

MIL-P-18035C  
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~~SUPERSEDED~~  
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**MILITARY SPECIFICATION**  
**PLASTIC SHEET: LAMINATED, THERMOSETTING,**  
**COTTON-FABRIC-BASE, PHENOLIC-RESIN**

This specification has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

**1. SCOPE**

1.1 Scope. - This specification covers class A<sup>1/</sup> plastic laminated thermosetting sheet material used for electrical insulating and mechanical purposes, wherein a greater degree of mechanical strength is required than can be obtained with phenolic resin paper base laminates, but with some sacrifice in electrical characteristics.

1.2 Classification. - Laminated thermosetting sheet shall be of the following types, as specified (see 6.1):

Type FBM - Mechanical grade.  
Type FBG - General-purpose grade.  
Type FBE - Electrical grade.  
Type FBI - For fine machining applications.

**2. APPLICABLE DOCUMENTS**

2.1 The following documents, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

**SPECIFICATIONS**

**FEDERAL**

L-P-406 - Plastics, Organic: General Specifications, Test Methods.  
PPP-B-576 - Box, Wood, Cleated, Veneer, Paper Overlaid.  
PPP-B-595 - Boxes, Wood, Wirebound.  
PPP-B-591 - Boxes, Fiberboard, Wood-Cleated.  
PPP-B-601 - Boxes, Wood, Cleated Plywood.  
PPP-B-621 - Boxes, Wood, Nailed and Lock-Corner.  
PPP-B-636 - Boxes, Fiberboard.  
PPP-T-76 - Tape, Pressure-Sensitive Adhesive, Paper, Water Resistant.

**MILITARY**

MIL-L-10457 - Liners, Case, Waterproof.

**STANDARDS**

**MILITARY**

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.  
MIL-STD-129 - Marking for Shipment and Storage.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

<sup>1/</sup> AIKE temperature classification as given in AIKE Standard No. 1.

FBC 9330

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**2.2 Other publications.** - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

**AMERICAN SOCIETY FOR TESTING MATERIALS**

**D-150 - Methods of Test for Power Factor and Dielectric Constant of Electrical Insulating Materials.**

(Application for copies should be addressed to the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.)

**OFFICIAL CLASSIFICATION COMMITTEE**

**Uniform Freight Classification Rules.**

(Application for copies should be addressed to the Official Classification Committee, 1 Park Avenue at 33rd Street, New York 16, New York.)

**3. REQUIREMENTS**

**3.1 Preproduction sample.** - Prior to production, a preproduction sample shall be submitted (see 4.2).

**3.2 Material.** -

**3.2.1 Construction.** - The material shall consist of a suitable cotton fabric base or filler properly impregnated and bonded with a phenolic thermosetting resin compound or binder, processed to meet the requirements of this specification.

**3.2.2 Property values.** - The material shall conform to the property values shown in tables IV to XI, inclusive. The values obtained from each set of specimens taken from the same sheet shall be averaged before comparison with the applicable table.

**3.2.3 Uniformity.** - All sheets of any lot shall be uniform in texture, finish, and specified properties.

**3.2.4 Surface defects.** - The material shall be free from blisters, wrinkles, or cracks, and reasonably free from other small defects such as scratches, dents, heat marks, etc.

**3.2.5 Warp or twist (applicable only to sheets 36 inches and greater in length and in width).** - The warp or twist of material, as delivered, shall not exceed that shown in table I (see 3.6.9). Percentage of warp is given in terms of the lateral dimensions (length and width), of the material; percentage of twist is given in terms of dimensions from one corner to the opposite corner.

**Table I - Warp or twist.**

Thickness	Permissible variation, on basis of 36-inch dimension
Inch	Maximum percent
1/32 to under 1/16	5.00
1/16 to under 1/8	2.50
1/8 to 1/4, inclusive	1.00
Over 1/4, up to and including 3/4	0.50
Over 3/4	0.25

**3.3 Dimensions and tolerances.** -

**3.3.1 Length and width.** - Unless otherwise specified, the manufacturer's standard sizes between 36 and 50 inches in width and between 36 and 96 inches in length will be acceptable. The length and width of sheets may vary 1 inch over or under the manufacturer's standard size. Nonuniform standard sheet dimensions caused by cutting specimens for tests required by this specification shall not be cause for rejection, unless particular dimensions are specified in the contract or order. Where particular sheet

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dimensions are specified (see 6.1), the permissible variations from the specified length or width shall be as shown in table II.

Table II - Permissible variations in length or width.

Nominal thickness	Permissible variations in length or width (inch) ( $\pm$ )		
	6 inches and under	Over 6 to under 24 inches	24 inches and over
Inches			
Up to 1/4, inclusive . . . . .	0.010	0.015	1/32
17/64 to 1/2, inclusive . . . . .	.012	.017	1/32
23/64 to 1, inclusive . . . . .	.015	.020	1/32
1-1/64 to 1-1/2, inclusive . . . . .	.018	.030	1/16
1-33/64 to 2, inclusive $\frac{1}{2}$ . . . . .	.022	.040	1/16

$\frac{1}{2}$  For type FBM, tolerances apply to sheets up to and including 10 inches thick,

3.3.2 Thickness. - Sheets shall be furnished in the nominal thicknesses shown in table III, as specified (see 6.1). At least 90 percent of the area of the sheet shall be within the variations shown in table III, and at no point shall the thickness as measured vary from the nominal thickness by a value greater than 125 percent of the permissible variations.

Table III - Thicknesses.

Nominal thickness		Permissible variations $\frac{1}{2}$ (inch) ( $\pm$ )			
Inches	Decimal equivalent	Type FBM	Type FBG	Type FBE	Type FBI
0.010	0.010	-----	-----	-----	0.003
.015	.015	-----	-----	0.0035	.0035
.020	.020	-----	-----	.004	.004
.025	.025	-----	-----	.0045	.0045
1/32	.031	0.0065	0.0065	.005	.005
3/64	.047	.0075	.0075	.0055	.0055
1/16	.0625	.0075	.0075	.006	.006
3/32	0.094	.009	.009	.007	.007
1/8	.125	.010	.010	.008	.008
5/32	.156	.011	.011	.009	.009
3/16	.1875	.0125	.0125	.010	.010
7/32	.219	.014	.014	.011	.011
1/4	.250	$\frac{2}{2}$ .020	.015	.012	$\frac{2}{2}$ .014
5/16	.3125	.025	.0175	.0145	.020
3/8	.375	.040	.020	.017	.024
7/16	.438	.044	.022	.019	.028
1/2	.500	.048	.024	.021	.032
5/8	.625	.053	.027	.024	.040
3/4	.750	.058	.029	.027	.044
7/8	.875	.063	.031	.030	.050
1	1.000	.065	.033	.033	.055

See footnotes at end of table.

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Table III - Thicknesses (Cont'd).

Nominal thickness		Permissible variations <sup>1/</sup> (inch) (±)			
Inches	Decimal equivalent	Type FBM	Type FBG	Type FBE	Type FBI
1-1/8	1.125	.069	.035	.035	.069
1-1/4	1.250	.073	.037	.037	.073
1-3/8	1.375	.077	.039	.039	.077
1-1/2	1.500	.081	.041	.041	.081
1-5/8	1.625	.085	.043	.043	.085
1-3/4	1.750	.089	.045	.045	.089
1-7/8	1.875	.093	.047	.047	.093
2	2.000	.097	.049	.049	.097
2-1/4	2.250	.106	-----	-----	-----
2-1/2	2.500	.113	-----	-----	-----
2-3/4	2.750	.121	-----	-----	-----
3	3.000	.130	-----	-----	-----
3-1/2	3.500	.146	-----	-----	-----
4	4.000	.163	-----	-----	-----
4-1/2	4.500	.179	-----	-----	-----
5	5.000	.190	-----	-----	-----
5-1/2	5.500	.210	-----	-----	-----
6	6.000	.230	-----	-----	-----
6-1/2	6.500	.240	-----	-----	-----
7	7.000	.260	-----	-----	-----
7-1/2	7.500	.280	-----	-----	-----
8	8.000	.290	-----	-----	-----
8-1/2	8.500	.310	-----	-----	-----
9	9.000	.330	-----	-----	-----
9-1/2	9.500	.340	-----	-----	-----
10	10.000	.360	-----	-----	-----

<sup>1/</sup> On sheets of nominal thicknesses not listed in this table the permissible variations shall be the same as for the next greater thickness.

<sup>2/</sup> For types FBM and FBI, tolerances above 7/32 inch are plus only.

3.4 **Color.** - The laminated sheets shall be natural in color. Natural is the color produced by the natural, undyed cotton fabric and the resin used.

3.5 **Machinability.** - The material shall be such that it can be drilled, tapped, sawed, and machined in all directions <sup>2/</sup> in accordance with the manufacturer's recommended technique without cracking, splitting, or otherwise impairing the material for general use. Types FBE and FBI material shall be suitable for fine machining applications, requiring close tolerances.

3.6 **Surface finish.** - Unless otherwise specified, the surface finish of sheets shall be either polished or semigloss as produced by the laminating operation, except that type FBM shall be furnished in semigloss only.

3.7 **Marking.** - Each full-size sheet shall be legibly marked on the right-hand corner on each side with the manufacturer's name or trade-mark, and the type. The method of marking shall be satisfactory to the bureau or agency concerned.

3.8 **Workmanship.** - Laminated materials shall be manufactured and processed in a careful and workmanlike manner free from defects which may affect the appearance or serviceability.

<sup>2/</sup> The nature of laminated materials necessitates special precaution when drilling and tapping parallel to laminations.

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#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. The government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Preproduction tests. - Prior to production, a preproduction sample shall be submitted to a laboratory satisfactory to the bureau or agency concerned. Preproduction tests and sample thicknesses of material required for the tests shall be as shown in tables IV, V, VI, and VII.

4.3 Lot-acceptance inspection. - Each sheet of every lot shall be subjected to surface inspection to determine compliance with section 3, except 3.1 and 3.2.2. If any of the sheets fail to conform to any of these requirements, such sheets shall be rejected.

#### 4.4 Lot-acceptance tests. -

4.4.1 Lot-acceptance tests shall be conducted on material selected from production lots offered under one or several contracts or orders. A production lot shall consist of all sheets of a given machine run and of a particular thickness range as shown in tables VIII, IX, X, and XI. (For instance, sheets of 1/16 and 3/32 inch thickness fall within one thickness range (0.032 to 0.094) and may be included on one production lot.) A machine run shall consist of all the material pressed from a coating operation in which the basic resin and filler and treating conditions are the same. The number of samples for testing shall consist of 10 percent of the lot, but in no case shall be less than one or more than three sheets. The results of the tests on four specimens cut from each sample sheet shall be averaged for each test specified in tables VIII, IX, X, and XI to determine conformance with the specified requirements for the applicable thickness ranges.

4.4.2 Acceptance or rejection of lots. - If any of the sample sheets tested fail any of the tests shown in tables VIII, IX, X, and XI the entire lot shall be rejected.

#### 4.5 Conditioning of test specimens. -

4.5.1 Nomenclature. - The following letters shall be used to indicate the respective general conditioning procedures:

- Condition A - As received; no special conditioning.
- Condition C - Humidity conditioning.
- Condition D - Immersion conditioning in distilled water.
- Condition E - Temperature conditioning.

NOTE: Whenever a conditioning letter is followed by an inferior 1, as D<sub>1</sub>, a prior temperature conditioning has been carried out.

#### 4.5.2 Designation. - Conditioning procedures shall be designated as follows:

- a. A capital letter indicating the general condition of the specimen, i.e., as received, humidity, immersion, or temperature conditioning.
- b. A number indicating in hours the duration of the conditioning.
- c. A number indicating in degrees centigrade the conditioning temperature.
- d. A number indicating relative humidity when ever relative humidity is controlled.

The numbers shall be separated from each other by a slant mark, and from the capital letter by a dash.

#### Examples:

- Condition C-96/35/90-Humidity condition, 96 hours at 35°C. and 90 percent relative humidity.
- Condition D-48/50-Immersion condition, 48 hours in distilled water at 50°C.
- Condition E-48/50-Temperature condition, 48 hours at 50°C.

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TABLE IV. -- Preproduction tests for property values of type F15M.

Property to be tested	Test paragraph	Number of specimens for each thickness	Tests per specimen	Conditioning (see 4.5)	Unit of value	Value required for each sample thickness		
						1/16 inch	1/8 inch	1/2 inch
Dielectric breakdown parallel to laminations step-by-step test. ....	4.6.2	1/1 3/4	1 1	A. ....	Min. kv.	15.0	15.0	15.0
Impact strength, tested edgewise: cut lengthwise. .... cut crosswise. ....	4.6.3	4 4	1 1	HI-48/50 ....	Min. ft.-lb. per inch	3/ 5/	2.10 1.90	2.10 1.90
Flexural strength, tested flatwise: cut lengthwise. .... cut crosswise. ....	4.6.4	4 4	1 1	A. ....	Min. lb. per sq. in.	17,000 16,000	17,000 16,000	16,000 16,000
Bonding strength, cut lengthwise. ....	4.6.5	4 4	1 1	A. .... D-48/50 ....	Min. lb.	3/ 5/	3/ 5/	1,000 1,000
Water absorption. ....	4.6.6	4	1	Precondition at E-1/106: Condition at D <sub>1</sub> -34/33	Max. Percent	4.4	2.5	1.2

1/ Short-time.  
2/ Step-by-step.  
3/ Not required.

Table V - Preproduction tests for property values of type FBO.

Property to be tested	Test paragraph	Number of specimens for each	Tests per specimen	Conditioning (see 4.5)	Unit of value	Value required for each sample thickness		
						1/16 inch	1/8 inch	1/2 inch
Dielectric breakdown parallel to laminations, step-by-step test . . . . .	4.6.2	1/1	1	A . . . . . D-48/50 . . . . .	Min. kv.	35.0	35.0	35.0
		2/4	1			2.5	2.5	2.5
		1/1	1					
		3/4	1					
Impact strength, tested edgewise: cut lengthwise . . . . . cut crosswise . . . . .	4.6.3	4	1	E-48/50 . . . . .	Min. ft. lb. per. in.	3/	1.60	1.60
		4	1				1.40	1.40
Flexural strength, tested flatwise: cut lengthwise . . . . . cut crosswise . . . . .	4.6.4	4	1	A . . . . .	Min. lb. per sq. in.	17,000	17,000	17,000
		4	1			14,000	14,000	14,000
Bonding strength, cut lengthwise . . . . .	4.6.5	4	1	A . . . . . D-8/50 . . . . .	Min. lb.	3/	3/	1,800
Water absorption . . . . .	4.6.6	4	1	Precondition at E-1/106; Condition at D1-34/35.	Max. percent	2.2	1.60	0.75

1/ Short-time.  
2/ Step-by-step.  
3/ Not required.

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Table VI - Preproduction tests for property values of type FBE.

Property to be tested	Test paragraph	Number of specimens for each thickness	Tests per specimen	Conditioning (see 4.5)	Unit of value	Value required for each sample thickness		
						1/16 Inch	1/8 Inch	1/2 Inch
Dielectric breakdown parallel to laminae - 100% step-by-step test . . . . .	4.6.2	1/1	1	A . . . . . D-48/50 . . . . .	Min. kv.	40.0	40.0	40.0
		2/4	1					
		1/1	1					
		2/4	1					
Impact strength, tested edge-wise: . . . . .	4.6.3	4	1	E-48/50 . . . . .	Min. ft.-lb. per in.	3/	1.25	1.25
			1					
Flexural strength, tested flatwise: . . . . .	4.6.4	4	1	A . . . . .	Min. lb. per sq. in.	15,000 13,500	15,000 13,500	15,000 13,500
			1					
Bonding strength, edge-wise . . . . .	4.6.5	4	1	A . . . . . D-48/50 . . . . .	Min. lb.	3/	3/	1,600 1,500
			1					
Water absorption . . . . .	4.6.6	4	1	Precondition at E-1/105, Conditions at D1-24/23	Max. percent	1.95	1.30	0.70
Dielectric constant at 1 megacycle . . . . .	4.6.7	4	1	D-24/23 . . . . .	Max.	---	6.0	3/
Dissipation factor at 1 megacycle . . . . .	4.6.7	4	1	D-24/23 . . . . .	Max.	---	0.070	3/
Surface resistance . . . . .	4.6.8	4	1	C-96/35/90 . . . . .	Min. meg.	3/	0.5	3/

1/ Start time.  
2/ Step-by-step.  
3/ Not required.



Table VII - Preproduction tests for property values of type FHM.

Property to be tested	Test paragraph	Number of specimens for each thickness	Tests per specimen	Conditioning (see 4.5)	Unit of value	Value required for each sample thickness		
						1/16 Inch	1/8 Inch	1/2 Inch
Dielectric breakdown parallel to laminations, step-by-step test .....	4.6.2	1/1	1	A.....	Min.kv.	15.0	15.0	15.0
		3/4	1					
Impact strength, tested edgewise: cut lengthwise .....	4.6.3	4	1	E-48/50 .....	Min. (ft.-lb. per in.	3/	1.35	1.35
		4	1					
Flexural strength, tested flatwise: cut lengthwise .....	4.6.4	4	1	A.....	Min. p.s.i.	15,000 14,000	15,000 14,000	15,000 14,000
		4	1					
Bonding strength .....	4.6.5	4	1	A..... D-48/50 .....	Min.lb.	3/	3/	1,600 1,500
		4	1					
Water absorption .....	4.6.6	4	1	Precondition at E-1/105, Condition at D <sub>1</sub> -24/23	Max. percent	2.5	1.6	0.090

1/ Short-time.

2/ Step-by-step.

3/ Not required.

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Table VIII - Lot-acceptance tests for property values of type FBM.

Property to be tested	Test paragraph	Number of specimens for each sample	Tests per specimen	Conditioning (see 4.5)	Unit of value	Value required for each sample thickness range $\frac{3}{4}$ (inch)					
						0.031 to 0.032	0.032 to 0.034	0.035 to 0.036	0.036 to 0.038	0.038 to 0.040	0.040 to 0.042
Dielectric breakdown parallel to laminations, step-by-step test..	4.6.2	1/1	1	A. ....	Min.kv.	15.0	15.0	15.0	15.0	15.0	10.0
		2/4	1								
Flexural strength, tested flatwise: cut lengthwise .....	4.6.4	4	1	A. ....	Min. lb. per (sq. in.	17,000	17,000	17,000	17,000	17,000	14,000
		4	1			16,000	16,000	16,000	16,000	16,000	14,000
Bonding strength, cut lengthwise.	4.6.5	4	1	A. ....	Min.lb.	4/	4/	4/	4/	4/	1,800

1/ Short-time.

2/ Step-by-step.

3/ These ranges are for nominal thicknesses subject to the tolerance specified in table III.

4/ Not required.

Table IX - Lot-acceptance tests for property values of type FBG.

Property to be tested	Test paragraph	Number of specimens for each thickness	Tests per specimen	Conditioning (see 4.5)	Unit of value	Value required for each sample thickness $\frac{1}{4}$ (inch)					
						0.031	0.032 to 0.034	0.035 to 0.036	0.037 to 0.038	0.039 to 0.040	0.041 to 0.042
Dielectric breakdown parallel to laminations, step-by-step test.	4.6.2	$\frac{1}{1}$ $\frac{2}{4}$	1 1	A. . . . .	Min. kv.	35.0	35.0	35.0	35.0	35.0	35.0
Flexural strength, tested flatwise: cut lengthwise . . . . . cut crosswise . . . . .	4.6.4	4 4	1 1	A. . . . .	Min. lb. per sq. in.	17,000 14,000	17,000 14,000	17,000 14,000	17,000 14,000	17,000 14,000	15,300 12,600
Bonding strength	4.6.5	4	1	A. . . . .	Min. lb.	3/	3/	3/	3/	3/	1,800

1/ Short-time

2/ Step-by-step.

3/ Not required.

4/ These ranges are for nominal thicknesses subject to the tolerance specified in table III.

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Table X—Lot-acceptance tests for property values of type FBII.

Property to be tested	Test paragraph	Number of specimens for each sample	Tests per specimen	Conditioning (see 4.5)	Units of value	Value required for each sample thickness range <sup>1/</sup> (inch)					
						0.031 to 0.094	0.095 to 0.125	0.126 to 0.250	0.251 to 0.499	0.500 to 1.000	1.001 to 2.000
Dielectric breakdown parallel to laminations, step-by-step test . . . . .	4.6.3	1/2 4	1	A . . . . .	Min. kv.	40.0	40.0	40.0	40.0	40.0	30.0
			1	A . . . . .							
Flexural strength, tested flatwise: cut lengthwise . . . . .	4.6.4	4 4	1	A . . . . .	Min. lb. per sq. in.	15,000	15,000	15,000	15,000	15,000	15,500
			1	A . . . . .		15,500	15,500	15,500	15,500	15,500	12,000
Bonding strength . . . . .	4.6.5	4	1	A . . . . .	Min. lb.	(2/)	(2/)	(2/)	(2/)	1,800	1,800

1/ Short-time.

2/ Step-by-step.

3/ Not required.

4/ These ranges are for nominal thicknesses subject to the tolerance specified in table III.

5/ Not required for sizes under 0.031 inch in thickness.

Table XI—Lot-acceptance tests for property values of type FBI.

Property to be tested	Test paragraph	Number of specimens for each sample	Tests per specimen	Conditioning (see 4.5)	Unit of value	Value required for each sample thickness range <sup>3/</sup> (inch)					
						0.031 and Under	0.032 to 0.094	0.095 to 0.125	0.126 to 0.250	0.251 to 0.499	0.500 to 1.000
Dielectric breakdown parallel to luminations, step-by-step test . . . . .	4.6.2	1/2 4	1 1	A . . . . .	Min.kv.	15.0	15.0	15.0	15.0	15.0	10.0
Flexural strength, tested flatwise: cut lengthwise . . . . . cut crosswise . . . . .	4.6.4	4 4	1 1	A . . . . .	Min. p.s.i.	4/15,000 2/14,000	15,000 14,000	15,000 14,000	15,000 14,000	15,000 14,000	13,500 12,500
Bonding strength . . .	4.6.5	4	1	A . . . . .	Min.lb.	(5/)	(5/)	(5/)	(5/)	1,600	1,600

1/Short-time.

2/Step-by-step.

3/These ranges are for nominal thicknesses subject to the tolerance specified in table III.

4/Not required for sizes under 0.031 inch in thickness.

5/Not required.

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4.5.3 Time tolerances. - Oven conditioning shall be followed by a cooling to room temperature (23°C.) in a desiccator and immersion conditioning shall be followed by cooling to room temperature in distilled water, as specified in table XII.

4.5.4 Temperature tolerances. - The conditioning temperature tolerances shall be as follows:

Nominal temperature, °C:	Tolerance (±) °C.
23 .....	3
35 .....	1
50 .....	2
105 .....	2

4.5.5 Humidity tolerances. - Tolerance on the nominal relative humidity of 90 percent shall be ± 2 percent.

4.6 Test methods. -

4.6.1 Definitions. - In conducting tests, the term "lengthwise" shall be interpreted to mean that sheet direction known to be the stronger in flexure. "Crosswise" shall then be the sheet direction known to be the weaker in flexure.

4.6.2 Dielectric breakdown parallel to laminations (step-by-step). -

4.6.2.1 Specimens. - The test specimens shall be 2 by 3 inches by the thickness of the sheet. American standard tapered pins having a taper of 1/4 inch per foot shall be used. For test specimens having a thickness up to 1/2 inch, inclusive, No. 3 American standard tapered pins 3/32 inches long and having a diameter at the large end of 7/32 inch shall be used. Drill two 3/16 inch diameter holes, centrally located, 1 inch apart, center to center, and perpendicular to the faces of the specimen. Using standard tapered pin reamer, ream holes to a sufficient depth to allow the pins to extend approximately 1-1/3 inches from the small end of the hole. For test specimens having a thickness over 1/2 up to 2 inches, inclusive, No. 4 American standard tapered pins 4 inches long and having a diameter at the large end of 1/4 inch shall be used. Drill two 3/16 inch diameter holes, centrally located, 1 inch apart, center to center, and perpendicular to the faces of the specimen. Using standard tapered pin reamers, ream holes to a sufficient depth to allow the pins to extend approximately 1 inch from the small end of the hole. The electrodes shall be inserted after the conditioning of the test specimen. Spheres having a 1/2 inch diameter, when placed on the extremities of the tapered pins, will decrease the tendency to flashover.

4.6.2.2 Procedure. - All tests shall be made under oil, at commercial power frequency of 60 cycles. One specimen only shall be tested by the short-time method for the purpose of providing a basis for the initial voltage applied in the step-by-step test. In the short-time test, starting at zero, the testing voltage shall be increased as uniformly as possible at a rate of 500 volts per second. On the remaining specimens, the step-by-step method shall be used. The initial voltage applied in the step-by-step test shall be 50 percent of the short-time breakdown voltage. The initial voltage in the step-by-step tests, shall be applied for 1 minute and the voltage shall then be increased in increments as follows, holding the voltage at each step for 1 minute:

Breakdown voltage by short-time method (kilovolts)	Increment of increase for step-by-step method (kilovolts)
12.5 or less. ....	0.5
12.5 to 25 .....	1.0
25 to 50. ....	2.5
50 to 100. ....	5.0

<sup>3/</sup> For information on tapered pins, see Kents Mechanical Engineers Handbook, 12th Edition, Design and Production, page 15-14." (This handbook may be obtained from John Wiley and Sons, Inc., 440 - 4th Ave., New York 16, N. Y.)

TABLE XII-Conditioning time tolerances.

Conditioning		Cooling		Comments
Condition	Time tolerance	Time	Time tolerance	
E-48/50	{ -0 hours +3 hours }	{ 16 hours or more }	{ -0 hours }	Cool in desiccator. Start test within 1/2 hour after removing specimen from desiccator.
D-48/50 D-24/23	{ -0 hours + 1/2 hour }	{ 1 hour }	{ -0 hours +2 hours }	Cool by immersion in a sufficient quantity of distilled water to reduce the temperature to 23° C. within 1 hour. Remove individually as needed, and wipe surface water off with a cloth. Start test within 1 minute after removing specimen from water.
E-1/106	{ -0 minutes +6 minutes }	{ 2 hours or more }	{ -0 hours }	See water absorption test (see 4.6.6).
D <sub>1</sub> -24/23	{ -0 hours +3 hours }	{ ..... }	{ ..... }	Do.
C-98/35/50	{ -0 hours +2 hours }	{ ..... }	{ ..... }	Tests after humidity conditioning shall be made on specimens in the humidity chamber (see 4.6.6). Forced air circulation shall be used in the humidity chamber.

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4.6.2.3 **Report.** - The breakdown voltage shall be reported in kilovolts and the time required to break each specimen shall be reported in seconds.

4.6.3 **Impact strength (tested edgewise).** -

4.6.3.1 **Specimens.** - Specimens of sheets in thicknesses of 1/8 to 1/2 inch, inclusive, shall be tested in sizes 2-1/2 inches by 1/2 inch by thickness without build-up. Each specimen shall be notched in one edge (side). The notch shall be centrally located with respect to the ends of the specimen. The angle of the notch shall be 45 degrees and the depth under the notch shall be  $0.400 \pm 0.005$  inch with a curvature at the bottom of the notch of  $0.010 \pm 0.002$  inch. Different sets of specimens shall be cut lengthwise and crosswise of the sheet.

4.6.3.2 **Procedure.** - After the conditioning of the specimen, the impact strength shall be determined on a pendulum-type Izod impact machine. Accurate corrections shall be made for friction and windage losses. The specimen shall be located in the machine by means of a jig, with center line of notch on the level of the top of the clamping surface. In the striking position, the striking edge of the pendulum shall be 0.866 inch from the edge of the specimen clamp. The pendulum shall be released from such a position that the linear velocity of the striking edge at the instant of impact shall be approximately 11 feet per second, which is the linear velocity corresponding to an initial elevation of the striking edge of 2 feet. The blow shall be struck on the notched side. The pointer setting shall be recorded and corresponding correction shall be obtained from a chart. This chart shall be constructed by measuring the friction and windage losses, using the proportionate amount of these losses as the correction factor.

4.6.3.3 **Calculations.** - The impact strength shall be taken as the energy absorbed in breaking the specimen. It shall equal the difference between the energy remaining after breaking the specimen the pendulum's initial energy, and shall be expressed in foot-pounds per inch of notch.

4.6.4 **Flexural strength (tested flatwise).** -

4.6.4.1 **Specimens.** - Specimens of sheets in the thicknesses of 1/32 to 2 inches, inclusive, shall be tested flatwise in accordance with method 1031 of Specification L-P-406, except that the dimensions and speed of test shown in table XIII shall be used and that specimens over 1 inch in nominal thickness shall be machined on both surfaces to a specimen thickness of 1 inch. Different sets of specimens shall be cut lengthwise and crosswise of the sheet.

TABLE XIII—Dimensions of specimen and speed of test.

Nominal specimen thickness	Width of specimen	Length of specimen	Span	Speed of test per minute
Inch	Inch	Inches	Inches	Inch
1/32	1	2 1/2	* 5/8	0.025
1/16	1	3	1	.026
3/32	1	3 1/2	1 1/2	.040
1/8	1	4	2	.053
3/16	1/2	5	3	.080
1/4	1/2	6	4	.106
3/8	1/2	8	6	.160
1/2	1/2	10	8	.213
3/4	3/4	14	12	.320
1	1	18	16	.426

\* This span depth ratio is greater than 16 to 1 in order to give clearance between moving head and specimen supports.

4.6.4.2 **Procedure.** - The breadth and depth of the specimens shall be measured to the nearest 0.001 inch. The span length shall be measured to the nearest 0.01 inch. No modulus data need be taken. Care shall be taken that the specimens are centered properly in the jig prior to being tested.



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4.6.4.3 Calculations. - The maximum fiber stress shall be calculated as follows:

$$\text{Maximum fiber stress} = \frac{3PL}{2bd^2}$$

where:

- P = breaking load in pounds.  
 L = the span in inches.  
 b = breadth of specimen in inches.  
 d = depth of specimen in inches.

4.6.5 Bonding strength. -

4.6.5.1 Specimens. - Specimens shall be 1 by 1 by 1/2 inch in size. Specimens from sheets over 1/2-inch nominal thickness shall be formed by machining down both surfaces.

4.6.5.2 Procedure. - The thickness of the specimens shall be recorded. The test machine shall be fitted with a head containing a steel ball 10 millimeters in diameter. After the specimen has been conditioned, it shall be placed on edge and centered accurately beneath the steel ball so that the load is applied in the lengthwise direction of the specimen. The load shall be applied to the specimen until failure occurs. The speed of the test shall be 0.050 inch per minute.

4.6.5.3 Report. - The bonding strength shall be reported in pounds.

4.6.6 Water absorption. -

4.6.6.1 Specimens. - The specimens shall be 3 inches by 1 inch by thickness.

4.6.6.2 Procedure. - The specimens shall be weighed individually and then subjected to 105° C. for 1 hour, cooled in a desiccator for at least 2 hours, and reweighed (W<sub>1</sub>). The specimens shall then be immersed in distilled water for 24 hours at 23° C. They shall be removed individually as needed, all surfaces wiped off with a damp cloth, and then reweighed immediately (W<sub>2</sub>). The test shall begin not more than 1 minute after removal of the specimens from the water and shall be completed as rapidly as consistent with accuracy. Specimens 1/16 inch or less in thickness shall be placed in a weighing bottle immediately after wiping and shall be weighed in the bottle. No correction shall be made for water-soluble matter.

4.6.6.3 Calculations. - The percentage of water absorption shall be calculated as follows:

$$\text{Percentage of water absorption in 24 hours} = \frac{W_2 - W_1}{W_1} \times 100$$

4.6.7 Dielectric constant and dissipation factor (at 1 megacycle). -

4.6.7.1 Specimens. - The specimens for dielectric constant and dissipation factor tests at 1 megacycle frequency, perpendicular to laminations, shall be 4-inch-diameter disks for 4-inch squares cut from sheets 1/8 inch in thickness.

4.6.7.2 Procedure. - After the conditioning of the specimens, the electrical measurements shall be made by using a suitable bridge method, a twin-T impedance-measuring circuit, or a resonant-circuit substitution method. The method used shall have an accuracy of determination of dielectric constant of  $\pm 5$  percent and an accuracy of determination of dissipation factor of  $\pm 5$  percent but in no case closer than 0.0001. The specimens shall have been covered on both sides with metal foil using a thin layer of petroleum as an adhesive or with conductive silver paint electrodes. The dissipation factor shall be directly computed from the instrument readings and shall be considered nominally equivalent to the power factor.

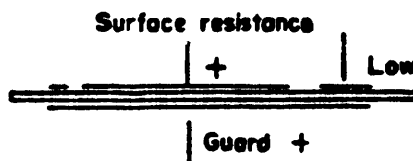
Note. - For a complete discussion of theory, apparatus, electrodes, and calculations refer to ASTM D-150.

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4.6.8 Surface resistance. -

4.6.8.1 Specimens. - The specimens for volume-resistivity and surface-resistance tests shall be 4 inches by 4 inches by thickness.

4.4.8.2 Procedure. - The test electrodes shall be made of silver paint sprayed or brushed on the surfaces of the specimen. The upper electrode shall be in the shape of a circle 2 inches in diameter. A guard ring 1/4 inch wide shall be located concentrically with respect to the upper electrode and shall be spaced 1/4 inch from it. The bottom electrode shall be in the shape of a circle 3 inches in diameter. The centers of the upper and lower electrodes shall be centered as accurately as possible so that they are on the same axis. The potentials applied shall be as follows:



The surface resistance shall be measured by means of a 500-volt megohm bridge exactly 1 minute after the current is applied. Tests following the humidity conditioning shall be made on specimens in the humidity chamber. Surface resistance shall be reported in megohms.

4.6.9 Warp and twist. - The warp and twist test shall conform to method 6051 of Specification L-P-406 (see 3.2.5).

4.7 Sampling and examination of packaging, packing and marking. - Sample packs shall be selected from each lot in accordance with Standard MIL-STD-105 at inspection level I and inspected to verify conformance to the requirements of 5.1, 5.2, and 5.3, as specified (see 6.2). The acceptable quality level shall be 4.0 percent.

## 5. PREPARATION FOR DELIVERY

5.1 Packaging. - Packaging shall be level A or C as specified (see 6.2).

5.1.1 Level A. - The sheets shall be wrapped individually or interleaved with kraft paper to protect sheets from abrasion. Kraft paper used shall weigh not less than 30 pounds for a 500-sheet ream of 24-inch by 36-inch sheets.

5.1.2 Level C. - Preservation and packaging shall be sufficient to afford adequate protection against physical damage during shipment from the supply source to the first receiving activity for early use. This level may conform to the supply commercial practice when such meets the requirements of this level.

5.2 Packing. - Packing shall be level A or C as specified (see 6.1).

5.2.1 Level A. - The sheets packaged as specified (see 6.1), shall be packed in boxes conforming to any of the following specifications at the option of the supplier:

<u>Applicable specification</u>	<u>Type or class</u>
PPP-B-576	Class 2
PPP-B-585	Class 3 use
PPP-B-591	Overseas type
PPP-B-601	Overseas type
PPP-B-621	Class 2
PPP-B-636	Class 2

Shipping containers shall have caseliners conforming to Specification MIL-L-10547, type I or II, grade A, B, or C, class 2. Caseliners shall be closed and sealed in accordance with the appendix to Specification MIL-L-10547. Caseliners may be omitted from fiber boxes conforming to Specification PPP-B-636

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provided all corner and edge seams and manufacturer's joints are sealed with minimum 2-inch wide pressure sensitive tape conforming to Specification PPP-T-76. Box closure strapping or banding shall be as specified in the applicable box specification or appendix thereto. The gross weight of shipping containers shall not exceed the weight limitations of the applicable box specification for fiberboard boxes or 200 pounds for wood or wood-crested boxes unless the weight of a single sheet exceeds this limit in which case only one sheet shall be packed in a container.

5.2.2 Level B. - The sheets, packaged as specified (see 6.1), shall be packed in boxes conforming to any of the following specifications at the option of the supplier:

<u>Applicable specification</u>	<u>Type or class</u>
PPP-B-576	Class 1
PPP-B-585	Class 1 or 2 use
PPP-B-591	Domestic type
PPP-B-601	Domestic type
PPP-B-621	Class 1
PPP-B-636	Class 1

Box closure shall be as specified in the applicable box specification or appendix thereto. The gross weight of shipping containers shall not exceed the weight limitations of the applicable box specification for fiberboard boxes or 200-pounds for wood or wood-crested boxes, unless the weight of a single sheet exceeds this limit, in which case only one sheet shall be packed in a container.

5.2.3 Level C. - The sheets, packaged as specified (see 6.1), shall be packed in a manner which will insure carrier acceptance and safe delivery at destination. Shipping containers or method of packing shall comply with the Uniform Freight Classification Rules or other carrier regulations as applicable to the mode of transportation.

5.3 Marking. - In addition to any special marking required by the contract or order, interior packages and exterior shipping containers shall be marked in accordance with Standard MIL-STD-129.

## 6. NOTES

6.1 Ordering data. - Procurement documents should specify the following:

- Title, number, and date of this specification.
- Type, sheet size and thickness required (see 1.2 and 3.3).
- Whether sheets, smaller in dimension than specified in the procurement document due to cutting specimens for lot acceptance tests are acceptable (see 3.3.1).
- Applicable level of packaging and packing required (see 5.1 and 5.2).

6.2 Fabricated parts or equipment. - Requirements applicable to fabricated parts or equipment incorporating cotton fabric base, phenolic resin laminated material should be specified in separate specifications or as part of contracts or orders.

6.3 Engineering information. - Table XIV gives engineering information for properties of the material covered by this specification. This information will not be used for approval action nor for acceptance or rejection of lots under this specification.

6.4 Cross-reference list of designations. - Because of the past practices of the several Government agencies and industry, the following is provided as a cross-reference for equivalent designation of laminates:

Type PGB: LTS-E-2, and XX.  
 Type PBE: LTS-E-4, and XXX.  
 Type PBE-P: LTS-E-5, and XXXP  
 Type FBM: LTS-M-4, and C.  
 Type FBL: LTS-M-3, and L.  
 Type FBG: LTS-EM-1, and CE.  
 Type FBE: LTS-EM-2, and LE.

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Table XIV—Engineering Information for properties of cotton-fabric-base, phenolic-resin, laminated materials.

Property	Condition	Unit of value	Average value or range				Test procedure
			Type FBM	Type FBG	Type FBE	Type FBI	
Specific gravity . . .	A . . . . .	. . . . .	1.30-1.39	1.30-1.36	1.31-1.36	1.29-1.36	Method 5011 of Specification L-P-406.
Tensile strength: length direction . . cross direction . .	A . . . . .	P.s.i. . .	{ 8,660-17,600 5,930-13,000	7,890-18,700 6,660-15,300	10,400-20,900 7,210-17,300	9,520-18,300 7,580-13,800	Method 1011 of Specification L-P-406.
Compressive strength: flatwise . . . . . edge wise . . . . .	A . . . . .	P.s.i. . .	{ 35,000 19,600-29,700	35,000 21,000-26,900	35,000 22,300-28,900	36,000 18,300-27,900	Method 1022 of Specification L-P-406.
Flexural strength, flatwise: length direction . . cross direction . .	A . . . . .	P.s.i. . .	{ 14,400-29,965 14,400-24,900	15,300-29,300 12,600-25,300	13,500-30,405 12,000-21,800	13,500-30,300 12,600-22,300	Method 1031 of Specification L-P-406.
Izod impact strength: flatwise . . . . . edge wise . . . . .	E-48/50 . .	{ Ft. lb. per inch notch	{ 3.66-6.65 2.04-4.02	2.77-5.94 1.49-2.73	1.75-4.52 1.03-2.3	2.12-6.26 1.10-2.79	Method 1071 of Specification L-P-406.
Shear strength . . . .	A . . . . .	P.s.i. . .	11,000-15,000	11,000-15,000	11,000-15,000	11,000-15,000	Method 1041 of Specification L-P-406.
Modulus of elasticity in flexure, flatwise	A . . . . .	P.s.i. . .	(1.0-1.9) x 10 <sup>6</sup>	(1.0-1.8) x 10 <sup>6</sup>	(1.0-1.8) x 10 <sup>6</sup>	(1.0-1.8) x 10 <sup>6</sup>	Method 1031 of Specification L-P-406.
Hardness, Rockwell M . . . . .	A . . . . .	. . . . .	70-107	84-111	88-117	89-114	Method 1061 of Specification L-P-406.
Water absorption: 1/16-inch thickness 1/8-inch thickness 1/2-inch thickness	E-1/106, followed by D <sub>1</sub> -24/23	Percent	{ 0.98-4.4 0.7 -2.1 0.4 -1.2	0.865-2.15 0.6 -1.6 0.316-0.70	0.7 -1.95 0.49-1.30 0.25-0.67	1.04 -2.50 0.68 -1.60 0.323-0.90	See 4.6.6

Table XIV—Engineering information for properties of cotton-fabric-base, phenolic-resin, laminated materials. (Cont'd)

Property	Condition	Unit of value	Average value or range				Test procedure
			Type FBM	Type FBG	Type FEE	Type FBI	
Dielectric breakdown parallel to laminations, step-by-step test	{ A..... D-48/50 }	{ kv ..... }	{ 20-96 2.3-17 }	36.3-89 2.5-19	42.0-100 3.0-90	17-100 2.0-9.5	{ See 4.6.2 }
Dielectric strength perpendicular to laminations, step-by-step test (-1/8 inch thickness)	A.....	Volts per mil	170-470	282-643	304-701	207-312	{ See ASTM D229 - except voltage ap- plied as in 4.6.2.2 and electrodes 3/4 inch in diameter 1 inch long used when more than 50 kv. required for punc- ture. Sample size is 6 by 6 inches by thickness. }
Dielectric constant at 1 megacycle, -1/8 inch thickness	{ E-96/50 D-24/23 }	{ ..... }	.....	.....	{ 5.1-4.8 5.9-5.0 }	{ ..... }	{ See 4.6.7 }
Power factor at 1 megacycle 1/8-inch thickness	{ E-96/50 D-24/23 }	{ ..... }	.....	.....	{ 0.06-0.03 0.07-0.03 }	{ ..... }	{ See 4.6.7 }
Insulation resistance	{ E-96/50 D1-96/50 C-96/35/90 }	{ Meg... }	{ 81,000-656,000 0.5-131 0.8-48 }	46,500-538,000 1.25-2.56 1.0-108	50,000-583,000 2.10-12.4 3.5-1,074	43,000-650,000 1.50-26.5 0.34-10.3	{ See ASTM D257 - using tapered pin electrodes. Sample size is 2 by 3 inches by thickness }
Bonding strength	{ A..... D-48/50 }	{ Lb... }	{ 1,985-2,890 1,600-2,440 }	1,850-2,840 1,780-2,530	1,770-2,420 1,620-2,320	1,700-2,340 1,500-2,220	{ See 4.6.5 }
Arc resistance	A.....	Seconds	Less than 15	Less than 15	Less than 15	Less than 15	Method 4011 of Specification L-P-406.

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Table XIV--Engineering Information for properties of cotton-fabric-base, phenolic-resin, laminated materials. (Cont'd)

Property	Condition	Unit of value	Average value or range				Test procedure
			Type FBM	Type FBG	Type FBE	Type FBI	
Flame resistance:							
Ignition time . . . . .		Seconds	92-150	92-150	92-150	92-150	
Burning time . . . . .			260-440	260-440	260-440	260-440	
Flexural strength . . . . .	A. . . . .	Percent	0	0	0	0	Method 2023 of Specification L-P-406.
Remaining after burning							
Toxicity when burned:		ML of gas					
Carbon monoxide . . . . .			74-163	74-163	74-163	74-163	
Cyanides . . . . .			2.5-3.1	2.5-3.1	2.5-3.1	2.5-3.1	
Ammonia . . . . .			6.6-8.8	6.6-8.8	6.6-8.8	6.6-8.8	See Bureau of Mines Report of Investigations R. I. 4134: dated October 1947. (Sample size 1/2 by 1/2 by 5 inches)

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6.5 Certain provisions of this specification are the subject of international standardization agreements (ABC-NAVY-STD-17). When amendment, revision or cancellation of this specification is proposed, the departmental custodians will inform their respective Departmental Standardization Offices so that appropriate action may be taken respecting the International agreement concerned.

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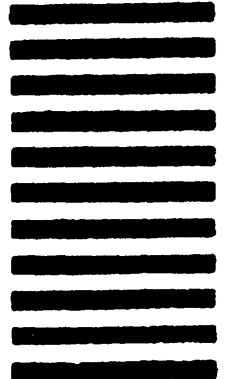
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