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NEMA STANDARDS PUBLICATION

NEMA FI 1

MANUFACTURED ELECTRICAL MICA

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NEMA Standards Publication FI 1-1996
MANUFACTURED ELECTRICAL MICA

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Foreword

This publication represents a revision of the NEMA Standards Publication *Manufactured Electrical Mica*, FI 1-1983.

These standards have been developed and revised over a period of years in close coordination with user needs. Those which deal with the more traditional dry or cured tape type mica products have for the most part remained unchanged. However, this revision provides a set of new listings for such products as VPI tapes, resin-rich or B staged products, as well as blends of aramid and mica products. This revision also adds and/or updates several test methods as a result in changes in industry practices and/or the addition of these new product listings.

This document should now contain a majority of the types of constructions of manufactured electrical mica products used and produced by industry today. In some cases, only typical constructions are listed. Alternate constructions and the performance specifications of these products should be a matter of negotiation between buyer and seller.

Metric tables for each of the constructions are included in this document. In most, if not all cases, the english units have been converted to their metric equivalents.

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
1300 North 17th Street, Suite 1847
Rosslyn, Virginia

This Standards Publication was developed by the Flexible Insulation and Mica Section. Section approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Flexible Insulation and Mica Section was composed of the following members:

Dennison Manufacturing Company—Framingham, MA
EHV—Weidmann Industries, Inc.—St. Johnsbury, VT
E. I. DuPont de Nemours and Company—Wilmington, DE
Essex Group, Inc., MacAllen Mica—New Market, NH
Essex Group, Inc., U. S. Samica—Rutland, VT
Insulating Materials, Inc.—Schenectady, NY
Lydall, Inc., Manning Nonwovens Division—Troy, NY
Kirkwood Industries, Midwest Mica and Insulation—Cleveland, OH
Westinghouse Electric Corp.—Bedford, PA

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Section 1
GENERAL

1.1 SCOPE

This Standards Publication covers manufacturing, measurement, and testing of manufactured electrical mica.

1.2 DEFINITIONS

Manufactured mica plates are composed of:
a. binder and mica splittings
b. binder and mica paper
c. binder, mica paper, and mica splittings, with no reinforcement, in the form of flat pieces of standard dimensions or in rolls from 4 to 40 inches (102 to 1016 mm) wide.

Manufactured mica sheets are composed of:
a. binder and mica splittings
b. binder and mica paper, with reinforcement on one or both sides
c. an intimately blended aramid and mica paper, in the form of flat pieces of standard dimensions or in rolls

These rolls are typically available in widths from 4 to 40 inches (102 to 1016 mm) wide for types (a.) and (b.), and in widths from 4 to 72 inches (102 to 1828 mm) for type (c.). Rolls wider than 4 inches (102 mm) are commonly referred to as *wrappers*.

The binder and mica papers with reinforcements on one or both sides [type (2)], come in three styles designated by binder content and primary use application. *Tapes primarily used in VPI applications* have low binder content (5–20%) and are designed in constructions to aid resin absorption in the VPI process. *Dry or cured tapes and sheets* have a medium binder content (20–30%), which has been largely cured and are general purpose products used in most applications. *Resin-rich "B-staged" tapes* are typically high in binder content (30–40%), and have only been partially cured to a non-tacky state. Resin-rich tapes normally need no further addition of resin in their intended use except for cosmetic reasons.

Manufactured mica tapes are composed of:
a. binder and mica splittings
b. binder and mica paper, with reinforcement on one or both sides
c. an intimately blended aramid and mica paper, in the form of rolls up to 4 inches (102 mm) wide and containing not less than 10 linear feet (3048 mm)

There are three broad classes of bonding materials for making mica composites. In this document, organic bonded refers to non-silicone organic resins such as epoxy, polyester, acrylics, etc. Silicone resin binders consist of a molecule which contains both inorganic (silica) and organic constituents. Inorganic binders are rigid molecules containing no organic constituents. They are glass-like compounds.

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1.3 REFERENCES

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

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

ASTM D295-89	*Standard Test Methods for Varnished Cotton Fabrics Used for Electrical Insulation*
ASTM D348-89	*Standard Test Methods for Rigid Tubes Used for Electrical Insulation*
ASTM D352-77	*Standard Methods of Testing Pasted Mica Used in Electrical Insulation*
ASTM D374-88	*Standard Test Methods for Thickness of Solid Electrical Insulation*
ASTM D668-89	*Standard Methods of Measuring Dimensions of Rigid Rods and Tubes Used for Electrical Insulation*
ASTM D828-87	*Standard Test Method for Tensile Breaking Strength of Paper and Paperboard*
ASTM D1830-89	*Standard Test Method for Thermal Endurance of Flexible Sheet Materials Used for Electrical Insulation by the Curved Electrode Method*
ASTM D2131-85	*Standard Specification for Natural Muscovite Mica Splittings*

Bureau Central de la Commission Electrotechnique Internationale
3, rue de Varemb_
Gen_ve, Suisse

IEC 216-1(1987) *Part 1: General procedures for the determination of thermal endurance properties, temperature indices and thermal endurance profiles*

Underwriters Laboratories, Inc.
Publications Stock
333 Pfingsten Road
Northbrook, IL 60062

UL 746B-91 *Polymeric Materials—Long Term Property Evaluations*
UL 1446-90 *Systems of Insulating Materials—General*

Technical Association of the Pulp and Paper Industry
One Dunwoody Park
Atlanta, GA 30338

TAPPI T543-84 *Stiffness of paper (Gurley type stiffness tester)*

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Section 2
TOLERANCES

2.1 TOLERANCES ON THICKNESS

For tolerances on the thickness of fabricated mica splitting segments, see 2.4.

For tolerances on the thickness of manufactured mica splitting plates, sheets, and tapes, see Section 4.

For tolerances on the thickness of manufactured mica paper plates, sheets, and tapes, see Section 5.

2.2 TOLERANCES ON WIDTH OF MICA TAPES WITH GLASS CLOTH REINFORCEMENT

The tolerance in the width of tapes from 1/2 to 1-1/2 inches (12.7 to 38.1 mm) wide shall be ±1/32 inch (0.79 mm).

2.3 TOLERANCES FOR DIMENSIONS OF MICA SHEETS

The tolerance for the length and width of sheets which are 18 x 36 inches (457 x 914 mm) or larger shall be ±1/2 inch (12.7 mm).

2.4 TOLERANCES FOR THICKNESS OF FABRICATED MICA SPLITTING SEGMENTS

The tolerances for the thickness of segments which are fabricated from rigid milled plate (segment) (Grade 3, 3P and 4) shall be:

a. Nominal thickness range—20 up to 63 mils (0.51 up to 1.60 mm).
b. Average thickness of 10 measurements—±1 mil (0.025 mm) from the specified nominal thickness.
c. Individual thickness—± 2 mils (0.051 mm) from the specified nominal thickness.

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Section 3
CLASSIFICATION OF MICA SPLITTINGS

3.1 CLASSIFICATION OF MUSCOVITE MICA SPLITTINGS

3.1.1 Definitions of Mica Splittings

a. Laminae—are splittings taken from mica blocks and having an average area of 0.4 to 10 square inches (2.5 to 65 square centimeters) and an average thickness of 0.0006 to 0.0012 inches (0.015 to 0.030 millimeters).
b. Bookform splittings—are arranged and supplied in the form of individual books or bunches, each comprised of consecutive splittings obtained from the same piece of block or thins. These laminae are generally dusted with mica powder to offset residual cohesive effects.
c. Loose splittings—are of heterogeneous shapes not arranged in any particular order, but packed loosely in bulk form. Loose splittings, as such have not been dusted with mica powder.
d. Loose with powder splittings—are loose splittings which are dusted with mica powder.

3.1.2 Size and Defects

In order to be within the grade classifications given herein, splittings shall:

a. Meet the size requirements specified in Table 3-1.
b. Have not more than the maximum allowable total defects specified in Table 3-2, based on percent weight. Such defects shall not lie predominantly in any one category.
c. Not have foreign matter included among the splittings.

3.1.3 Sampling

a. Bookform splittings—50 books shall be drawn at random from each case sampled. At least 10 percent of the cases in the lots shall be sampled.
b. Loose splittings, with and without powder—A minimum of 1 ounce (0.035 grams) shall be taken from each case sampled. At least 10 percent of the cases in the lot shall be sampled.

3.1.4 Method of Calculation

Splittings shall be examined for defects in the order of separate values listed and shall be counted defective for the first defective characteristic noted. Defects for which separate values are not given may be aggregated. Each group shall be weighed to determine the percentage it represents of the total sample weight less undersizes [see footnote 6 below Table 3-2]. In computing percentages, 1/2 percent or more shall be considered 1 percent, and less than 1/2 percent shall be considered 0.

3.1.5 Definitions of Defects

Rough or burred edges—are frayed or serrated edges usually 1/32 inch (0.79 mm) deep or greater, or an edge turned up or down as caused by trimming with scissors, etc., or by rubbing the edge against sandpaper, stone, etc.

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Table 3-1
SIZE AND AVERAGE THICKNESS

Commercial Grade[1]	NEMA Grade	Form[2]	Size, Square Inches[3]	Minimum Dimension of Usable Rectangle	Thickness of Splitting, Inches
4	AA	Book form	6 up to 10	1.5	0.006 to 0.009
5	A	Book form	3 up to 6	1	0.006 to 0.009
5.5	B-1	Book form	2 up to 3	7/8	0.006 to 0.009
4	AA	Dust loose	6 up to 10	1.5	0.006 to 0.009
5	A	Dust loose	3 up to 6	1	0.006 to 0.009
5.5	B-2	Dust loose	1.5 up to 3	7/8	0.007 to 0.010
6	C	Dust loose	1 up to 1.5	¾	0.007 to 0.010
6-1st	D	Loose	At least 70% shall be 1 up to 1.5. Not more than 3% average per lot and not more than 6% per case shall pass through a screen having ¾-inch round openings	...	0.007 to 0.010
6-2nd	E	Loose	At least 50% shall be 1 up to 1.5. Not more than 6% average per lot and not more than 12% per case shall pass through a screen having ¾-inch round openings	...	0.007 to 0.011
6-3rd	F	Loose	At least 65% shall be 1 up to 1.5. Not more than 12% average per lot and not more than 18% per case shall pass through a screen having ¾-inch round openings	...	0.007 to 0.011

[1] Commercial Grade designations were not developed by NEMA but are listed for information only. (This note has been approved as Authorized Engineering Information.)
[2] See 3.1.1.
[3] "Up to" means "not including". Splittings shall not all be of the minimum area specified but shall contain a fair proportion of sizes throughout the range specified. The areas specified do not refer to the total area of the splittings, but to the rectangular size which each grade will produce. For example, Grade A splitting shall be large enough to provide rectangular pieces measuring 1½ X 2, 2 X 2, 2 X 2 1/3 Inches, and so forth

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TABLE 3-2
MAXIMUM ALLOWABLE DEFECTS, PERCENT[4]

Commercial Grade[5]	NEMA Grade	Undersize	Stain	Waviness	Tears & Fractures	Thick Splittings	Thin Splittings	"V" Cuts	Rough or Burred Edges	Other Defects	Total Allowable Defects[6]
4 Book form	AA	3[7]	1[8]	Δ[9]	Δ	Δ	Δ	Δ	Δ[10]	Δ	15
5 Book form	A	3[4]	1[5]	Δ[6]	Δ	Δ	Δ	Δ	Δ[7]	Δ	15
5½ Book form	B-1	3[4]	1[5]	Δ[6]	Δ	Δ	Δ	Δ	Δ[7]	Δ	15
4 Dust loose	AA	10[4]	7[5]	Δ	Δ	Δ	Δ	Δ	Δ[11]	Δ	25
5 Dust loose	A	10[4]	7[5]	Δ	Δ	Δ	Δ	Δ	Δ[8]	Δ	25
5 ½ Dust loose	B-2	10[4]	7[5]	Δ	Δ	Δ	Δ	Δ	Δ[8]	Δ	25
6 Dust loose	C	10[4]	7[5]	Δ	Δ	Δ	•	•	Δ[8]	Δ	25
6-1st Loose	D	See table 3-1	12[12]	•	•	3	•	•	•	•	•
6-2nd Loose	E	See table 3-1	20[9]	•	•	4	•	•	•	•	•
6-3rd Loose	F	See table 3-1	20[9]	•	•	5	•	•	•	•	•

[4] See 3.1.5
[5] Commercial Grade designations were not developed by NEMA but are listed for information only. (This note has been approved as Authorized Engineering Information.) See 3.1.1
[6] Shall include an evaluation of undersize splitting for other defects.
[7] Not to be included with total allowable defects
[8] Book form -No mineral stains shall be permitted. Lots which contain more than 0.2 percent stained Splittings in which the sum of the major dimensions of the stains exceeds ¼ inch shall not be regarded as meeting these standards.
Dust loose -Lots which contain more than 2.0 percent of stained splitting in which the sum of the major dimensions of the stains exceeds ¼ install not be regarded as meeting these standards. No more than 10 percent of the stain in Nos. 4,5, and 5½ shall be mineral stain. No more than 20 percent of the stain in No. 6 shall be mineral stain.
[9] No more than 10 percent of the total allowable defects shall be waviness.
[10] Count as a defect if more than 20 percent of the periphery is rough or burred
[11] Count as a defect if more than 35 percent of the periphery is rough or burred
[12] Lots which contain more than 2 percent of stained Splittings in which the sum of the major dimensions of the stains exceeds ¼ in shall not be regarded as meeting these standards. No more than 40 percent of the stain shall be mineral stain.

Δ Means "examine for the defect listed."
• Means "do not examine for the defect listed."

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Stain or inclusion—is an area of color other than the basic color of the mica itself (except in the case of crystallographic discoloration where both colors shall be considered basic) exceeding 15 mils (0.38 mm) in its major dimension by incident or reflected light. For the purpose of this test method, a splitting shall be considered as stained when the major dimension of a stain, or the sum of the major dimensions of more than one stain, exceeds 1/16 inch (1.59 mm).

NOTES

1 "Vegetable" and smokey stains appear by transmitted light as areas of pastel colors of low to medium saturation such as pale yellow, pale brown, pale green, etc. These are dispersed metallic oxides. The term "vegetable" is a misnomer.
2 Clay stains appear by any light as areas of blue, gray, brown, etc., and are intrusions of earthy materials.
3 "Mineral" stains appear by transmitted light as areas of deep distinct and highly saturated colors such as black, brown, green, red, etc. These are concentrated metallic oxides.
4 Air inclusions appear by transmitted light as grayish areas and as silvery areas by reflected light. These are gaseous inclusions.
5 No data are available to support the implied organic nature of "vegetable" stains. Tests which have been conducted indicate that these result from finer dispersions of the metallic oxides present in "mineral" stains.

Tears and fractures—are tears or fractures extending from the periphery more than:

Grade	Inch	Millimeters
AA (No. 4)	1/2	12.70
A (No. 5)	3/8	9.53
B-1 (No. 5-1/2)	1/4	6.35
C (No. 6)	1/4	6.35

Thick edges—are edges of splittings which, because of the nature of the mica used or the act of splitting, are thicker at one end or edge than the other. Splittings shall be considered to have a thick edge if the edge or end in question is more than 1-1/2 times the minimum thickness measured at any point on the splitting or if the thickness of the edge or end exceeds the maximum average thickness allowed for the grade of splittings.

Thick splittings—are splittings whose thickness in the major section of their area or over the entire area exceeds the following:

a. A bookform splitting that exceeds the maximum average thickness allowed for the grade.
b. A loose splitting that exceeds 1.2 mils (0.030 mm).
c. A loose with powder splitting that exceeds 1 mil (0.025 mm).

Thin splittings are splittings whose thickness in the major section of their area, or over the entire area, is less than the minimum average for the grade.

"V" cuts are cuts or trims into the splitting roughly shaped as a "V." A splitting shall be considered V-cut if it contains an indentation having an included angle of 120 degrees or less extending from the periphery more than:

Grade	Inches	Millimeters
AA (No. 4)	1/2	12.70
A (No. 5)	3/8	9.53
B-1 (No. 5-1/2)	1/4	6.35
B-2 (No. 5-1/2)	1/4	6.35
C (No. 6)	1/4	6.35

Waviness—is one or a series of elevation(s) or depression(s), or both, which are readily noticeable and which include the conditions called buckles, ridges, and so forth.

Weathering—is loss of gloss usually caused by exposure to the elements; under some circumstances it is like clay stain in appearance.

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Section 4
MANUFACTURING MICA SPLITTING PLATES, SHEETS, AND TAPES

4.1 MICA SPLITTING PLATES

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Table 4-1
MICA SPLITTING PLATES

NEMA Grade	Type of Material*	Maximum Bond Content, Percent	Nominal Thickness, Mils, Incl.	Variation from Nominal, Mils (See 7.2)				Average Short-time Electric Strength** (Minimum), Volts per mil
				Average Thickness		Individual Measurements		
				Plus	Minus	Plus	Minus	
1	Hot-forming milled plate, organic bond	18	15–35	2	2	3	3	650
		18	36–62.5	2	2	3	3	550
81	Hot-forming milled plate, silicone bond	25	15–35	2	2	3	3	550
		25	36–62.5	2	2	3	3	450
2	Hot-forming unmilled plate, organic bond	18	15–62.5	5	5	8	8	550
	Rigid milled plate, organic bond (Segment)							
3†	Muscovite	7	15–32	1	1	2	2	650
3†	Muscovite	7	33–62.5	1	1	2	2	550
4†	Phlogopite	7	15–32	1	1	2	2	650
4†	Phlogopite	7	33–62.5	1	1	2	2	550
	Rigid milled plate, silicone bond							
83	Muscovite	15	15–32	1	1	2	2	650
83	Muscovite	15	33–62.5	1	1	2	2	550
5	Rigid unmilled plate, organic bond	7	15–32	5	5	8	8	600
	Rigid plate, organic bond (Heater)							
7	Muscovite	4	10–20	3	3	8	5	550
8	Phlogopite	4	10–20	3	3	8	5	550
	Rigid plate, inorganic bond (Heater)							
9	Muscovite	††	10–20	3	3	8	5	550
10	Phlogopite	††	10–20	3	3	8	5	550

* These products are made with muscovite mica splittings unless otherwise specified.
** The average electric strength (as measured with 2-inch electrodes in accordance with 7.4) shall be not less than the values listed.
† The maximum hot compression shall be 3% for NEMA Grades 3 and 4 when tested in accordance with 7.9.
††No standard test method available.

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Table 4-1 (Continued)
MICA SPLITTING PLATES

NEMA Grade	Type of Material*	Maximum Bond Content, Percent	Nominal Thickness, mm, Incl.	Variation from Nominal, mm (See 7.2)				Average Short-time Electric Strength** (Minimum), Kilovolts per mm
				Average Thickness		Individual Measurements		
				Plus	Minus	Plus	Minus	
1	Hot-forming milled plate, organic bond	18	0.38–0.89	0.05	0.05	0.08	0.08	25.6
		18	0.91–1.59	0.05	0.05	0.08	0.08	21.7
81	Hot-forming milled plate, silicone bond	25	0.38–0.89	0.05	0.05	0.08	0.08	21.7
		25	0.91–1.59	0.05	0.05	0.08	0.08	17.7
2	Hot-forming unmilled plate, organic bond	18	0.38–1.59	0.13	0.13	0.20	0.20	21.7
	Rigid milled plate, organic bond (Segment)							
3†	Muscovite	7	0.38–0.81	0.03	0.03	0.05	0.05	25.6
3†	Muscovite.	7	0.84–1.59	0.03	0.03	0.05	0.05	21.7
4†	Phlogopite	7	0.38–0.81	0.03	0.03	0.05	0.05	25.6
4†	Phlogopite	7	0.84–1.59	0.03	0.03	0.05	0.05	21.7
	Rigid milled plate, silicone bond							
83	Muscovite	15	0.38–0.81	0.03	0.03	0.05	0.05	25.6
83	Muscovite	15	0.84–1.59	0.03	0.03	0.05	0.05	21.7
5	Rigid unmilled plate, organic bond	7	0.38–0.81	0.13	0.13	0.20	0.20	23.6
	Rigid plate, organic bond (Heater)	7	0.84–1.59	0.18	0.18	0.25	0.25	21.7
7	Muscovite	4	0.25–0.51	0.08	0.08	0.20	0.13	21.7
8	Phlogopite	4	0.25–0.51	0.08	0.08	0.20	0.13	21.7
	Rigid plate, inorganic bond (Heater)							
9	Muscovite	††	0.25–0.51	0.08	0.08	0.20	0.13	21.7
10	Phlogopite	††	0.25–0.51	0.08	0.08	0.20	0.13	21.7

*These products are made with muscovite mica splittings unless otherwise specified.
**The average electric strength (as measured with 51-mm electrodes in accordance with 7.4) shall be not less than the values listed.
† The maximum hot compression shall be 3% for NEMA Grades 3 and 4 when tested in accordance with 7.9.
††No standard test method available.

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Table 4-2
FLEXIBLE PLATES—GRADE 6 (ORGANIC BONDED) AND GRADE 86 (SILICONE BONDED)*

Nominal Thickness Mils	Minimum Grade of Splittings	Variation from Thickness, Mils				Average Short-time Electric Strength** (Minimum) Volts per Mil
		Average Thickness		Individual Measurements		
		Plus	Minus	Plus	Minus	
5	A	2	1	4	3	600
10	D	3	3	7	5	500
15	D	3	3	7	5	500
20	D	3	3	8	6	400
25	E	3	3	8	6	400
30	E	5	3	8	6	400

* The maximum bond content shall be 20% for Grade 6 plates and 25% for Grade 86 plates.
**The average electric strength (as measured with 2-inch electrodes in accordance with 7.4) shall be not less than the values listed.

Table 4-2 (Continued)
FLEXIBLE PLATES—GRADE 6 (ORGANIC BONDED) AND GRADE 86 (SILICONE BONDED)*

Nominal Thickness mm	Minimum Grade of Splittings	Variation from Thickness, mm				Average Short-time Electric Strength** (Minimum) Kilovolts per mm
		Average Thickness		Individual Measurements		
		Plus	Minus	Plus	Minus	
0.13	A	0.05	0.03	0.10	0.08	23.6
0.25	D	0.08	0.08	0.18	0.13	19.7
0.38	D	0.08	0.08	0.18	0.13	19.7
0.51	D	0.08	0.08	0.20	0.15	15.7
0.64	E	0.08	0.08	0.20	0.15	15.7
0.76	E	0.13	0.08	0.20	0.15	15.7

* The maximum bond content shall be 20% for Grade 6 plates and 25% for Grade 86 plates.
**The average electric strength (as measured with 2-inch electrodes in accordance with 7.4) shall be not less than the values listed.

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Table 4-3
MICA SPLITTING ORGANIC-BONDED NON-SILICONE COMPOSITE FLEXIBLE TAPE*

NEMA Grade	Type of Material**	Mica Core Thickness, Mils	Nominal Thickness of Glass Reinforcement, Mils		Nominal Thickness of Composite Tape, Mils	Variation from Nominal, Mils (See 7.2)				Average Short-Time Electric Strength† (Minimum) Volts per mil
						Average Thickness		Individual Measurements		
			Base	Treated		Plus	Minus	Plus	Minus	
301	Mica between glass cloths.	1.7	1.0	...	4.0	1.0	1.0	2.0	2.0	500
		3.5	1.0	...	6.0	1.5	1.5	3.0	3.0	500
313	Mica between glass cloth and 1.5-mil polyester film	1.7	1.7	...	5.0	1.5	1.0	2.5	2.0	400
		3.5	1.7	...	6.0	1.5	1.0	3.5	2.5	500
315	Mica between glass cloth and 0.25-mil polyester film	1.7	...	...	4.0	1.0	1.0	2.5	1.5	500††
		3.5	...	...	6.0	1.0	1.0	3.0	3.0	500††
321	Mica between 1-mil polyester films	1.7	...	...	4.0	1.0	1.0	1.5	1.5	500††
		3.5	...	...	6.0	1.0	1.0	2.5	2.0	500††
		5.0	...	...	7.0	1.5	1.0	3.0	2.0	500††
325	Mica between thin polyester fiber non-wovens	3.5	...	...	7.0	1.5	1.5	2.0	2.0	500
		5.0	...	...	8.0	1.5	1.5	3.5	3.5	500
327	Mica between glass cloth and thin polyester non-woven	5.0	2.0	...	8.5	1.5	1.5	3.5	3.5	500
329	Mica between glass cloth and 1-mil polyimide film	1.7	2.0	...	5.0	1.5	1.5	2.0	2.0	500[4]
		3.5	2.0	...	6.5	2.0	2.0	2.5	2.5	500[4]
		5.0	2.0	...	8.0	2.0	2.0	3.5	3.5	500[4]
331	Mica between 1-mil polyimide films	1.7	...	...	4.0	1.0	1.0	1.5	1.5	500[4]
		3.5	...	...	6.0	1.0	1.0	2.5	2.0	500[4]
		5.0	...	...	7.0	1.5	1.0	3.5	3.5	500[4]

NOTES

* Depending on application of use, other parameters such as thermal class and binder type may be negotiated between buyer and seller.
** These products are made with muscovite mica splittings unless otherwise specified.
† The average electric strength (as measured with 1/4-inch electrodes in accordance with 7.4) shall be not less than the values listed.
†† These electric strength values are for the mica portion only. Data obtained on composites with films are unrealistically high. Meaningful value can be obtained only with voltage endurance tests. (This note is approved as Authorized Engineering Information.)

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Table 4-3
MICA SPLITTING ORGANIC-BONDED NON-SILICONE COMPOSITE FLEXIBLE TAPE*

NEMA Grade	Type of Material**	Mica Core Thickness, mm	Nominal Thickness of Glass Reinforcement, mm		Nominal Thickness of Composite Tape, mm	Variation from Nominal, mm (See 7.2)				Average Short-Time Electric Strength† (Minimum) Kilovolts per mm
						Average Thickness		Individual Measurements		
			Base	Treated		Plus	Minus	Plus	Minus	
301	Mica between glass cloths	0.04	0.03	...	0.10	0.03	0.03	0.05	0.05	19.7
		0.09	0.03	...	0.15	0.04	0.04	0.08	0.08	19.7
313	Mica between glass cloth and 0.038-mm polyester fiber non-woven	0.04	0.04	...	0.13	0.04	0.03	0.06	0.05	15.7
		0.09	0.04	...	0.15	0.04	0.03	0.09	0.06	19.7
315	Mica between glass cloth and 0.006-mm polyester film	0.04	...	...	0.10	0.03	0.03	0.06	0.04	19.7††
		0.09	...	...	0.15	0.03	0.03	0.08	0.08	19.7††
321	Mica between 0.025-mm polyester films	0.04	...	...	0.10	0.03	0.03	0.04	0.04	19.7††
		0.09	...	...	0.15	0.03	0.03	0.06	0.05	19.7††
		0.13	...	...	0.18	0.04	0.03	0.08	0.05	19.7††
325	Mica between thin polyester fiber non-wovens	0.09	...	...	0.18	0.04	0.04	0.05	0.05	19.7
		0.13	...	...	0.20	0.04	0.04	0.09	0.09	19.7
327	Mica between glass cloth and thin polyester non-woven	0.13	0.05	...	0.22	0.04	0.04	0.09	0.09	19.7
329	Mica between glass cloth and 0.025-mm polyimide film	0.04	0.05	...	0.13	0.04	0.04	0.05	0.05	19.7[4]
		0.09	0.05	...	0.17	0.05	0.05	0.06	0.06	19.7[4]
		0.13	0.05	...	0.20	0.05	0.05	0.09	0.09	19.7[4]
331	Mica between 0.025-mm polyimide films	0.04	...	...	0.10	0.03	0.03	0.04	0.04	19.7[4]
		0.09	...	...	0.15	0.03	0.03	0.06	0.05	19.7[4]
		0.13	...	...	0.18	0.04	0.03	0.09	0.09	19.7[4]

NOTES

* Depending on application of use, other parameters such as thermal class and binder type may be negotiated between buyer and seller.

** These products are made with muscovite mica splittings unless otherwise specified.

† The average electric strength (as measured with 6.4-mm electrodes in accordance with 7.4) shall be not less than the values listed.

†† These electric strength values are for the mica portion only. Data obtained on composites with films are unrealistically high. Meaningful value can be obtained only with voltage endurance tests. (This note is approved as Authorized Engineering Information.)

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Table 4-4
MICA SPLITTING ORGANIC-BONDED NON-SILICONE COMPOSITE FLEXIBLE SHEET*

NEMA Grade	Type of Material**	Mica Core Thickness, Mils	Nominal Thickness of Glass Reinforcement, Mils		Nominal Thickness of Composite Sheet, Mils	Variation from Nominal, Mils (See 7.2)				Average Short-Time Electric Strength† (Minimum) Volts per mil
						Average Thickness		Individual Measurements		
			Base	Treated		Plus	Minus	Plus	Minus	
301	Mica between glass cloths	3.5	3.0	...	10.0	2.0	2.0	3.5	3.5	300
		5.0	1.7	...	10.0	1.0	2.0	3.0	4.0	300
		5.0	3.0	...	12.0	2.0	2.0	3.0	4.0	300
		10.0	3.0	...	17.0	3.5	3.5	7.0	5.0	300
		15.0	3.0	...	22.0	4.0	4.0	8.0	6.0	300
		20.0	3.0	...	27.0	4.0	4.0	9.0	7.0	300
305	Mica with varnished glass cloth on one side only	3.5	2.0	3.5	7.0	1.5	1.5	3.0	3.0	750
		5.0	2.0	3.5	9.0	1.5	1.5	3.0	3.0	750
		7.0	2.0	3.5	11.0	2.0	3.0	3.5	4.0	500
		10.0	2.0	3.5	14.0	3.0	3.0	7.0	5.0	500
309	Mica with glass cloth on one side only	7.0	3.0	...	11.0	2.0	3.0	3.0	4.0	400
		10.0	3.0	...	14.0	3.0	3.0	6.0	5.0	400
		15.0	3.0	...	19.0	4.0	3.0	8.0	5.0	400
311	Mica between varnished glass cloths	3.5	2.0	3.5	11.0	2.0	2.0	4.0	4.0	600
		5.0	2.0	3.5	12.0	2.0	1.5	4.5	3.5	600
		5.0	3.0	5.0	15.0	2.0	2.0	4.5	4.5	600
		7.0	2.0	3.5	14.0	3.0	2.5	5.0	4.0	600
		10.0	2.0	3.5	17.0	3.5	3.0	8.0	5.0	550
		10.0	3.0	5.0	20.0	4.0	3.0	8.5	5.5	550
		15.0	2.0	3.5	22.0	4.0	3.5	9.0	6.0	550
		15.0	3.0	5.0	25.0	4.5	3.5	9.5	6.5	450
		20.0	2.0	3.5	27.0	4.0	3.5	10.	7.0	450
321	Mica between 1-mil polyester films	7.0	...	...	9.0	2.5	1.5	3.5	2.5	500††
		10.0	...	...	12.0	3.0	2.0	6.5	3.5	450††
		15.0	...	...	17.0	3.5	2.5	7.5	4.5	450††
		20.0	...	...	22.0	3.5	2.5	8.5	5.5	400††
323	Mica between 2-mil polyester films	7.0	...	...	11.0	2.5	2.0	4.0	3.0	500[4]

NOTES

* Depending on application of use, other parameters such as thermal class and binder type may be negotiated between buyer and seller.

** These products are made with muscovite mica splittings unless otherwise specified.

† The average electric strength (as measured with 2-inch electrodes in accordance with 7.4) shall be not less than the values listed.

†† These electric strength values are for the mica portion only. Data obtained on composites with films are unrealistically high. Meaningful value can be obtained only with voltage endurance tests. (This note is approved as Authorized Engineering Information.)

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Table 4
MICA SPLITTING ORGANIC-BONDED NON-SILICONE COMPOSITE FLEXIBLE SHEET*

NEMA Grade	Type of Material**	Mica Core Thickness, mm	Nominal Thickness of Glass Reinforcement, mm		Nominal Thickness of Composite Sheet, mm	Variation from Nominal, mm (See 7.2)				Average Short-Time Electric Strength† (Minimum) Kilovolts per mm
						Average Thickness		Individual Measurements		
			Base	Treated		Plus	Minus	Plus	Minus	
301	Mica between glass cloths	0.09	0.08	...	0.25	0.05	0.05	0.09	0.09	11.8
		0.13	0.04	...	0.25	0.03	0.05	0.08	0.10	11.8
		0.13	0.08	...	0.30	0.05	0.05	0.08	0.10	11.8
		0.25	0.08	...	0.43	0.09	0.09	0.18	0.13	11.8
		0.38	0.08	...	0.56	0.10	0.10	0.20	0.15	11.8
		0.51	0.08	...	0.69	0.10	0.10	0.23	0.18	11.8
305	Mica with varnished glass cloth on one side only	0.09	0.05	0.09	0.18	0.04	0.04	0.08	0.08	29.5
		0.13	0.05	0.09	0.23	0.04	0.04	0.08	0.08	29.5
		0.18	0.05	0.09	0.28	0.05	0.08	0.09	0.10	19.7
		0.25	0.05	0.09	0.36	0.08	0.08	0.18	0.13	19.7
309	Mica with glass cloth on one side only	0.18	0.08	...	0.28	0.05	0.08	0.08	0.10	15.7
		0.25	0.08	...	0.36	0.08	0.08	0.15	0.13	15.7
		0.38	0.08	...	0.48	0.10	0.08	0.20	0.13	15.7
311	Mica between varnished glass cloths	0.09	0.05	0.09	0.28	0.05	0.05	0.10	0.10	23.6
		0.13	0.05	0.09	0.30	0.05	0.04	0.11	0.09	23.6
		0.13	0.08	0.13	0.38	0.05	0.05	0.11	0.11	23.6
		0.18	0.05	0.09	0.36	0.08	0.06	0.13	0.10	23.6
		0.25	0.05	0.09	0.43	0.09	0.08	0.20	0.13	21.7
		0.25	0.08	0.13	0.51	0.10	0.08	0.22	0.14	21.7
		0.38	0.05	0.09	0.56	0.10	0.09	0.23	0.15	21.7
		0.38	0.05	0.13	0.64	0.11	0.09	0.24	0.17	17.7
		0.51	0.05	0.09	0.69	0.10	0.09	0.25	0.18	17.7
321	Mica between 0.025-mm polyester films	0.18	...	...	0.23	0.06	0.04	0.09	0.06	19.7††
		0.25	...	...	0.30	0.08	0.05	0.17	0.09	17.7††
		0.38	...	...	0.43	0.09	0.06	0.19	0.11	17.7††
		0.51	...	...	0.56	0.09	0.06	0.22	0.14	15.7††
323	Mica between 0.051-mm polyester films	0.18	...	...	0.28	0.06	0.05	0.10	0.08	19.7††

NOTES

* Depending on application of use, other parameters such as thermal class and binder type may be negotiated between buyer and seller.

** These products are made with muscovite mica splittings unless otherwise specified.

† The average electric strength (as measured with 51-mm electrodes in accordance with 7.4) shall be not less than the values listed.

†† These electric strength values are for the mica portion only. Data obtained on composites with films are unrealistically high. Meaningful value can be obtained only with voltage endurance tests. (This note is approved as Authorized Engineering Information.)

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Table 4-5
MICA SPLITTING SILICONE-BONDED COMPOSITE FLEXIBLE TAPE

NEMA Grade	Type of Materia*[1]	Mica Core Thickness, Mils	Nominal Thickness of Glass Reinforcement, Mils		Nominal Thickness of Composite Tape, Mils	Variation from Nominal, Mils (See 7.2)				Average Short-Time Electric Strength** (Minimum) Volts per mil
						Average Thickness		Individual Measurements		
			Base	Treated		Plus	Minus	Plus	Minus	
302	Mica between glass cloths	3.5	1.0	...	6.0	1.5	1.5	3.0	3.0	500
314	Mica with varnished glass cloth on one side only	1.7	1.0	...	3.0	1.0	1.0	1.5	1.5	650
		1.7	1.7	...	4.0	1.0	1.0	2.0	2.0	500
		3.5	1.0	...	5.0	1.0	1.5	1.5	2.0	600
316	Mica with glass cloth on one side only	1.7	1.7	...	4.0	1.0	1.0	2.5	1.5	500†
		3.5	1.7	...	6.0	1.5	1.0	3.5	3.0	500†

NOTES
* These products are made with muscovite mica splittings unless otherwise specified.
** The average electric strength (as measured with 1/4-inch electrodes in accordance with 7.4) shall be not less than the values listed.
† These electric strength values are for the mica portion only. Data obtained on composites with films are unrealistically high. Meaningful value can be obtained only with voltage endurance tests. (This note is approved as Authorized Engineering Information.)

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Table 4-5
MICA SPLITTING SILICONE-BONDED COMPOSITE FLEXIBLE TAPE

NEMA Grade	Type of Material*	Mica Core Thickness, mm	Nominal Thickness of Glass Reinforcement, mm		Nominal Thickness of Composite Tape, mm	Variation from Nominal, mm (See 7.2)				Average Short-Time Electric Strength** (Minimum) Kilovolts per mm
						Average Thickness		Individual Measurements		
			Base	Treated		Plus	Minus	Plus	Minus	
302	Mica between glass cloths	0.09	0.03	...	0.15	0.04	0.04	0.08	0.08	19.7
314	Mica with varnished glass cloth on one side only	0.04	0.03	...	0.08	0.03	0.03	0.04	0.04	25.6
		0.04	0.04	...	0.10	0.03	0.03	0.05	0.05	19.7
		0.09	0.03	...	0.13	0.03	0.04	0.04	0.05	23.6
316	Mica with glass cloth and 0.006-mm polyester film	0.04	0.04	...	0.10	0.03	0.03	0.06	0.04	19.7†
		0.09	0.04	...	0.15	0.04	0.03	0.09	0.08	19.7†

NOTES

* These products are made with muscovite mica splittings unless otherwise specified.

** The average electric strength (as measured with 6.4-mm electrodes in accordance with 7.4) shall be not less than the values listed.

† These electric strength values are for the mica portion only. Data obtained on composites with films are unrealistically high. Meaningful value can be obtained only with voltage endurance tests. (This note is approved as Authorized Engineering Information.)

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Table 4-6
MICA SPLITTING SILICONE-BONDED COMPOSITE FLEXIBLE SHEET

NEMA Grade	Type of Material*	Mica Core Thickness, Mils	Nominal Thickness of Glass Reinforcement, Mils		Nominal Thickness of Composite Sheet, Mils	Variation from Nominal, Mils (See 7.2)				Average Short-Time Electric Strength** (Minimum) Volts per mil
						Average Thickness		Individual Measurements		
			Base	Treated		Plus	Minus	Plus	Minus	
306	Mica with silicone varnished glass cloth on one side	1.7	2.0	3.5	5.0	1.5	1.0	2.5	2.0	750
		3.5	2.0	3.5	7.0	1.5	1.5	3.0	3.0	750
		5.0	2.0	3.5	9.0	1.5	1.5	3.0	3.0	750
		7.0	2.0	3.5	11.0	2.0	3.0	3.5	4.0	500
		10.0	2.0	3.5	14.0	3.0	3.0	7.0	5.0	500
312	Mica between silicone varnished glass cloths	1.7	2.0	3.5	9.0	1.5	1.5	2.0	1.5	600
		3.5	2.0	3.5	11.0	2.0	1.5	4.0	4.0	550
		3.5	3.0	5.0	11.0	2.0	2.0	4.5	4.5	500
		5.0	2.0	3.5	12.0	2.0	1.5	4.5	3.5	550
		7.0	2.0	3.5	14.0	3.0	2.5	5.0	4.0	550
		10.0	2.0	3.5	17.0	3.5	2.5	8.0	5.0	550
		10.0	3.0	5.0	20.0	4.0	3.0	8.5	5.5	500
		15.0	2.0	3.5	22.0	4.0	3.5	9.0	6.0	500
		20.0	2.0	3.5	27.0	4.0	3.5	10.0	7.0	400

NOTES
* These products are made with muscovite mica splittings unless otherwise specified.
** The average electric strength (as measured with 2-inch electrodes in accordance with 7.4) shall be not less than the values listed.

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Table 4-6
MICA SPLITTING SILICONE-BONDED COMPOSITE FLEXIBLE SHEET

NEMA Grade	Type of Material*	Mica Core Thickness, mm	Nominal Thickness of Glass Reinforcement, mm		Nominal Thickness of Composite Sheet, mm	Variation from Nominal, mm (See 7.2)				Average Short-Time Electric Strength** (Minimum) Kilovolts per mm
						Average Thickness		Individual Measurements		
			Base	Treated		Plus	Minus	Plus	Minus	
306	Mica with silicone varnished glass cloth on one side only	0.04	0.05	0.09	0.13	0.04	0.03	0.06	0.05	29.5
		0.09	0.05	0.09	0.18	0.04	0.04	0.08	0.08	29.5
		0.13	0.05	0.09	0.23.	0.04	0.04	0.08	0.08	29.5
		0.18	0.05	0.09	0.28	0.05	0.08	0.09	0.10	19.7
		0.25	0.05	0.09	0.36	0.08	0.08	0.18	0.13	19.7
312	Mica between silicone varnished glass cloths	0.04	0.05	0.09	0.23	0.04	0.04	0.05	0.04	23.6
		0.09	0.05	0.09	0.28	0.05	0.04	0.10	0.10	21.7
		0.09	0.08	0.13	0.28	0.05	0.05	0.11	0.11	19.7
		0.13	0.05	0.09	0.30	0.05	0.04	0.11	0.09	21.7
		0.18	0.05	0.09	0.36	0.08	0.06	0.13	0.10	21.7
		0.25	0.05	0.09	0.43	0.09	0.06	0.20	0.13	21.7
		0.25	0.08	0.13	0.51	0.10	0.08	0.22	0.14	19.7
		0.38	0.05	0.09	0.56	0.10	0.09	0.23	0.15	19.7
		0.51	0.05	0.09	0.69	0.10	0.09	0.25	0.18	15.7

NOTES
* These products are made with muscovite mica splittings unless otherwise specified.
** The average electric strength (as measured with 51-mm electrodes in accordance with 7.4) shall be not less than the values listed.

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Section 5
MANUFACTURED MICA PAPER PLATES, SHEETS, AND TAPES

5.1 UNSUPPORTED

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Table 5-1
UNSUPPORTED*

NEMA Grade	Type of Material	Maximum Bond Content, Percent	Nominal Thickness, Mils, Incl.	Variation from Nominal, Mils (See 7.2)				Average Electric Strength** (Minimum), Volts per Mil	
				Average Thickness		Individual Measurements			
				Plus	Minus	Plus	Minus	Short Time	Step by Step
2P	Hot-forming unmilled plate, organic bond	25	10–63	2.0	20.	3.0	3.0	850	800
82P	Hot-forming unmilled plate, silicone bond	25	10–63	2.0	2.0	3.0	3.0	850	700
3P	Rigid milled plate, organic bond (Segment)	10	10–63	1.0	1.0	2.0	2.0	800	700
5P	Rigid unmilled plate, organic bond	10	10–63	2.0	2.0	3.0	3.0	800	700
6P	Flexible plate, organic bond	25	5–20	3.0	3.0	4.0	4.0	700	600
		25	21–32	3.0	3.0	4.0	4.0	600	500
86P	Flexible plate, silicone bond	25	1–5	0.5	0.5	1.0	1.0	650	550
		25	5–20	1.0	1.0	2.0	2.0	650	550
		25	21–32	3.0	3.0	4.0	4.0	550	450
8P	Rigid plate, silicone bond	12	6–62	2.0	2.0	3.0	3.0	350	300
9P	Rigid plate, inorganic bond (Heater)	†	7–30	2.0	2.0	3.0	3.0	800	500
11P	Rigid plate, inorganic bond (Segment)	†	10–63	2.0	2.0	3.0	3.0	800	500

NOTES

* Depending on application of use, other parameters such a thermal class and binder type may be negotiated between buyer and seller.

** The average electric strength (as measured with 2-inch electrodes in accordance with 7.4) shall be not less than the values listed. Where 1/4-inch electrodes are used, the values shall be 110% of those listed.

† No standard test method available.

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Table 5-1
UPSUPPORTED*

NEMA Grade	Type of Material	Maximum Bond Content, Percent	Nominal Thickness, mm, Incl.	Variation from Nominal, mm (See 7.2)				Average Electric Strength** (Minimum), Kilovolts per mm	
				Average Thickness		Individual Measurements			
				Plus	Minus	Plus	Minus	Short Time	Step by Step
2P	Hot-forming unmilled plate, organic bond	25	0.25-1.60	0.05	0.05	0.08	0.08	33.5	31.5
82P	Hot-forming unmilled plate, silicone bond	25	0.25–1.60	0.05	0.05	0.08	0.08	33.5	27.6
3P	Rigid milled plate, organic bond (Segment)	10	0.25–1.60	0.03	0.03	0.05	0.05	31.5	27.6
5P	Rigid unmilled plate, organic bond	10	0.25–1.60	0.05	0.05	0.08	0.08	31.5	27.6
6P	Flexible plate, organic bond	25	0.13–0.51	0.08	0.08	0.10	0.10	27.6	23.6
		25	0.53–0.81	0.08	0.08	0.10	0.10	23.6	19.7
86P	Flexible plate, silicone bond	25	0.03–0.13	0.01	0.01	0.03	0.03	25.6	21.7
		25	0.13–0.51	0.03	0.03	0.05	0.05	25.6	21.7
		25	0.53–0.81	0.08	0.08	0.10	0.10	21.7	17.7
8P	Rigid plate, silicone bond	12	0.15–1.57	0.05	0.05	0.08	0.08	13.8	11.8
9P	Rigid plate, inorganic bond (Heater)	†	0.18–0.76	0.05	0.05	0.08	0.08	31.5	19.7
11P	Rigid plate, inorganic bond (Segment)	†	0.25–1.60	0.05	0.05	0.08	0.08	31.5	19.7

NOTES
* Depending on application of use, other parameters such a thermal class and binder type may be negotiated between buyer and seller.
** The average electric strength (as measured with 51-mm electrodes in accordance with 7.4) shall be not less than the values listed. Where 6.4-mm electrodes are used, the values shall be 110% of those listed.
† No standard test method available.

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Table 5-2
SUPPORTED ORGANIC-BONDED*

NEMA Grade	Type of Material	Mica Core Thickness, Mils	Nominal Thickness of Glass Reinforcement, Mils		Nominal Thickness of Composite Sheet, Mils	Variation from Nominal Average Thickness**, Mils		Average Short-time Electric Strength† (Minimum) Volts per mil
			Base	Treated		Plus	Minus	
18P	Mica paper between 1-mil polyester films	3.0	...	...	6.0	1.0	1.0	800
19P	Mica paper between glass cloth and 0.25-mil polyester film	2.0	1.7	...	5.5	...	...	700
		3.0	1.0	...	5.5	1.0	1.0	700
		3.0	1.7	...	6.0	1.0	1.0	700
		4.0	1.7	...	8.0	...	...	700
301P	Mica paper between glass cloths	4.0	1.7	...	9.0	1.0	1.0	400
309P	Mica paper with glass cloth on one side only	2.0	1.0	...	4.0	1.0	1.0	500
		3.0	1.7	...	6.0	1.0	1.0	500
		3.0	1.7	...	6.0	1.5	1.5	400
311P	Mica paper between varnished glass cloths	4.0	2.0	3.5	12.0	1.5	1.5	800
313P	Mica paper between glass cloth and thin polyester fiber non-woven	2.0	2.0	...	6.5	1.0	1.0	400
		4.0	2.0	...	8.5	1.0	1.0	400

NOTES

* Depending on application of use, other parameters such as thermal class, binder type, relative flexibility and/or tensile strength may be negotiated between buyer and seller.

** The thickness shall be measured in accordance with 7.2 except that for mica paper tapes only one layer shall be measured.

† The average electric strength (as measured with 2-inch electrodes in accordance with 7.4) shall be not less than the values listed. Where 1/4-inch electrodes are used, the values shall be 110% of those listed.

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Table 5-2
SUPPORTED ORGANIC-BONDED (CONTINUED)*

NEMA Grade	Type of Material	Mica Core Thickness, Mils	Nominal Thickness of Glass Reinforcement, Mils		Nominal Thickness of Composite Sheet, Mils	Variation from Nominal Average Thickness**, Mils		Average Short-time Electric Strength† (Minimum) Volts per mil
			Base	Treated		Plus	Minus	
325P	Mica paper between thin polyester non-wovens	2.0	...	...	6.0	1.5	1.5	400
		4.0	...	...	8.0	1.5	1.5	400
327P	Mica paper between glass cloth and thin glass fiber non-woven	2.0	2.0	...	7.0	1.5	1.5	400
		4.0	2.0	...	9.0	1.5	1.5	400
329P	Mica paper between glass cloth and 1-mil polyimide film	2.0	2.0	...	6.0	1.5	1.5	500
		4.0	2.0	...	8.0	1.5	1.5	500
331P	Mica paper between 1-mil polyimide films	2.0	...	...	5.0	1.0	1.0	800
		4.0	...	...	8.0	1.0	1.0	800
333P	Mica paper with 1-mil polyimide film on one side	2.0	...	...	4.0	1.0	1.0	600
		4.0	...	...	6.0	1.0	1.0	600
335P	Mica paper with parallel (nonwoven) glass and a 0.25-mil polyester film on one side	2.0	1.5††	...	5.0	1.5	1.5	600
		4.0	1.5††	...	7.0	1.5	1.5	600
337P	Mica paper with parallel (nonwoven) glass and a 1-mil polyimide film on one side	2.0	1.5††	...	6.0	1.5	1.5	600
		4.0	1.5††	...	8.0	1.5	1.5	600

NOTES
* Depending on application of use, other parameters such as thermal class, binder type, relative flexibility and/or tensile strength may be negotiated between buyer and seller.
** The thickness shall be measured in accordance with 7.2 except that for mica paper tapes only one layer shall be measured.
† The average electric strength (as measured with 2-inch electrodes in accordance with 7.4) shall be not less than the values listed. Where 1/4-inch electrodes are used, the values shall be 110% of those listed.
†† Thickness indication is that of a single glass yarn.

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Table 5-2
SUPPORTED ORGANIC-BONDED (CONTINUED)*

NEMA Grade	Type of Material	Mica Core Thickness, mm	Nominal Thickness of Glass Reinforcement, mm		Nominal Thickness of Composite Sheet, mm	Variation from Nominal Average Thickness**, mm		Average Short-time Electric Strength† (Minimum) Kilovolts per mm
			Base	Treated		Plus	Minus	
325P	Mica paper between thin polyester non-wovens	0.05	...	...	0.15	0.04	0.04	15.7
		0.10	...	...	0.20	0.04	0.04	15.7
327P	Mica paper between glass cloth and thin glass fiber non-woven	0.05	0.05	...	0.18	0.04	0.04	15.7
		0.10	0.05	...	0.23	0.04	0.04	15.7
329P	Mica paper between glass cloth and 0.025-mm polyimide film	0.05	0.05	...	0.15	0.04	0.04	19.7
		0.10	0.05	...	0.20	0.04	0.04	19.7
331P	Mica paper between 0.025-mm polyimide films	0.05	...	...	0.13	0.03	0.03	31.5
		0.10	...	...	0.20	0.03	0.03	31.5
333P	Mica paper with 0.025-mm polyimide film on one side	0.05	...	...	0.10	0.03	0.03	23.6
		0.10	...	...	0.15	0.03	0.03	23.6
335P	Mica paper with parallel (nonwoven) glass and a 0.006-mm polyester film on one side	0.05	0.04††	...	0.13	0.04	0.04	23.6
		0.10	0.04††	...	0.18	0.04	0.04	23.6
337P	Mica paper with parallel (nonwoven) glass and a 0.025-mm polyimide film on one side	0.05	0.04††	...	0.15	0.04	0.04	23.6
		0.10	0.04††	...	0.20	0.04	0.04	23.6

NOTES

* Depending on application of use, other parameters such as thermal class, binder type, relative flexibility and/or tensile strength may be negotiated between buyer and seller.

** The thickness shall be measured in accordance with 7.2 except that for mica paper tapes only one layer shall be measured.

† The average electric strength (as measured with 51-mm electrodes in accordance with 7.4) shall be not less than the values listed. Where 6.4-mm electrodes are used, the values shall be 110% of those listed.

†† Thickness indication is that of a single glass yarn.

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Table 5-2
SUPPORTED ORGANIC-BONDED* (CONTINUED)

NEMA Grade	Type of Material	Mica Core Thickness, mm	Nominal Thickness of Glass Reinforcement, mm		Nominal Thickness of Composite Sheet, mm	Variation from Nominal Average Thickness**, mm		Average Short-time Electric Strength† (Minimum) Kilovolts per mm
			Base	Treated		Plus	Minus	
18P	Mica paper between 0.025-mm polyester films	0.08	...	...	0.15	0.03	0.03	31.5
19P	Mica paper between glass cloth and 0.006-mm polyester film	0.05	0.04	...	0.14	...	...	27.6
		0.08	0.03	...	0.14	0.03	0.03	27.6
		0.08	0.04	...	0.15	0.03	0.03	27.6
		0.10	0.04	...	0.20	...	...	27.6
301P	Mica paper between glass cloths	0.10	0.04	...	0.23	0.03	0.03	15.7
309P	Mica paper with glass cloth on one side only	0.05	0.03	...	0.10	0.03	0.03	19.7
		0.08	0.04	...	0.15	0.03	0.03	19.7
		0.08	0.04	...	0.15	0.04	0.04	15.7
311P	Mica paper between varnished glass cloths	0.10	0.05	0.09	0.30	0.04	0.04	31.5
313P	Mica paper between glass cloths and thin polyester fiber non-woven	0.05	0.05	...	0.17	0.03	0.03	15.7
		0.10	0.05	...	0.22	0.03	0.03	15.7

NOTES

* Depending on application of use, other parameters such as thermal class, binder type, relative flexibility and/or tensile strength may be negotiated between buyer and seller.

** The thickness shall be measured in accordance with 7.2 except that for mica paper tapes only one layer shall be measured.

† The average electric strength (as measured with 51-mm electrodes in accordance with 7.4) shall be not less than the values listed. Where 6.4-mm electrodes are used, the values shall be 110% of those listed.

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Table 5-3
SUPPORTED SILICONE-BONDED*

NEMA Grade	Type of Material	Mica Core Thickness, Mils	Nominal Thickness of Glass Reinforcement, Mils		Nominal Thickness of Composite Sheet, Mils	Variation from Nominal Average Thickness**, Mils		Average Short-time Electric Strength† (Minimum) Volts per mil
			Base	Treated		Plus	Minus	
304P	Mica paper between varnished glass cloth and 1-mil polyester film	4.0	2.0	3.5	10.0	1.5	1.5	900
310P	Mica paper with glass cloth on one side only	2.0	2.0	...	5.0	1.0	1.0	300
		4.0	2.0	...	7.0	1.0	1.0	300
		6.0	2.0	...	9.0	1.0	1.0	300
312P	Mica paper between varnished glass cloths	2.0	2.0	3.5	10.	1.5	1.5	700
		3.0	3.0	5.0	15.0	2.0	2.0	700
		4.0	2.0	3.5	12.0	1.5	1.5	700
		10.0	2.0	3.5	20.0	2.0	2.0	700
334P	Mica paper with 1-mil polyimide film on one side	2.0	...	...	4.0	1.0	1.0	600
		4.0	...	...	6.0	1.0	1.0	600

NOTES

* Depending on application of use, other parameters such as relative flexibility and/or tensile strength may be negotiated between buyer and seller.

** The thickness shall be measured in accordance with 7.2 except that for mica paper tapes only one layer shall be measured.

† The average electric strength (as measured with 2-inch electrodes in accordance with 7.4) shall be not less than the values listed. Where 1/4-inch electrodes are used, the values shall be 110% of those listed.

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Table 5-3
SUPPORTED SILICONE-BONDED* (CONTINUED)

NEMA Grade	Type of Material	Mica Core Thickness, mm	Nominal Thickness of Glass Reinforcement, mm		Nominal Thickness of Composite Sheet, mm	Variation from Nominal Average Thickness**, mm		Average Short-time Electric Strength† (Minimum) Kilovolts per mm
			Base	Treated		Plus	Minus	
304P	Mica paper between varnished glass cloth and 0.025-mm polyester film	0.10	0.05	0.09	0.25	0.04	0.04	35.4
310P	Mica paper with glass cloth on one side only	0.05	0.05	...	0.13	0.03	0.03	11.8
		0.10	0.05	...	0.18	0.03	0.03	11.8
		0.15	0.05	...	0.23	0.03	0.03	11.8
312P	Mica paper between varnished glass cloths	0.05	0.05	0.09	0.25	0.04	0.04	27.6
		0.08	0.08	0.13	0.38	0.05	0.05	27.6
		0.10	0.05	0.09	0.30	0.04	0.04	27.6
		0.25	0.05	0.09	0.51	0.05	0.05	27.6
334P	Mica paper with 0.025-mm polyimide film on one side	0.05	...	...	0.10	0.03	0.03	23.6
		0.10	...	...	0.15	0.03	0.03	23.6

NOTES

* Depending on application of use, other parameters such as relative flexibility and/or tensile strength may be negotiated between buyer and seller.

** The thickness shall be measured in accordance with 7.2 except that for mica paper tapes only one layer shall be measured.

† The average electric strength (as measured with 51-mm electrodes in accordance with 7.4) shall be not less than the values listed. Where 6.4-mm electrodes are used, the values shall be 110% of those listed.

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Table 5-4
VPI (VACUUM PRESSURE IMPREGNATION) TAPES*

NEMA Grade	Type of Material	Mica Core Thickness, Mils	Nominal Reinforcement Thickness, Mils		Nominal Thickness of Composite Sheet, Mils	Variation from Nominal Average Thickness**, Mils	
			Cloth	Matte		Plus	Minus
401P	Mica paper with glass cloth on one side only	2.0	2.0	...	4.5	1.0	1.0
		3.0	2.0	...	5.5	1.0	1.0
		4.0	2.0	...	6.5	1.0	1.0
421P	Mica paper between one layer of glass cloth and one layer of polyester matte	2.0	2.0	0.08	5.5	1.0	1.0
		3.0	2.0	0.08	6.5	1.0	1.0
		3.0	2.0	1.4	7.0	1.0	1.0
		4.0	2.0	1.4	8.0	1.0	1.0

NOTES

* This specification deals with products typically used in VPI processes. The construction and thicknesses listed here are typical of those available in the trade. Other constructions and thicknesses and the performance specifications for those products are a matter of negotiation between buyer and seller.
Depending on application of use, other parameters such a thermal class, binder type and content, relative flexibility and/or tensile strength may be negotiated between buyer and seller.

** The thickness shall be measured in accordance with 7.2 except that only one layer shall be measured.

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Table 5-4
VPI (VACUUM PRESSURE IMPREGNATION) TAPES* (CONTINUED)

NEMA Grade	Type of Material	Mica Core Thickness, mm	Nominal Reinforcement Thickness, mm		Nominal Thickness of Composite Sheet, mm	Variation from Nominal Average Thickness**, mm	
			Cloth	Matte		Plus	Minus
401P	Mica paper with glass cloth on one side only	0.05	0.05	...	0.11	0.03	0.03
		0.08	0.05	...	0.14	0.03	0.03
		0.10	0.05	...	0.17	0.03	0.03
421P	Mica paper between one layer of glass cloth and one layer of polyester matte	0.05	0.05	0.02	0.14	0.03	0.03
		0.08	0.05	0.02	0.17	0.03	0.03
		0.08	0.05	0.04	0.18	0.03	0.03
		0.10	0.05	0.04	0.20	0.03	0.03

NOTES

* This specification deals with products typically used in VPI processes. The construction and thicknesses listed here are typical of those available in the trade. Other constructions and thicknesses and the performance specifications for those products are a matter of negotiation between buyer and seller. Depending on application of use, other parameters such a thermal class, binder type and content, relative flexibility and/or tensile strength may be negotiated between buyer and seller.

** The thickness shall be measured in accordance with 7.2 except that only one layer shall be measured.

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Table 5.5
ARAMID/MICA BLENDED FLEXIBLE SHEET*

NEMA Grade	Type of Material	Approximate Mica Percentage	Nominal Thickness of Sheet, Mils	Variation from Nominal Average Thickness**, Mils		Average Short-time Electric Strength† (Minimum) Volts per Mil
				Plus	Minus	
418B	Densified aramid/mica blended paper††	50	3.0	1.0	1.0	500
			5.0	1.0	1.0	550
			8.0	1.0	1.0	700
			10.0	2.0	1.5	700
			14.0	2.5	2.0	700
419B	Aramid/mica blended paper††	50	7.0	1.5	1.0	250
			13.0	2.5	2.0	250

NOTES
* These products are made with muscovite mica. Depending on application of use, other parameters such as tensile strength may be negotiated between buyer and seller.
** The thickness shall be measured in accordance with 7.2 except that for mica paper tapes only one layer shall be measured.
† The average electric strength (as measured with 2-inch electrodes in accordance with 7.4) shall be not less than the values listed. Where 1/4-inch electrodes are used, the values shall be 110% of those listed.,
†† An intimate blend of products, not a lamination. Aramid is the generic term for aromatic polyamide compounds.

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Table 5-5
ARAMID/MICA BLENDED FLEXIBLE SHEET* (CONTINUED)

NEMA Grade	Type of Material	Approximate Mica Percentage	Nominal Thickness of Sheet, mm	Variation from Nominal Average Thickness**, mm		Average Short-time Electric Strength† (Minimum) Kilovolts per mm
				Plus	Minus	
418B	Densified aramid/mica blended paper††	50	0.08	0.03	0.03	19.7
			0.13	0.03	0.03	21.7
			0.20	0.04	0.03	27.6
			0.25	0.05	0.04	27.6
			0.36	0.06	0.05	27.6
419B	Aramid/mica blended paper††	50	0.18	0.04	0.03	9.8
			0.33	0.06	0.05	9.8

NOTES

* These products are made with muscovite mica. Depending on application of use, other parameters such as tensile strength may be negotiated between buyer and seller.

** The thickness shall be measured in accordance with 7.2 except that for mica paper tapes only one layer shall be measured.

† The average electric strength (as measured with 51-mm electrodes in accordance with 7.4) shall be not less than the values listed. Where 6.4-mm electrodes are used, the values shall be 110% of those listed.

†† An intimate blend of products, not a lamination. Aramid is the generic term for aromatic polyamide compounds.

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Table 5-6
RESIN RICH (B-STAGED) TAPES*

NEMA Grade	Type of Material	Mica Core Thickness, Mils	Nominal Reinforcement Thickness, Mils		Nominal Thickness of Composite Sheet, Mils	Variation from Nominal Average Thickness**, Mils		Average Short-time Electric Strength† (Minimum) Volts per mil
			Glass	Matte		Plus	Minus	
415P	Mica paper with glass cloth on one side only	2.0	2.0	...	6.0	1.0	1.0	300††
		3.0	2.0	...	7.0	1.0	1.0	300††
		4.0	2.0	...	8.0	1.0	1.0	300††
		6.0	2.0	...	10.0	1.5	1.5	300††
471P	Mica paper between one layer of glass cloth and one layer of polyester matte	3.0	2.0	0.8	7.0	1.0	1.0	300††
		4.0	2.0	0.8	8.0	1.0	1.0	300††
		4.0	2.0	1.4	8.5	1.0	1.0	300††

NOTES

* This specification deals with resin-rich (B-staged) tapes. The construction and thicknesses listed here are typical of those available in the trade. Other constructions and thicknesses and the performance specifications for those products are a matter of negotiation between buyer and seller. Depending on application of use, other parameters such as binder type and content, volatile content, thermal class, relative flexibility and/or tensile strength may be negotiated between buyer and seller.

** The thickness shall be measured in accordance with 7.2 except that only one layer shall be measured.

† The average electric strength (as measured with 1/4-inch electrodes in accordance with 7.4) shall be not less than the values listed.

†† The ultimate electrical strength of these products depend on curing and processing; these numbers are for reference only.

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Table 5-6
RESIN RICH (B-STAGED) TAPES* (CONTINUED)

NEMA Grade	Type of Material	Mica Core Thickness, mm	Nominal Reinforcement Thickness, mm		Nominal Thickness of Composite Sheet, mm	Variation from Nominal Average Thickness**, mm		Average Short-time Electric Strength† (Minimum) Kilovolts per mm
			Glass	Matte		Plus	Minus	
415P	Mica paper with glass cloth on one side only	0.05	0.05	...	0.15	0.03	0.03	11.8††
		0.08	0.05	...	0.18	0.03	0.03	11.8††
		0.10	0.05	...	0.20	0.03	0.03	11.8††
		0.15	0.05	...	0.25	0.04	0.04	11.8††
471P	Mica paper between one layer of glass cloth and one layer of polyester matte	0.08	0.05	0.02	0.18	0.03	0.03	11.8††
		0.10	0.05	0.02	0.20	0.03	0.03	11.8††
		0.10	0.05	0.04	0.22	0.03	0.03	11.8††

NOTES

* This specification deals with resin-rich (B-staged) tapes. The construction and thicknesses listed here are typical of those available in the trade. Other constructions and thicknesses and the performance specifications for those products are a matter of negotiation between buyer and seller. Depending on application of use, other parameters such as binder type and content, volatile content, thermal class, relative flexibility and/or tensile strength may be negotiated between buyer and seller.

** The thickness shall be measured in accordance with 7.2 except that only one layer shall be measured.

† The average electric strength (as measured with 6.4-mm electrodes in accordance with 7.4) shall be not less than the values listed.

†† The ultimate electrical strength of these products depend on curing and processing; these numbers are for reference only.

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Section 6
ROUND TUBES

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Table 6-1
ROUND MICA SPLITTING TUBES

NEMA Grade	Type of Material	Approximate Percentage of Manufactured Mica	Minimum Wall Thickness, Inches	Nominal Inside Diameter, Inches*	Average Tolerances in Diameter, Mils (Plus or Minus)**				Average Electric Strength† (Minimum) Volts per Mil (See 7.4)††	
					Wall Thickness Up to 1/16 Inch[1]		Wall Thickness 1/16 up to 5/32 Inch[1]			
					Inside Diameter	Outside Diameter	Inside Diameter	Outside Diameter	Short Time	Step by Step
101	100 percent manufactured mica§	100	0.032	Up to 1	5	15	5	20	300	200
				1 up to 2	8	15	8	20	300	200
				2 up to 4	10	15	10	25	300	200
103	Paper-covered manufactured mica	80	0.032	Up to 1	5	15	5	20	250	170
				1 up to 2	8	15	8	20	250	170
				2 up to 4	10	15	10	25	250	170

NOTES
* "Up to" means "not including."
** See 7.3 for method of measuring the diameter of tubes.
† The electric strength values, stated in volts per mil, decrease with an increase in thickness. Therefore, the values given in this column are applicable to tubes having a nominal wall thickness of not more than 0.125 inch.
†† The average electric strength (when measured in accordance with 7.4.2) shall not be less than the values listed.
§ When the inside diameter is 2 inches or less, a paper starter shall be permitted to be used.

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Table 6-1
ROUND MICA SPLITTING TUBES (CONTINUED)

NEMA Grade	Type of Material	Approximate Percentage of Manufactured Mica	Minimum Wall Thickness, Millimeters*	Nominal Inside Diameter, Millimeters[1]	Average Tolerances in Diameter, Mils (Plus or Minus)**				Average Electric Strength† (Minimum) Kilovolts per mm (See 7.4)††	
					Wall Thickness Up to 1.59-mm[1]		Wall Thickness 1.59 up to 3.97-mm[1]			
					Inside Diameter	Outside Diameter	Inside Diameter	Outside Diameter	Short Time	Step by Step
101	100 percent manufactured mica§	100	0.032	Up to 25.4	0.13	0.38	0.13	0.51	11.8	7.9
				25.4 up to 50.8	0.20	0.38	0.20	0.51	11.8	7.9
				50.8 up to 101.6	0.25	0.38	0.25	0.64	11.8	7.9
103	Paper-covered manufactured mica	80	0.032	Up to 25.4	0.13	0.38	0.13	0.51	9.8	6.7
				25.4 up to 50.8	0.20	0.38	0.20	0.51	9.8	6.7
				50.8 up to 101.6	0.25	0.38	0.25	0.64	9.8	6.7

NOTES
* "Up to" means "not including."
** See 7.3 for method of measuring the diameter of tubes.
† The electric strength values, stated in kilovolts per mm, decrease with an increase in thickness. Therefore, the values given in this column are applicable to tubes having a nominal wall thickness of not more than 3.2-mm.
†† The average electric strength (when measured in accordance with 7.4.2) shall not be less than the values listed.
§ When the inside diameter is 51-mm or less, a paper starter shall be permitted to be used.

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Table 6-2
ROUND MICA PAPER TUBES

NEMA Grade	Nominal Inside Diameter Inches, Incl.	Average Tolerances in Diameters, Mils (Plus or Minus)*								Average Electric Strength (Minimum), Volts per Mil (See 7.4)**	
		Wall Thicknesses Up to 0.032 Inch, Incl.		Wall Thicknesses 0.033-0.063 Inch, Incl.		Wall Thicknesses 0.064-0.125 Inch, Incl.		Wall Thicknesses 0.126-0.250 Inch, Incl.			
		Inside Diameter	Outside Diameter	Inside Diameter	Outside Diameter	Inside Diameter	Outside Diameter	Inside Diameter	Outside Diameter	Short Time	Step by Step
101P	Up to 1	5.0	7.5	5.0	10.0	5.0	15.0	5.0	25.0	600	550
	Over 1 to 2	7.5	7.5	7.5	10.0	7.5	15.0	7.5	25.0	600	550
	Over 2 to 4	10.0	7.5	10.0	10.0	10.0	15.0	10.0	25.0	600	550

NOTES
* See 7.3 for method of measuring the diameter of tubes.
**The average electric strength (when measured in accordance with 7.4.2) shall not be less than the values listed.

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Table 6-2
ROUND MICA PAPER TUBES (CONTINUED)

NEMA Grade	Nominal Inside Diameter Millimeters, Incl.	Average Tolerances in Diameters, mm (Plus or Minus)*								Average Electric Strength (Minimum), Kilovolts per mm (See 7.4)**	
		Wall Thicknesses Up to 0.81-mm, Incl.		Wall Thicknesses 0.84-1.6-mm, Incl.		Wall Thicknesses 1.63-3.18-mm, Incl.		Wall Thicknesses 3.20-6.35-mm, Incl.			
		Inside Diameter	Outside Diameter	Inside Diameter	Outside Diameter	Inside Diameter	Outside Diameter	Inside Diameter	Outside Diameter	Short Time	Step by Step
101P	Up to 25.4	0.13	0.19	0.13	0.25	0.13	0.38	0.13	0.64	23.6	21.7
	Over 25.4 to 50.8	0.19	0.19	0.19	0.25	0.19	0.38	0.19	0.64	23.6	21.7
	Over 50.8 to 101.6	0.25	0.19	0.25	0.25	0.25	0.38	0.25	0.64	23.6	21.7

NOTES
* See 7.3 for method of measuring the diameter of tubes.
**The average electric strength (when measured in accordance with 7.4.2) shall not be less than the values listed.

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Section 7
METHODS OF MEASURING

7.1 SAMPLING

Sampling shall be in accordance with the following:

a. For lots up to 500—three units or one percent of the lot, rounded to the nearest unit, whichever is greater.
b. For lots of 500 to 2000—five units or one-half of one percent of the lot, rounded to the nearest unit, whichever is greater.

If all of the samples selected for the test meet all of the requirements, the lot shall be considered as conforming to these standards. If two samples fail any of the tests, the lot shall be considered as not conforming to these standards. If one sample fails to meet any one requirement, a sufficient number of additional samples shall be selected to make a total of ten. If a total of two out of the ten samples fail to meet any of the tests, the lot shall be considered as not conforming to these standards.

7.2 METHODS OF MEASURING THICKNESS

7.2.1 Sheets and Plates

Ten measurements of the thickness shall be taken at equal intervals over the entire sheet or plate in accordance with Method C or D as given in ASTM D374, modified so that the anvil pressure will be 23 to 27 psi (1.6 to 1.9 kPa) for flexible mica splitting materials and 140 to 160 psi (9.7 to 11.0 kPa) for rigid materials, using a 1/4-inch (6.35-mm) diameter presser foot and anvil. Method A or B, given in ASTM D374 may also be used, but the Methods C or D shall constitute the referee methods. An individual measurement is a single reading.

The average of the ten individual measurements shall constitute the average thickness of the sheet or plate.

7.2.2 Tapes

A roll shall be selected at random from any lot. Test the product in accordance with Method C or D as given in ASTM D374 modified so that the anvil pressure will be 23 to 27 psi (1.6 to 1.9 kPa) for flexible mica splitting materials, using a 1/4-inch (6.35-mm) diameter presser foot and anvil. Approximately 20 feet (6.1 meters) of the roll shall constitute the sample, and ten measurements of the thickness shall be taken at equal intervals of this sample. An individual measurement is a single reading.

Should Method A or B as given in ASTM D374 be used, the tape sample shall be folded so that it will form five layers of tape, each approximately 4 feet (1.22 meters) long. Ten measurements of the thickness of the five layers shall be taken at equal intervals over the entire length of the tape in accordance with Method A or B given in ASTM D374. An individual measurement is a single reading taken on five layers of tape and divided by 5.

The average of the ten individual measurements shall constitute the average thickness of the tape.

7.3 METHOD OF MEASURING DIMENSIONS OF TUBES

The dimensions of tubes shall be measured in accordance with the ASTM D668.

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7.4 METHODS OF MEASURING ELECTRIC STRENGTH

7.4.1 Sheets, Plates and Tapes

The electric strength of sheets, plates and tapes shall be measured in accordance with ASTM D352, with the following exceptions:

a. Size of Electrodes—Two-inch electrodes shall be used. For materials where one dimension is not great enough to prevent flashover in air (such as tapes), 1/4-inch (6.35-mm) electrodes shall be used as specified in Section 45 of ASTM D295.
b. Conditioning—No special conditioning is required, unless appropriate, and then condition per ASTM D295.
c. Medium—All electric strength tests shall be made in air.
d. Electric Strength—The average electric strength shall be the average of 10 electric breakdowns divided by the average thickness of the specimens.

The aramid/mica blended papers are not directly covered within ASTM D352. However, the test method listed above for electric strength is valid for these products.

7.4.2 Tubes

The electrical strength of tubes shall be measured in air in the transverse direction in accordance with ASTM D348, with the following exceptions:

a. Electrode—The metal inner electrode shall be at least 7 inches(178 mm) long. The outer metal-foil electrode shall be 2 inches (50.8 mm) long and shall be positioned so that the electric field is transverse. The distance measured axially between the ends of the outer and inner electrodes shall be not less than 2 inches (50.8 mm).
b. Length of Test Specimen—The test specimen shall be of sufficient length to prevent flashover.
c. Conditioning—Specimens shall be tested without special conditioning. When required, specimens shall be conditioned for at least 48 hours at 50 ±2 % relative humidity and 23°C ± 1.1°C (73°F ± 2°F) and shall be tested immediately thereafter.
d. Calculation—The calculations in volts per mil shall be based on the breakdown voltage and the average wall thickness.

7.5 METHOD OF MEASURING MICA OR ORGANIC BINDER CONTENT

7.5.1 Purpose

The purpose of this test is to ascertain the relative percentage of mica and binder for both plates and fabricated parts having no mechanical reinforcement. For those products which contain organic mechanical reinforcement, the supplier can provide a factor to determine what portion of the organic content is binder.

7.5.2 Apparatus

The apparatus shall consist of the following:

a. An electrically heated muffle furnace which will provide a temperature of 525°C ± 25°C (977°F ● 45°F).
b. Dishes of porcelain, platinum, or other materials not affected by the test conditions.
c. An analytical balance having an accuracy of at least 0.001 gram.

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7.5.3 Test Specimen

a. Plates—Discard a 2-inch (50.8-mm) strip cut from the length of the plate and then cut 1/2-inch (12.7-mm) strips for test. Discard 2 inches (50.8 mm) from both ends of the strips. If the material has not been sanded or has been surface coated, sand lightly on both sides to remove any excess surface binder. Cut 5 to 10 grams from spots evenly distributed along the strip.
b. Fabricated Parts—A representative test specimen weighing not less than 5 grams shall be selected from the lot. If the parts are small, take at random a sufficient number of specimens to give the required weight. If the parts are large, cut 5 grams from a cross-section of one of the parts chosen at random.

7.5.4 Procedure

a. Unpressed plates and flexible materials shall be dried in a forced-air oven at 150°C (302°F) for 10 minutes to remove volatiles.
b. Each specimen shall be weighed to the nearest 0.001 gram in a tared dish.
c. Place the dish with the specimen in a muffle furnace at 525°C ± 25°C(977°F ± 45°F) for 30 minutes. Examine the sample at the end of this period for black spots of partially burned binder. If the sample has more than a trace of this condition, heat for an additional 10 minutes and re-examine. Cool in a desiccator and determine the weight of the residue.
d. As an alternative method where a muffle furnace is not available, the dish with the specimen shall be placed over a Meeker or Fisher type burner and heated at a low red heat to avoid dehydration of mica until all of the organic material and carbon are burned off.
e. The general procedure for making tests is as follows:
   1. Obtain a representative sample.
   2. Dry in a forced-air oven where required.
   3. Weigh a clean dish (weight C).
   4. Place a sample of the proper weight in the dish.
   5. Weigh the dish with the sample (weight E).
   6. Burn out organic materials.
   7. Cool in a desiccator.
   8. Weigh dish with burned sample (weight H).

7.5.5 Report

The report shall include the percent organic or percent mica, or both, as follows:

$$\frac{\text{Weight E} - \text{Weight H}}{\text{Weight E} - \text{Weight C}} \times 100 = \text{Percent Organic}$$

$$\frac{\text{Weight H} - \text{Weight C}}{\text{Weight E} - \text{Weight C}} \times 100 = \text{Percent Mica}$$

For those products containing organic mechanical reinforcement, the percent organic number represents both binder and reinforcement. The supplier of the product can provide factors to enable the purchaser to estimate the percent binder content.

7.6 METHOD OF DETERMINING VOLATILE CONTENT

7.6.1 Purpose

The purpose of this test is to ascertain the percentage of residual volatiles remaining in resin-rich "B-staged" mica products. This determination may also be done as part of 7.5.4 item 1, during the determination of organic binder content.

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7.6.2 Apparatus

The apparatus shall consist of the following:

a. An electrically heated, forced-air oven which will provide a temperature of 150°C ± 5°C (302°F ± 9°F).
b. Dishes of aluminum, or other materials not affected by the test conditions.
c. An analytical balance having an accuracy of at least 0.001 gram.

7.6.3 Test Specimen

A representative test specimen weighing not less than 5 grams shall be selected from the lot.

7.6.4 Procedure

a. Each specimen shall be weighed to the nearest 0.001 gram in a tared dish.
b. Place the dish with the specimen in the oven at 150°C ± 5°C (30°F ± 9°F) for 10 minutes.
c. Cool in a desiccator and determine the weight of the residue.
d. The general procedure for making tests is as follows:
   1. Obtain a representative sample.
   2. Weigh a clean dish (weight C).
   3. Place a sample of the proper weight in the dish.
   4. Weigh the dish with the sample (weight E).
   5. Bake out volatile content.
   6. Cool in a desiccator.
   7. Weigh dish with dried sample (weight H).

7.6.5 Report

The report shall include the percent volatiles or percent mica and reinforcement, or both, as follows:

$$\frac{\text{Weight E} - \text{Weight H}}{\text{Weight E} - \text{Weight C}} \times 100 = \text{Percent Volatiles}$$

$$\frac{\text{Weight H} - \text{Weight C}}{\text{Weight E} - \text{Weight C}} \times 100 = \text{Percent Mica and Reinforcement}$$

7.7 METHOD OF MEASURING MICA OR SILICONE BINDER CONTENT

The mica or silicone binder content shall be measured in accordance with ASTM D352.

7.8 METHOD OF MEASURING MICA OR ARAMID CONTENT

7.8.1 Purpose

The purpose of this test is to ascertain the relative percentage of mica and aramid for both papers and tapes made of an aramid/mica blend.

7.8.2 Apparatus

The apparatus shall consist of the following:

a. An electrically heated muffle furnace which will provide a temperature of 900°C ± 20°C (1652°F ± 36°F).
b. Dishes of porcelain, quartz, or other materials not affected by the test conditions.
c. An analytical balance having an accuracy of at least 0.001 gram.

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7.8.3 Test Specimen

Papers and Tapes—The test method requires 8 to 10 grams of sample. Take samples at random to give the required weight.

7.8.4 Procedure

a. The paper and tape samples shall be dried in a forced-air oven at 180°C (356°F) for 1 hour to remove water.
b. Each specimen shall be weighed to the nearest 0.001 gram in a tared dish.
c. Place the dish with the specimen in a muffle furnace at 900°C ± 20°C (1652°F ± 36°F) for 60 minutes. Examine the sample at the end of this period for black spots of partially burned aramid component. If the sample has more than a trace of this condition, heat for an additional 10 minutes and re-examine. Cool in a desiccator and determine the weight of the residue.
d. The general procedure for making tests is as follows:
   1. Obtain a representative sample.
   2. Dry in a forced-air oven where required.
   3. Weigh a clean dish (weight C).
   4. Place a sample of the proper weight in the dish.
   5. Weigh the dish with the sample (weight E).
   6. Burn out aramid materials.
   7. Cool in a desiccator.
   8. Weigh dish with burned sample (weight H).

7.8.5 Report

The report shall include the percent aramid or percent mica, or both, as follows:

$$\frac{\text{Weight E} - \text{Weight H}}{\text{Weight E} - \text{Weight C}} \times 100 = \text{Percent Aramid}$$

$$\frac{\text{Weight H} - \text{Weight C}}{\text{Weight E} - \text{Weight C}} \times \text{Percent Mica}$$

7.9 METHOD OF MEASURING MOLDABILITY

7.9.1 Purpose

The purpose of this test is to measure the ability of hot-forming plate to be formed when heated and to retain its shape when cooled to room temperature.

7.9.2 Apparatus

The apparatus shall consist of the following:

a. For specimens having a thickness of 1/16 inch (1.33 mm) and less, a mandrel having a diameter of 1 1/2 inches (38.1 mm) shall be used.
b. For specimens over 1/16 inch (1.33 mm) up to and including 3/32 inch (2.38 mm) in thickness, a mandrel having a diameter of 2 inches (50.8 mm) shall be used.
c. A hot plate which provides a temperature within the range of 100°C to 150°C (212°F to 302°F).
d. A cold surface plate.

7.9.3 Test Specimen

The test specimen shall be 2 inches (50.8 mm) in width and of sufficient length to form a butt joint on the mandrel.

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7.9.4 Procedure

The test specimen shall be heated on a hot plate having a temperature within the range of 100°C to 150°C (212°F to 302°F) and then formed around the mandrel. The specimen shall then be rolled on a cold surface plate until it is cooled, and the mandrel shall then be removed.

7.9.5 Report

The report shall include the following:

a. Original thickness of the test specimen in thousandths of an inch.
b. The temperature of the hot plate.
c. The degree to which the mica plate flakes or buckles.
d. The change in diameter 10 minutes after the mandrel is removed.

7.10 METHOD OF MEASURING HOT COMPRESSION OF MICA PLATE

7.10.1 Scope

This method is intended to apply to the testing of bonded mica splittings and bonded mica paper for use as commutator segment plate.

7.10.2 Definition

The hot compression test determines the change in thickness of bonded micaceous materials as a result of maintaining a compressive load while the material is thermally cycled.

7.10.3 Significance

This test provides values which relate to the amount of change in thickness which is anticipated when the material is subject to compressive loading at elevated temperature.

7.10.4 Apparatus

The apparatus shall consist of the following:

a. Press—A hydraulic press having thermostatically-controlled electrically-heated platens, or a hydraulic press with other provisions for heating the specimen and controlling the temperature. The platen shall be large enough to accommodate a 2 × 2 inch (50.8 × 50.8 mm) specimen and permit the use of inside micrometers or calipers, if they are used. The press shall be capable of exerting sufficient force to obtain a pressure of at least 1000 psi (69.0 kPa) on the test specimen. The apparatus shall be capable of maintaining a specimen temperature of 200°C ± 5°C (392°F ± 9°F). It is desirable that some provision be made for cooling, such as using platens containing water ducts or forced circulation of air.
b. Pressure gage—A pressure gage or gages, as required, capable of determining the pressure on the specimen with an accuracy of plus or minus 5 percent.
c. Thickness gage—A thickness gage capable of measuring the thickness of the specimen to the nearest 1 mil (0.025 mm).
d. Thermocouple—The thermocouple used for measuring the specimen temperature shall be not less than 30 B&S gage nor larger than 20 B&S gage.

It shall be permissible to use steel plates between the surface of the mica and the platen in order to protect the surface of the platen.

7.10.5 Test Specimen

The test specimen shall consist of sufficient pieces of bonded micaceous plate, 2 × 2 inches (50.8 × 50.8 mm) in size, to form a stack approximately but not greater than 1.000 inch (25.4 mm) in thickness.

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7.10.6 Sampling

A sufficient number of mica pieces 2 inches (50.8 mm) square shall be sheared from a mica plate in such a manner as to represent the entire sheet. The sample shall not contain any pieces cut from an edge of the sheet. The presence of a surface film of any appreciable thickness will tend to increase the percent compression and may cause slippage in the sample. It may be desirable that material which has been surface coated with shellac or other resinous materials be sanded as necessary to remove such coating prior to testing. (This paragraph is approved as Authorized Engineering Information).

7.10.7 Procedure

Center the stacked specimen in the press with the thermocouple junction as near as practicable to the center of the stack. Carefully align the stack to form a right parallelpiped. Apply a pressure of 1000 psi (69.0 kPa) on the specimen and, after 5 minutes, carefully determine the average thickness by means of a suitable gage. Where inside gages are used, measure the thickness at each of the four corners as close to the specimen as possible. Pack thermal insulation to approximately 2 inches of loose rock wool around the test specimen without disturbing it. The platen temperature or surrounding medium shall not exceed the specified test temperature by more that 10°C (18°F). Heat the specimen while maintaining 1000 psi (69.0 kPa) until the stack reaches a temperature of 160°C ± 5 ¡C (320°F ± 9°F) or, for silicone bonded materials, 200°C ± 5°C (392°F ± 9°F) and hold for 2 hours. The specified temperature of the stack shall be reached in not less than 1/2 hour nor more than 1 1/4 hour. Cool the stack while maintaining 1000 psi (69.0 kPa). When the temperature of the stack reaches 5°C (9°F) above the temperature at which the original thickness was measured, the thickness of the specimen shall be again measured. The cooling rate for the specimen shall be approximately the same as the heating rate.

7.10.8 Report

The report shall include the following:

a. The nominal thickness of the material and the thickness of the specimen under specified test pressure.
b. The percent hot compression, calculated as follows:

$$\frac{\text{Reduction in Thickness}}{\text{Original specimen thickness under spedified test pressure}} \times 100$$

c. The temperature and pressure at which the test was run.

7.11 METHOD OF DETERMINING THERMAL CLASS

There are many methods for measuring the thermal class of an insulation material, including ASTM D1830, UL 746, IEC 216, UL 1446, etc. The thermal class referenced for resin-rich "B-staged" products may differ with each of these methods, and hence both the thermal class and referee method for determining the class should be a matter of negotiation between buyer and seller.

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7.12 METHODS OF DETERMINING RELATIVE FLEXIBILITY

7.12.1 Scope

Flexible mica products are used in a variety of applications which require the product to have a flexibility or stiffness within a relative range which is dependent upon the application. Each application can have a vastly different requirements, from a slotliner which requires relatively stiff products to a conductor wrap which requires relatively flexible products. The relative flexibility or stiffness of the product must thus be tested in a way that simulates the intended end-use. Three methods are listed below, each of which is designed for specific applications. Which method should be used for a given product, and the relative flexibility requirements for that product is a matter of negotiation between buyer and seller.

7.12.2 Definitions

a. Flexibility: The flexibility of a flexible mica product is defined as its ability to conform to and to wrap tightly and snugly against or around the conductor using normal winding tension, without lifting, bulging, folding, creasing, delaminating or distortion that will adversely affect its performance.
b. Stiffness: The stiffness of a flexible mica product is its ability to resist an applied bending of flexing force.
c. Machine Direction Stiffness: The stiffness of a test specimen, clamped with the machine direction of the paper perpendicular to the clamp.
d. Cross Direction Stiffness: The stiffness of a test specimen, clamped with the cross direction of the paper perpendicular to the clamp.

NOTE: Cross Direction Stiffness is not normally measured on flexible mica products, however, where beneficial, this data can be measured on wide wrappers. (This note is approved as Authorized Engineering Information.)

7.12.3 Significance

The stiffness and relative flexibility of flexible mica products are basic to most of the uses to which these materials are put. These methods help provide convenient reproducible tests to measure these fundamental characteristics.

7.12.4 Sampling

Test rolls shall be selected at random from the lot, as specified in 7.1. Care should be taken to select test product free of unusual flaws or creases that might subsequently affect the test results.

7.12.5 Gurley Type Stiffness

This test method is used to measure the flexibility of flexible mica paper plates, sheets and tapes listed in Section 5, by determining the stiffness of these products. The stiffness test measures the force required to bend a specimen under controlled conditions. This method is based on TAPPI T543, but modified specifically for measuring flexible mica products. Testing of the flexibility of mica splittings plates sheets and tapes listed in Section 4, will be discussed in Section 7.12.7.

7.12.5.1 Apparatus

a. Stiffness Tester—The instrument, a Gurley type tester, or equivalent, consists of a balanced pendulum or pointer, pivoted at its center of gravity, and provided with holes for attaching weights at variable distances from the pivot point (such as 1 inch [25.4 mm], 2 inches [50.8 mm] and 4 inches [101.6 mm]). The tester shall have a method to measure the pendulum angle which is used to compute stiffness. One such method is a graduated scale, with a zero point, and units increasing in both the left and right directions. The tester should also have a specimen clamp, pendulum, and an arm which rotates about a geometric center, when driven by a reversing motor. The device should allow for variable test lengths of 0.5 to 4 inches (12.7 to 101.6 mm), as well as provide variable weights from 5 to 200 grams. The tester should have a method to insure level operation.

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b. Sample Cutter—Any device can be used, providing it meets the specimen size tolerances described in 7.12.5.2. Examples of such devices include double knife cutters and steel rule dies.

7.12.5.2 Test Specimens

From each sample roll, cut specimens 1 ± 1/64 inch (25.4 ± 0.4 mm) wide by 2.5 ± 1/64 inch (63.5 ± 0.4 mm) long. Five specimens should be cut in the direction of test (primarily machine) from the sample. Although the standard length of 2.5 inches (63.5 mm) and width of 1 inch (25.4 mm) should be used wherever possible, the test specimen length and width may be varied to provide a test reading in the middle 50% of the devices scale range (for example, 2 to 6 in a device which has a range from 0 to 8). Specimen widths between 0.5 inch (12.7 mm) and 2.0 inches (50.8 mm) can be used, and lengths can be selected from one of the following:

Cut Length Test Length, L_t				
in	(mm)	in	(mm)	Length Ratio, L_R
1.0	(25.4)	0.5	(12.7)	0.167
1.5	(38.1)	1.0	(25.4)	0.333
2.5	(63.5)	2.0	(50.8)	0.667
3.5	(88.9)	3.0	(76.2)	1.000
4.5	(114.2)	4.0	(101.6)	1.333

Specimens shall be conditioned to 23°C ± 1.1°C (73°F ± 2°F) and 50 ± 2% relative humidity and shall be tested immediately thereafter.

7.12.5.3 Procedure

a. Select an appropriate weight, mounting position and specimen size to give a deflection in the mid 50% of the scale range (2 to 6 on a range from 0 to 8). Level the base so that the pendulum pointer indicates zero after the weight is attached.
b. Fasten the specimen strip in the clamp in such a manner that 0.25 ± 0.01 inch (6.4 ± 0.2 mm) will be held in each of the jaws. Set the clamp in a position so that the specimen overlaps the top of the pendulum by 0.25 ± 0.01 inch (6.4 ± 0.2 mm).
c. Press the reversing switch to cause the clamp arm to bring the specimen in contact with the top of the pendulum. Record the reading to the nearest 1.25% (0.1 units on a 0 to 8 scale) at the point where the specimen clears the pendulum.
d. Reverse the motor, and load the specimen against the pendulum from the opposite side. Record the scale reading, and average it with the prior reading.
e. Repeat the test with 4 additional specimens.
f. Average the results from the 5 specimens.

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7.12.5.4 Report

The report shall include the following:

a. Specimen size
b. The average stiffness, calculated as follows:

$$S = 1000 * \frac{R}{10} * \frac{D^{LR}}{V^{WR}} * M * L^{R}$$

Where:

S = stiffness, mg
R = scale reading
D = distance from weight to pivot, mm
V = distance from tip of vane to pivot, mm (127 mm standard)
M = weight, g
L^R = length ratio = length test/length standard = length test/76.2 mm
W^R = width ratio = width test/width standard = width test/25.4 mm

Test results using this method can be somewhat variable. TAPPI quotes repeatability (within laboratory) of 5.4% and reproducibility (between laboratories) of 19.2% of the test result. The degree of flatness of the sample greatly affects the test result. (This note is approved as Authorized Engineering Information.)

7.12.6 IEC 371-2 Stiffness

This test method is used to measure the flexibility of flexible mica paper plates, sheets and tapes listed in Section 5, by determining the stiffness of these products. This method is specifically designed for testing products used as slot liners. This method is based on IEC 371-2 Paragraph 10. Testing of the flexibility of mica splittings plates sheets and tapes listed in Section 4, will be discussed in Section 7.12.7.

7.12.6.1 Apparatus

7.12.6.2 Test Specimens

Full Width Sample Rolls: Cut specimens 0.59 ± 0.02 inches (15 ± 0.5 mm) wide by 1.97 ± 0.02 (50 ± 0.5 mm) long. Five specimens should be cut in each direction.

Tape Samples:Cut five specimens of 1.97 ± 0.02 inches (50 ± 0.5 mm) in length, by the width of the tape greater than 0.39 ± 0.02 inches (10 ± 0.5 mm). For the transverse direction, the width of the tap will become the length of the test specimen.

7.12.6.3 Procedure

The test specimen is placed as shown in Figures 3 and 4 (page 43), with the glass fabric side on the outside of the fold, symmetrically on the support platform, parallel to the slot and with its two edges overlapping the slot by equal amounts on each side. The penetrator bar is driven into the slot against the resistance of the test specimen util the maximum force of resistance is reached. The rate of movement of the support platform against the penetrator bar shall be such that the maximum force is reached in 15 ± 3 seconds. A force-measuring device such as a table balance could be used to record the maximum force of resistance.

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The stiffness will be given in newtons per meter and is calculated as follows:

$$\text{Stiffness} = \frac{F_{max}}{l} \text{ (N/m)}$$

Where:

Fmax = maximum flexural load (N)

l = length of test specimen (m)

7.12.6.4 Report

The central values and the maximum and minimum values of the stiffness in machine direction (with deflection of weft yarns) and in transverse direction (with deflection of warp yarns) shall be reported separately.

The test temperature shall be noted in the report.

7.12.7 Wrapper Flexibility

This test method is used to measure the flexibility of mica splittings plates sheets and tapes listed in Section 4. This method is based on a mandrel flexibility test originally used in MIL-I-3505.

7.12.7.1 Procedure

The material shall be tested for flexibility by wrapping it 360 degrees around a one-half inch (12.7 mm) diameter mandrel with the varnished glass or glass component on the outside. The material shall be applied as a tape by hand under normal winding tension by half-lapping around the mandrel. The material shall withstand this bending without chipping, cracking, breaking or delaminating. This test is useful for determining the suitability of mica composites for slot and cell wrap insulation.

7.12.7.2 Report

The material will be reported as having passed or failed this flexibility test.

7.13 METHOD OF DETERMINING TENSILE STRENGTH

The tensile strength of manufactured electrical mica products shall be measured in accordance with ASTM D828. Unless otherwise specified, the product is tested as supplied by the manufacturer.

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Section 8
TEST METHODS

8.1 METHOD OF DETERMINING UNDERSIZE MICA SPLITTINGS—GRADE 6

The following method describes one type of classification test for mica splittings and is to be used with Table 3-1 (Size and Average Thickness for Muscovite Splittings). An alternate method and set of requirements is available in ASTM D2131. The method which is used is a matter of negotiation between seller and buyer.

8.1.1 Apparatus (See Figures 8-1, 8-2, and 8-3)

The apparatus shall consist of the following:

a. A perforated drum 18 inches (457 mm) long and 15 inches (381 mm) in diameter. The drum shall be made of 0.025-inch (0.63 mm) steel plate, with perforations 1/2 inch (19.1 mm) in diameter, and an open area of 61 percent. It shall be driven by a constant-speed motor at 15 rpm.
b. A catch pan below the drum to collect all particles which pass through the perforations.

8.1.2 Sampling

At least 10 percent of the cases in each lot, but no less than one case shall be tested, example:

Number of Cases in Lot	Number of Cases to be Tested
1–10	1
11–20	2
21–30	3
31–40	4
41–50	5
etc.	

One test shall be made for each case.

8.1.3 Procedure

Introduce 300 grams of mica splittings into the drum through the opening at one end. Rotate the drum for 2 minutes at 15 rpm. Weigh the particles which fall into the catch pan. Clean the drum in preparation for the next test.

8.1.4 Report

The report shall include the following for each case tested:

a. Purchase order number
b. Supplier's name
c. Grade and color of mica
d. Case number
e. Weight of mica placed in drum
f. Weight of particles which fall into catch pan
g. Percent of undersize splittings—(Item 6/Item 5) x 100

NOTE: The time required for the test is usually 6 to 8 minutes per case. (This note is approved as Authorized Engineering Information.)

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