To: Current Holders of FI 2-1992
From: NEMA Communications Department
Date: August 14, 2003
Subject: Reaffirmation of FI 2-1992

Setting Standards for Excellence

The NEMA Codes and Standards Committee has reaffirmed FI 2-1992, "*Untreated Mica Paper Used for Electrical Insulation.*"

The new designator for this standard is FI 2-1992 (R1999), "*Untreated Mica Paper Used for Electrical Insulation.*"

Please insert the attached revised title page into your standard.

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NEMA Standards Publication No. FI 2-1992 (R1999)

Untreated Mica Paper Used for Electrical Insulation

Published by:

National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209

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STANDARDS PUBLICATION NO. FI 2

nema

Untreated Mica Paper Used for Electrical Insulation

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 20037

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NEMA Standards Publication No. FI 2-1992

UNTREATED MICA PAPER USED FOR ELECTRICAL INSULATION

Published by

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Foreword

These standards have been developed and revised over a period of years in close coordination with user needs. The Flexible Insulation and Mica Section of NEMA reviews these standards periodically for any revisions necessary to keep them up to date. Proposed revisions or comments should be submitted to:

Vice President, Engineering Department
National Electrical Manufacturers Association
2101 L. Street, N.W., Suite 300
Washington, DC 20037

Scope

This Standards Publication covers the procedures, conditions, and methods of sampling and testing properties of untreated mica paper used as electrical insulation or as a component in a composite used for electrical insulating purposes. The tables in Section 2 are typical of commercially available mica papers. Actual property values are to be established between buyer and seller.

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Section 1
DEFINITIONS AND REFERENCES

1.1 REFERENCED STANDARDS

In this publication, reference is made to the standards listed below.

American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103

ASTM D374-88	*Standard Test Methods for Thickness of Solid Electrical Insulation*
ASTM D726-84	*Standard Test Method for Resistance of Nonporous Paper to Passage of Air*
ASTM D1677-86	*Standard Methods for Sampling and Testing Untreated Mica Paper Used for Electrical Insulation*
ASTM D3636-80 (1984)	*Standard Method for Sampling and Judging Quality of Solid Electrical Insulating Materials*

1.2 DEFINITIONS AND CHEMICAL COMPOSITION

1.2.1 Definitions

1.2.1.1 APPARENT DENSITY

Apparent density is the mass of the mica paper per unit volume and is expressed as g/cm3.

1.2.1.2 AIR RESISTANCE

Air resistance is the relative difficulty with which air can be forced perpendicularly through the plane of the sheet. It is an indication of formation and porosity of the mica paper.

1.2.1.3 AQUEOUS

Aqueous extract conductivity is a measure of the amount of electrolytes present in the mica paper that may be extracted in hot water under prescribed conditions.

1.2.1.4 BASIS WEIGHT

Basis weight is the mass per unit area; weight variation is a measure of the difference in weight uniformity across the full width of the sheet.

1.2.1.5 ELECTRIC BREAKDOWN

Electric breakdown voltage is the voltage at which electrical breakdown of a mica paper specimen between two electrodes occurs under prescribed conditions of test.

1.2.1.6 ELECTRIC STRENGTH

Electric strength is the ratio of the dielectric breakdown voltage to the thickness of the mica paper tested.

1.2.1.7 TENSILE STRENGTH

Tensile strength is the force required to rupture or break a test specimen of definite width and length, cut from each principle direction, that is, machine-direction and cross-machine direction, of the mica paper conditioned and tested as specified.

1.2.1.8 THICKNESS

Thickness is the measure of the average perpendicular distance between the two principal surfaces of the mica paper as determined in accordance with ASTM D1677.

1.2.1.9 THICKNESS VARIATION

Thickness variation is a measure of the nonuniformity (or uniformity) of adjacent and nearby areas of a given sample of mica paper across its full width.

1.2.1.10 MICA PAPER

Mica paper is defined as flexible, continuous, and uniform layers of mica reconstituted into a paper-like, electrical insulating material composed entirely of small, thin, overlapping flakes or platelets, and which has sufficient strength to be self-supporting and to be capable of being wound into roll form for commercial use. Mica paper as defined by this standard shall contain no binders, adhesives, foreign matter, or coloring agents, and shall be substantially free of any substance which will adversely affect its performance as electrical insulating material.

1.2.1.11 MOISTURE CONTENT

Moisture content is the loss in weight of the mica paper, as received, expressed as a percentage of the original weight of the specimen, after it has been dried under specified conditions of time and temperature.

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1.2.1.12 PENETRATION TIME

Penetration time is the time in seconds required for a liquid of definite composition and specific gravity to penetrate completely, that is, at least 95 percent of the area, from one surface of the mica paper to the other under specified conditions.

1.2.2 Chemical Composition of Type M—Muscovite (Granitic)

Type M—Muscovite (granitic) is sometimes called India, white, ruby, or potassium mica and is represented by typical, idealized chemical formulas $K_2Al_4Al_2Si_6O_{20}(OH)_4$ and $H_2KAl_3(SiO_4)_3$. However, some natural micas may contain other elements as isomorphous replacements in varying proportions.

1.2.3 Chemical Composition of Type P—Phlogopite (Pyroxenic)

Type P—Phlogopite (pyroxenic) is sometimes referred to as amber or magnesium mica and is represented by typical idealized chemical formulas $K_2Mg_6Al_2Si_6O_{20}(OH)_4$ and $H_2KMg_3Al(SiO_4)_3$, but naturally occurring phlogopite mica may also contain other elements in varying proportions as isomorphic replacements.

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Table 2-1
MUSCOVITE MICA PAPER, UNCALCINED (UNFIRED) AND NOT CHEMICALLY TREATED LARGE FLAKE SIZE (CLASSIFICATION 2.1)—TYPICAL PROPERTIES*

Average Basis Weight		Range of Basis Weight		Average Thickness		Range of Average Thickness		Tensile Strength		Penetration Time,	Electric Strength		Moisture Content,
g/ft²	(g/m²)	g/ft²	(g/m²)	In.	(mm)	In.	(mm)	lb/in.	(N/cm)	Seconds	V/mil	(kV/mm)	Maximum%
13.1	(141)	12.1–14.1	(130–152)	0.0033	(0.0838)	0.0029–0.0038	(0.0737–0.0965)	5	(8.8)	10–30	250	(9.84)	1.0
21.5	(231)	19.0–24.0	(205–258)	0.0053	(0.1346)	0.0044–0.0062	(0.1118–0.1575)	5	(8.8)	15–40	250	(9.84)	1.0
32.3	(347)	30.5–34.0	(328–366)	0.0080	(0.2032)	0.0070–0.0090	(0.1778–0.2286)	9	(15.8)	35–75	350	(13.78)	1.0
40.5	(436)	38.0–43.0	(409–463)	0.0100	(0.2540)	0.0088–0.0112	(0.2235–0.2845)	9	(15.8)	50–100	350	(13.78)	1.0

*These data are indicative of commercially available mica papers in general use. Actual product values are to be established between the vendor and the user.

Table 2-2
MUSCOVITE MICA PAPER, UNCALCINED (UNFIRED) AND NOT CHEMICALLY TREATED MEDIUM FLAKE SIZE (CLASSIFICATION 2.2)—TYPICAL PROPERTIES*

Average Basis Weight		Range of Basis Weight		Average Thickness		Range of Average Thickness		Tensile Strength		Penetration Time,	Electric Strength		Moisture Content,
g/ft²	(g/m²)	g/ft²	(g/m²)	In.	(mm)	In.	(mm)	lb/in.	(N/cm)	Seconds	V/mil	(kV/mm)	Maximum%
11.1	(120)	10.6–11.7	(114–126)	0.0035	(0.090)	0.0030–0.0041	(0.075–0.105)	...	...	10–20	...	...	1.0
14.9	(160)	14.1–15.6	(152–168)	0.0043	(0.110)	0.0037–0.0049	(0.095–0.125)	4.50	(7.9)	15–25	...	...	1.0
23.2	(250)	22.1–24.3	(238–262)	0.0063	(0.160)	0.0051–0.0075	(0.130–0.190)	...	...	25–50	...	...	1.0
31.2	(336)	28.0–34.4	(301–370)	0.0080	(0.203)	...	...	4.40	(7.7)	97–153	435	(17.13)	1.0
34.4	(370)	32.7–36.0	(352–387)	0.0094	(0.240)	0.0079–0.0114	(0.200–0.290)	4.50	(7.9)	60–100	...	...	1.0
39.0	(420)	35.0–43.0	(377–463)	0.0100	(0.254)	...	...	5.40	(9.5)	131–209	400	(15.75)	1.0
46.8	(504)	42.1–51.5	(453–554)	0.0120	(0.305)	...	...	6.25	(10.9)	154–246	375	(14.76)	1.0
54.6	(588)	49.0–60.2	(527–648)	0.0140	(0.356)	...	...	7.20	(12.6)	174–276	350	(13.78)	1.0
62.4	(672)	56.2–68.6	(605–738)	0.0160	(0.406)	...	...	8.10	(14.2)	185–295	335	(13.19)	1.0
70.1	(755)	63.0–77.2	(678–831)	0.0180	(0.457)	...	...	9.00	(15.8)	201–319	325	(12.80)	1.0
79.0	(850)	72.2–85.8	(777–924)	0.0200	(0.508)	...	...	10.00	(17.5)	212–338	315	(12.40)	1.0

*These data are indicative of commercially available mica papers in general use. Actual product values are to be established between the vendor and the user.

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Table 2-3
MUSCOVITE MICA PAPER, PARTIALLY CALCINED (FIRED) OR CHEMICALLY TREATED,* OR BOTH, FINE FLAKE SIZE (CLASSIFICATION 2.3)—TYPICAL PROPERTIES**

Average Basis Weight		Range of Basis Weight		Average Thickness		Range of Average Thickness		Tensile Strength		Penetration Time,	Electric Strength		Moisture Content,
g/ft²	(g/m²)	g/ft²	(g/m²)	In.	(mm)	In.	(mm)	lb/in.	(N/cm)	Seconds	V/mil	(kV/mm)	Maximum%
5.6	(60)	5.1–6.1	(55–66)	0.0015	(0.038)	0.00135–0.00165	(0.034–0.042)	3.5	(6.1)	28	600	(23.6)	1.0
6.7	(72)	6.0–7.4	(65–80)	0.0018	(0.046)	0.00160–0.00200	(0.041–0.051)	4.0	(7.0)	35	600	(23.6)	1.0
7.7	(83)	7.1–8.3	(76–89)	0.0020	(0.051)	0.00180–0.00220	(0.046–0.056)	4.5	(7.9)	40	600	(23.6)	1.0
10.1	(109)	9.1–11.1	(98–119)	0.0026	(0.066)	0.00240–0.00280	(0.061–0.071)	4.5	(7.9)	42	600	(23.6)	1.0
10.4	(112)	9.4–11.4	(101–123)	0.0030	(0.076)	0.00260–0.00340	(0.066–0.086)	5.0	(8.8)	70†	600	(23.6)	1.0
13.9	(150)	12.6–15.2	(136–164)	0.0040	(0.102)	0.00350–0.00450	(0.089–0.114)	5.0	(8.8)	88†	600	(23.6)	1.0
17.4	(187)	15.9–18.9	(171–203)	0.0050	(0.127)	0.00430–0.00560	(0.109–0.142)	6.0	(10.5)	70	600	(23.6)	1.0
20.6	(221)	18.8–22.3	(202–240)	0.0060	(0.152)	0.00530–0.00670	(0.135–0.170)	6.0	(10.5)	70	600	(23.6)	1.0

*The fine flakes used to make the paper may be chemically treated in the pulping operation.

**These data are indicative of commercially available mica papers in general use. Actual product values are to be established between the vendor and the user.

†These thicknesses are also available in softer varieties having penetration times of 43 and 53 seconds respectivly.

Table 2-4
MUSCOVITE MICA PAPER, CAPACITOR GRADE FINE FLAKE SIZE (CLASSIFICATION 2.4)—TYPICAL PROPERTIES*

Average Basis Weight		Range of Basis Weight		Average Thickness		Range of Average Thickness		Tensile Strength		Electric Strength		Moisture Content,	Maximum Aqueous Extract Conductivity
g/ft²	(g/m²)	g/ft²	(g/m²)	In.	(mm)	In.	(mm)	lb/in.	(N/cm)	V/mil	(kV/mm)	Maximum%	micromhos/cm
2.80	(30.1)	2.4–3.2	(25.8–34.4)	0.0007	(0.0178)	0.00060–0.00080	(0.0152–0.0203)	2.0	(3.5)	650	(25.6)	1.0	5.0
3.50	(37.7)	3.1–3.9	(33.4–42.0)	0.0009	(0.0229)	0.00075–0.00095	(0.0191–0.0241)	3.0	(5.3)	800	(31.5)	1.0	5.0
4.80	(51.7)	4.4–5.2	(47.4–56.0)	0.0013	(0.0330)	0.00115–0.00145	(0.0292–0.0368)	3.0	(5.3)	1200	(47.2)	1.0	5.0
5.70	(61.4)	5.0–6.4	(53.8–68.9)	0.0015	(0.0381)	0.00135–0.00175	(0.0343–0.0445)	3.0	(5.3)	1400	(55.1)	1.0	5.0
7.65	(82.3)	6.9–8.4	(74.3–90.4)	0.0020	(0.0508)	0.00175–0.00225	(0.0445–0.0572)	4.0	(7.0)	1800	(70.9)	1.0	5.0

*These data are indicative of commercially available mica papers in general use. Actual product values are to be established between the vendor and the user.

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Table 2-5

PHLOGOPITE MICA PAPER, UNCALCINED (UNFIRED) AND NOT CHEMICALLY TREATED MEDIUM FLAKE SIZE (CLASSIFICATION 2.5)—TYPICAL PROPERTIES*

Average Basis Weight		Range of Basis Weight		Average Thickness		Range of Average Thickness		Tensile Strength		Penetration Time,	Electric Strength		Moisture Content,
g/ft²	(g/m²)	g/ft²	(g/m²)	In.	(mm)	In.	(mm)	lb/in.	(N/cm)	Seconds	V/mil	(kV/mm)	Maximum%
5.6	(60)	5.3–5.9	(57–63)	0.0020	(0.050)	0.0016–0.0024	(0.040–0.060)	...	...	...	...	...	0.5
7.4	(80)	7.1–7.8	(76–84)	0.0026	(0.065)	0.0022–0.0030	(0.055–0.075)	4.50	(7.9)	7–15	...	...	0.5
11.1	(120)	10.6–11.7	(114–126)	0.0031	(0.080)	0.0026–0.0037	(0.065–0.095)	6.80	(11.9)	15–35	...	...	0.5
14.9	(160)	14.1–15.6	(152–168)	0.0039	(0.100)	0.0031–0.0047	(0.080–0.120)	7.90	(13.8)	25–70	...	...	0.5
23.2	(250)	22.1–24.3	(238–262)	0.0057	(0.145)	0.0045–0.0069	(0.115–0.175)	9.00	(15.8)	40–100	...	...	0.5
31.2	(336)	28.0–34.4	(301–370)	0.0080	(0.203)	...	...	4.40	(7.7)	97–153	435	(17.13)	0.5
39.0	(420)	35.0–43.0	(377–463)	0.0100	(0.254)	...	...	5.40	(9.5)	131–209	400	(15.75)	0.5
46.8	(504)	42.1–51.5	(453–554)	0.0120	(0.305)	...	...	6.25	(10.9)	154–246	375	(14.76)	0.5
54.6	(588)	49.0–60.2	(527–648)	0.0140	(0.356)	...	...	7.20	(12.6)	174–276	350	(13.78)	0.5
62.4	(672)	56.2–68.6	(605–738)	0.0160	(0.406)	...	...	8.10	(14.2)	185–295	335	(13.19)	0.5
70.1	(755)	63.0–77.2	(678–831)	0.0180	(0.457)	...	...	9.00	(15.8)	201–319	325	(12.80)	0.5
79.0	(850)	72.2–85.8	(777–924)	0.0200	(0.508)	...	...	10.00	(17.5)	212–338	315	(12.40)	0.5

*These data are indicative of commercially available mica papers in general use. Actual product values are to be established between the vendor and the user.

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Section 3
MANUFACTURING

3.1 ORDERING INFORMATION

Orders for mica paper materials should include the following information.

a. Mica paper classification
b. Basis weight, total mass per unit area in grams/foot^2 (grams/meter^2)
c. Nominal thickness, inches (mm)
d. Roll width, inches (mm)
e. Core size, inside diameter, inches (mm)
f. Roll weight or length per roll, or both

3.2 PACKAGING

The mica paper should be secured firmly to the core in a manner that prevents slippage under tension. Mica paper rolls should be packaged in high strength containers which should resist crushing during shipment. There should be adequate clearance between the sides of the container and the roll of mica paper so that slight crushing of the container does not cause damage to the mica paper. Well designed headers should be used to support the ends of the roll to prevent shifting of the mica paper during shipment. The outside of the roll should be wrapped with a suitable moisture-barrier material.

3.3 MARKING AND IDENTIFICATION

The shipping carton and core of each roll should be prominently and permanently marked with the following information.

a. Name of supplier
b. Roll number or lot number, or both
c. Mica paper class and basis weight in grams/foot^2 (grams/meter^2)
d. Weight or length of roll, or both
e. Penetration time in seconds

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Section 4
TEST METHODS

4.1 SPECIMENS AND CONDITIONING

Specimens shall be conditioned in accordance with ASTM D1677 insofar as it is practical to do so, or as mutually agreed upon by customer and supplier.

4.2 APPEARANCE-VISUAL INSPECTION

Upon visual inspection, the mica paper shall be examined for deleterious pieces of block mica, mineral, metallic inclusions, dirt, grit, wood, straw, paper, and so forth, and shall not contain any foreign substance which will cause staining of the mica paper when it is subsequently treated or impregnated with resinous solutions or solvents. Visible defects such as: excessive flaking of loose mica flakes and platelets, voids, cracks, folds or creases, interlaminar separation, thin edges or bands, and large variations in density or uniformity shall be noted.

4.3 THICKNESS AND THICKNESS VARIATION

4.3.1 Significance

4.3.1.1 THICKNESS

The nominal thickness and thickness tolerance is generally specified when ordering mica paper and therefore, accurate determination of thickness by a standard procedure is important for identification of the material. Also, thickness must be determined in order to determine mass per unit area, the apparent density, and electric strength.

4.3.1.2 THICKNESS VARIATION

Variation in thickness can adversely affect the quality of roll winding. Determination of thickness variation can be useful in judging the overall uniformity of a particular roll of mica paper and its performance, particularly with respect to dielectric breakdown voltage, impregnation time, and also in estimating the ultimate properties of the end product in which the mica paper is used.

4.3.2 Procedure

4.3.2.1 THICKNESS

The preferred method of test shall be Method D, Motor-Operated Dead-Weight Dial Gage, of ASTM D374, with a drop rate of 0.012 ±0.004 in./sec (0.3 ±0.1 mm/sec) and a dwell time of 3 ±1sec for thicknesses of 0.002 to 0.006 in. (0.05 to 0.15 mm) and 6 ±2sec for thicknesses greater than 0.006 in. (0.15 mm). However, Method C, Manually Operated Dead-Weight Dial-Type Thickness Gage, of ASTM D374 is an acceptable alternative. The diameter of the presser foot and the anvil shall be 0.250 ±0.001 in. (6.35 ±0.03 mm) and the pressure of the presser foot shall be 25 ±2 psi (172 ±14 kPa).

4.3.2.2 THICKNESS VARIATION

Thickness variation shall be determined on specimens which include the full roll width and which have a length at least twice the roll width whenever it is practical to do so. Two straight lines shall be marked at right angles to the machine direction of the mica paper, the two lines being separated by a distance equal to or greater than the roll width. Each line shall be divided into five equal segments and marked off in squares 2 × 2 in. (50 × 50 mm) at the midpoints of each segment. Three thickness measurements shall be taken within each area and the average values of these three readings shall be recorded as the thickness of each of the areas. The results shall be tabulated as follows.

	Column 1	Column 2
Area a	ta	Ta
Area b	tb	Tb
Area c	tc	Tc
Area d	td	Td
Area e	te	Te
Total t =	Σt	ΣT
Avg. t =	$\frac{\Sigma t}{5}$	$\frac{\Sigma T}{5}$

Thickness variation shall be calculated from the following: Take the difference between the minimum and maximum t in Column 1. Take the difference between the minimum and maximum T in Column 2. Take the difference between the average t and the average T.

4.3.3 Reporting

4.3.4.1 THICKNESS

Average, minimum, and maximum thicknesses shall be reported.

4.3.3.2 THICKNESS VARIATION

The thickness variation shall be whichever value is the largest difference of these three determinations and it shall be reported as a percent using the ratio of thickness variation to the nominal thickness of the paper.

4.4 BASIS WEIGHT AND WEIGHT VARIATION

4.4.1 Significance

The degree of variation in basis weight from point to point on a sheet of mica paper can have an effect on the physical and electrical properties of the sheet itself, as well as on the coated or laminated products of which the sheet is a component.

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4.4.2 Procedure

In general, weight variation is greater across the width of the sheet than along its length. For this reason, specimens for the determination of basis weight and weight variation must be representative of the entire width of the material sampled. Sampling and testing shall be in accordance with ASTM D1677. All specimens shall be carefully cut to specific dimensions—preferably by a sharp die—so as not to dislodge mica flakes on the edges. Sample size shall be at least 36 in.^{2} (232 cm^2) but not greater than 144 in.^{2} (929 cm^2).

4.4.3 Reporting

Basis weight shall be reported as g/ft^2 (g/m^2) and weight variability as the percentage variation of the smallest and largest individual basis weight values from the average.

4.5 APPARENT DENSITY

4.5.1 Procedure

Apparent density shall be determined from the thickness and basis weight measurements above in accordance with ASTM D1677 and shall be calculated as follows.

$$D = \frac{A}{B \times 10{,}000}$$

Where:

A= basis weight, g/m^2

B= thickness, cm

D= apparent density, g/cm^3

4.6 TENSILE STRENGTH

4.6.1 Significance

The results of the test are suitable for acceptance and product control. They are also useful for determining the ability of the mica paper to withstand the tensile stresses encountered in unwinding from a roll and in application processes.

4.6.2 Procedure

Because of the fragile nature of mica paper, extreme care must be exercised in preparing tensile strength test specimens so as not to damage the edges. Cutting with a sharp die is preferred. Tensile breaking strength shall be determined in accordance with ASTM D1677, except the specimens shall be 1 to 3 in. (25 to 77 mm) wide, and the distance between jaws (grips) shall be 3 to 5 in. (77 to 127 mm). Rate of jaw separation for the specimens 0.006 in. (0.15 mm) thick and below is normally 0.2 to 2 in. (5.1 to 50.8 mm) per minute. For specimens above 0.006 in. (0.15 mm) jaw separation can be up to 12 in. (305 mm) per minute.

4.6.3 Reporting

Tensile strength shall be reported as the force per unit width, either pounds per inch width (lb./in.) or Newtons per meter width (N/m).

4.7 PENETRATION (IMPREGNATION) TIME

4.7.1 Significance

Penetration (impregnation) time influences the speed and quality of resin penetration of the mica paper and the ultimate resin content in the product. Specimens shall be placed on the penetrometer with the core side (screen side) in contact with the solution.

4.7.2 Procedure

Penetration time shall be determined in accordance with ASTM 1677, using a test solution of approximately 60 parts cold pressed castor oil (USP No. 1 Grade) and 40 parts toluene, adjusted to a specific gravity of 0.917 ±0.001 at 77°F (25°C). A Williams Penetrometer, or similar instrument, shall be used to make the measurements. Because of the volatile nature of the impregnation solution, it shall be checked frequently and the specific gravity adjusted accordingly.

4.8 ELECTRIC STRENGTH

4.8.1 Significance

For mica paper to be used in the untreated state, this test gives some indication of its electrical strength. This test also has value for quality control purposes for mica paper that is subsequently treated.

4.8.2 Procedure

Dielectric strength shall be determined in accordance with ASTM D1677 using 2-in. (50.8 mm) diameter electrodes in air and the short-time (500 V/s), continuous-rise method.

4.8.3 Reporting

Electric strength is usually expressed in volts per mil (V/mil) or kilovolts per millimeter (kV/mm) and is obtained by dividing the average breakdown voltage by the average thickness of the mica paper specimen tested.

4.9 AIR RESISTANCE—POROSITY

4.9.1 Significance

These test results, considered together with results of other tests, as well as with past experience with the mica paper, can be used to estimate ease of impregnation with resins, dielectric strength, and other properties which may be of interest in processing and in the end application. The test may be useful for process-control, for drafting a material specification, and for providing information for further research.

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4.9.2 Procedure

Air resistance shall be determined in accordance with Method B of ASTM D726 using a Gurley-Hill SPS-Tester No. 932, or other suitable apparatus. Method A shall be permitted to be used for mica papers which are more porous.

4.9.3 Reporting

The report shall include the method; the average, minimum, and maximum number of seconds required for the passage of air through the mica paper in each direction; and the volume in cubic centimeters of air displaced.

4.10 ORGANIC MATERIAL

4.10.2 Significance

Mica paper is made from pure natural mica and, therefore, it should possess the excellent electrical properties of natural mica. Organic matter in mica paper will be present as an undesirable contaminant which should be held to as low a level as good commercial practice will allow.

4.10.2 Procedure

Dry mica paper sample to constant weight at 248°F (120°C) and then cool in desiccator and weigh. Place in suitable dried and weighed crucible and place in furnace for 30 minutes at 932°F (500°C). Cool in desiccator and weigh. Determine weight loss and calculate percent weight loss or percent organic material.

4.11 MOISTURE CONTENT

4.11.1 Significance

Excessive moisture content will significantly weaken untreated mica paper and can result in poor handling characteristics and low tear and tensile breaking strengths when the roll is unwound. It may also cause polar impregnants, or impregnants which are dissolved in polar solvents, to impregnate to a higher degree, or at a faster rate, or both, than is desired. Excessive moisture content may also contribute to blistering of the mica paper when these impregnants are subsequently dried with heat. It may, in addition, cause contiguous layers of untreated mica paper in the roll to stick to each other (blocking), making unwinding difficult or impossible. Very high levels of moisture over prolonged periods of time may also cause softening and weakening of the cardboard core upon which the mica paper is customarily wound. The effects of excessively low moisture contents are not generally as deleterious, although they may cause an increase in stiffness, cracking, and a loss of flatness when a roll is unwound, especially in some of the thicker mica papers.

4.11.2 Procedure

Moisture content shall be determined in accordance with ASTM D1677.

4.11.3 Reporting

Average, minimum, and maximum values shall be reported.

4.12 AQUEOUS EXTRACT CONDUCTIVITY

4.12.1 Significance

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

4.12.2 Procedure

Aqueous extract conductivity shall be determined and calculated in accordance with ASTM D1677.

4.13 ROLL QUALITY

Roll quality is an appraisal, based upon visual inspection, of the suitability of the wound roll for the intended application. 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. The degree to which they interfere with the intended use of the material shall also be reported.

Roll quality defects consist of:

a. Sticking (blocking) of layers to each other
b. Loose mica flakes and platelets
c. Delamination, separation, and cracking upon unwinding of the mica paper (that is, examine the mica paper for these defects when a full width section of it is unwound and bent back on itself in the reverse direction over a 3-inch [76.2 mm] diameter mandrel)
d. Uneven winding tension, loosely wound ends, and bagging
e. Telescoping or coning, indexing or stepping of the edges
f. Misalignment as determined by the 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 mica paper coincide with the center of the core or is it offset)
g. Misshapen roll; for example, the degree of roundness or flatness
h. Crushed roll ends which can cause tearing when the mica paper is unrolled
i. Nonlinear edges in which either edge follows a long sine wave curve or other pattern
j. Edge tears
k. Other unusual conditions

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4.14 ESTABLISHMENT OF ACCEPTABLE QUALITY LEVELS (AQLs)

Acceptable quality levels (AQLs) for each major and each minor property should be as mutually agreed upon by the customer and the supplier.

In addition, group AQLs may be established for given groups of properties or attributes and these, too, should be mutually agreed upon by the customer and supplier. ASTM D3636 is recommended as a guide for establishing an AQL system.

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NEMA STANDARDIZIATION BACKGROUND

The purpose of NEMA standards, their classification, and status are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced below:

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for their particular needs. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process, or procedure with reference to one or more of the following: nomenclature, composition, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Standardization Policies and Procedures, p. 1)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the Standards Publication may be capable of otherwise equivalent performance.

(Standardization Policies and Procedures, p. 6)

Categories of Standards

National Electrical Manufacturers Association Standards are of three classes, which have received the affirmative vote of at least two-thirds of the Subdivision votes cast in the affirmative or negative:

1. NEMA Standard, which relates to a product, process, or procedure commercially standardized and subject to repetitive manufacture.
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development.
3. Adoptive Standard, which is adopted in whole or in part from the standards of another organization, either domestic, regional, or international.

(Standardization Policies and Procedures, pp. 5)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design, which standard has received the affirmative vote of at least two-thirds of the Subdivision votes cast in the affirmative or negative.

(Standardization Policies and Procedures, pp. 5)

Identification of Status

Standards in NEMA Standards Publications are identified as "NEMA Standard," "Suggested Standard for Future Design," or "Adoptive Standard." These indicate the status of the standard. A statement incorporating the auxiliary verb "shall" indicates that compliance with a requirement is mandatory for compliance with the standard. These classes of standards are identified in the foreword or throughout the text.

The material identified as "Authorized Engineering Information" is designated similarly. Statements incorporating other auxiliary verbs such as "should," "may," etc. refer to the authorized engineering information and not to procedures required for compliance with the standard.

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