), and shall be known for each specimen within ±0.5 %.

30.3 Space the specimens uniformly across the width of the sample. If the sample is not of sufficient width to permit spacing across, two or more rows of specimens may be cut.

30.4 Weigh each specimen to the nearest 0.1 mg.

## 31. Report

31.1 Report the following information:

31.1.1 Identification of the sample,

31.1.2 Area of each specimen, or, if the range of areas between the smallest and largest specimen differs by less than 1 %,

31.1.3 Basis weight in grams per square metre for each specimen,

31.1.4 Average basis weight, and

31.1.5 Percentage variation of the smallest and largest individual basis weight values from the average.

# AQUEOUS EXTRACT CONDUCTIVITY

## 32. Significance and Use

32.1 For mica papers that are intended for use in capacitors, the results of this test are indicative of electrical properties of the finished capacitor, particularly dissipation factor and insulation resistance.

## 33. Procedure and Report

33.1 Prepare specimens from samples selected as specified in Section 3.

33.2 Determine the conductivity of the aqueous extract as specified in Methods D202.

33.3 Make calculations and report in accordance with Test Methods D202.

## 34. Keywords

34.1 air resistance; apparent density; aqueous extract conductivity; dielectric strength; impregnation time; mica paper; tensile strength; thickness; weight; weight variability