

MIL-P-18177C

25 MAY 1960

SUPERSEDING

MIL-P-18177B

31 MARCH 1960

MILITARY SPECIFICATION

PLASTIC SHEET, LAMINATED, THERMOSETTING, GLASS FIBER BASE, EPOXY-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 glass cloth, or oriented nonwoven parallel aligned glass fibers, epoxy-resin, plastic thermosetting sheet material primarily for electrical insulating purposes.

1.2 Classification. Laminated thermosetting sheets shall be of the following types, as specified (see 6.2):

Type GEE — General purpose type.

Type GEB — High temperature type.

2. APPLICABLE DOCUMENTS

2.1 The following specifications and standards, 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-585 — Boxes; Wood, Wire-bound.

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, Fiber.

PPP-T-76 — Tape, Pressure-Sensitive, Adhesive, Paper, Water Resistant.

PPP-T-97 — Tape, Pressure-Sensitive, Filament Reinforced.

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MIL-B-10377 — Boxes: Wood-Cleated, Veneer, Paper Overlaid.

MIL-L-10547 — Liners, Case, Waterproof.

STANDARDS

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MIL-STD-129 — Marking for Shipment and Storage.

FSC 9230

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(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.)

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

D150 — Methods of Tests for A-C Capacitance, Dielectric Constant, and Loss Characteristics, of Electrical Insulating Materials.

D229 — Method of Testing Sheet and Plate Materials Used for Electrical Insulation.

(Application for copies should be addressed to the American Society for Testing Materials, 1916 Race St., 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 St., New York 16, N. Y.)

3. REQUIREMENTS

3.1 Qualification. Glass fiber base, epoxy-resin thermosetting sheets furnished under this specification shall be a product which has been tested, and passed the qualification tests specified herein, and has been listed on or approved for listing on the applicable qualified products list.

3.2 Material

3.2.1 Construction. The material shall consist of plies or layers of glass cloth or nonwoven parallel aligned fibers properly impregnated and bonded with an epoxy-resin compound or binder, oriented and processed to conform to this specification.

3.2.2 Property values. The material shall conform to the property values shown in tables IV through IX as applicable. The values obtained for 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 and finish.

3.2.4 Surface defects. The material shall be free from blisters, wrinkles or cracks, and free from other small defects such as scratches, dents and heat marks to the degree that the usefulness of the sheet will not be affected. The material may contain streaks due to differential coloration of various warp or filler threads of the glass fabric or of filament of the nonwoven parallel aligned fibers.

3.2.5 Warp or twist. The warp or twist of material as delivered shall not exceed that shown in table I (see 4.7.9). Percentage of warp is given in terms of the lateral dimensions (length and width) of the material and 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 ¹
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 1/2	0.50

¹ These values do not apply to cut pieces but only to sheet size as manufactured. For any standard sheet size other than 36 inches, use the following formula:

$$\frac{D_1}{D_{36}} = \frac{L_1}{(36)^2}$$

Where:

D₁ = Permissible deviation from straight edge in inches for the given length.

D₃₆ = Permissible deviation in inches for 36 inch length.

L₁ = The given length in inches.

3.3 Dimensions and tolerances.

3.3.1 *Length and width.* Unless otherwise specified by the bureau or activity concerned, the manufacturer's standard sizes between 24 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 stand-

ard size. Nonuniform standard sheet dimensions caused by cutting specimens for test required by this specification shall not be cause for rejection, unless particular dimensions are specified. When particular sheet dimensions are specified (see 6.2), the permissible variation 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, in inches (\pm)		
	6 inches and under	Over 6 to under 24 inches	24 inches and over
<i>Inch</i>			
Up to $\frac{1}{4}$ inclusive	0.010	0.015	$\frac{1}{32}$
$1\frac{1}{4}$ to $\frac{1}{2}$ inclusive .....	.012	.017	$\frac{1}{32}$

3.3.2 *Thickness.* Sheets shall be furnished in the nominal thicknesses shown in table III, as specified (see 6.2). 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.

3.4 *Machinability.* The material shall be such that it can be drilled, tapped, sawed, and machined in all directions¹ in accordance with the manufacturer's recommended technique without cracking, splitting, or otherwise impairing the material for general use.

3.5 *Surface finish.* Unless otherwise specified by the bureau or activity concerned, the surface finish of sheets shall be semi-gloss as produced by the laminating operation.

3.6 *Marking.* Each full-size sheet shall be legibly marked with the manufacturer's name or trademark, and the type. The method of marking shall be satisfactory to the bureau or activity concerned.

¹ The nature of laminated materials necessitates special precaution when drilling and tapping parallel to lamination.

TABLE III. Thicknesses^{1, 2}

Nominal thickness		Permissible variations in inch (\pm)
Inch	Decimal equivalent in inch	
$\frac{1}{32}$	0.031	0.0065
$\frac{3}{64}$	.047	.0075
$\frac{1}{16}$	.0625	.0075
$\frac{3}{32}$	.094	.009
$\frac{1}{8}$	.125	.012
$\frac{5}{32}$	.156	.015
$\frac{3}{16}$	.1875	.019
$\frac{7}{32}$	.219	.021
$\frac{1}{4}$	.250	.022
$\frac{5}{16}$	.3125	.026
$\frac{3}{8}$	.375	.030
$\frac{7}{16}$	.438	.033
$\frac{1}{2}$	.500	.036

¹ On sheets of nominal thickness not listed in this table, the permissible variations shall be the same as for the next greater thickness.

² Thicknesses less than $1/32$ inch may use glass cloth of thinner weave, or nonwoven parallel aligned fibers with a thinner web, but in no case shall the material consist of less than two plies of cloth or web. Permissible variations in thickness for sheets of approximately 0.007 to $1/32$ inch shall conform to best commercial practices.

3.7 *Workmanship.* The laminated materials shall be manufactured by such process or manner as to assure compliance with the requirements of this specification.

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4. QUALITY ASSURANCE PROVISIONS

4.1 The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. 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 Classification of tests. The methods of sampling, examination and tests shall be classified as follows:

- (a) Qualification tests.
- (b) Periodic control tests.
- (c) Acceptance inspection.

4.3 Qualification tests. Qualification tests shall be conducted at a laboratory satisfactory to the activity responsible for qualification (see 6.3). These tests shall consist of tests specified in tables IV and VII, as applicable.

4.4 Periodic control tests. Periodic control tests and sample thicknesses of material re-

quired for the tests shall be as shown in tables V and VIII, as applicable. These tests shall be conducted under the supervision of the Government inspector at a laboratory satisfactory to the activity responsible for qualification (see 6.3) at intervals of 2 years after qualification tests have been completed. The tests shall be conducted on samples selected by the Government inspector. The material for test shall be taken either from production runs or from material manufactured by techniques representative of production runs. The material remaining after test, if satisfactory, may be applied to the contract or order.

4.4.1 *Reports of tests.* Five copies of the periodic control test report shall be forwarded to the activity responsible for qualification (see 6.3) via the Government inspector, who shall certify that tests were conducted under his supervision and in accordance with the test procedures specified in this specification.

4.4.2 *Approval action on tests.* Upon receipt by the activity responsible for qualification (see 6.3) of the periodic control test report, action to maintain or withdraw the approval will be taken on the basis of the test results. If periodic control test results are not received by the activity responsible for the qualification at the expiration of the 2 year period, the approval will automatically be withdrawn, and the product removed from the Qualified Products List.

TABLE IV. Qualification tests for type GEE

Property to be tested	Test paragraph	Number of specimens for each thickness	Tests per specimen	Conditioning (see 4.6)	Unit of value	Values required for each sample thickness		
						1/8 inch	1/4 inch	1/2 inch
Dielectric breakdown parallel to laminations, step-by-step test	4.7.2	11	1	A D-48/50	Minimum kv.	35.0	35.0	35.0
		14	1			30.0	30.0	30.0
		11	1					
		14	1					
Impact strength, tested edgewise: Cut lengthwise Cut crosswise	4.7.3	4	1	E-48/50	Minimum ft.-lbs. per inch	(*)	7.0	7.0
		4	1			(*)	5.5	5.5
Flexural strength, tested flatwise: Cut lengthwise Cut crosswise	4.7.4	4	1	A	Minimum p.s.i.	55,000	50,000	45,000
		4	1			45,000	40,000	35,000
		4	1			(*)	(*)	2,000
Rolling strength	4.7.5	4	1	A D-48/50	Minimum lbs.	(*)	(*)	1,600
		4	1			(*)	(*)	0.10
Water absorption	4.7.6	4	1	Precondition at E-1/106; condition at D ₁ -24/25	Maximum percent	0.35		
Dielectric constant at 1 megacycle	4.7.7	4	1	D-48/50	Maximum	(*)	5.8	(*)
		4	1			(*)	0.045	(*)
Dissipation factor at 1 megacycle	4.7.7	4	1	D-48/50	Maximum	(*)	100,000	(*)
		4	1			(*)		
Volume resistivity	4.7.8	4	1	C-08/35/90	Minimum meg.-cm.	(*)		
Surface resistance	4.7.8	4	1	C-08/35/90	Minimum meg.	(*)	1,000	(*)

* First time.
 * Step-by-step.
 * Not required.

TABLE V. Periodic control tests for type GSE

Property to be tested	Test paragraph	Number of specimens for each thickness	Tests per specimen	Conditioning (see 4.6)	Units of value	Values required for each sample thickness		
						1/4 inch	1/8 inch	1/16 inch
Dielectric breakdown parallel to laminations, step-by-step test	4.7.3	1	1	A	Minimum kv.	35.0	35.0	35.0
		4	1			45,000	50,000	45,000
Flexural strength, tested flatwise: Cut lengthwise	4.7.4	4	1	A	Minimum p.s.i.	55,000	50,000	45,000
		4	1			45,000	40,000	35,000
Cut crosswise	4.7.5	4	1	A	Minimum lbs.	(*)	(*)	2,000
		4	1			0.35	0.30	0.10
Bonding strength	4.7.6	4	1	Precondition at E-1/105; condition at D ₁ 24/23	Maximum percent	0.35	0.30	0.10
Water absorption						0.35	0.30	0.10

* Short time.
 * Step-by-step.
 * Not required.

TABLE VI. Lot-acceptance tests for type GEE

Property to be tested	Test paragraph	Number of specimens for each sample	Tests per specimen	Conditioning (see 4.6)	Unit of value	Values required for each sample thickness range ¹ (inches)								
						0.001 to 0.004	0.004 to 0.008	0.008 to 0.015	0.015 to 0.025	0.025 to 0.035	0.035 to 0.050	0.050 to 0.075	0.075 to 0.100	0.100 to 0.150
Dielectric breakdown parallel to laminations, step-by-step test	4.7.2	11	1	A	Minimum k.v.	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
		14												
Flexural strength, tested flatwise: Cut lengthwise Cut crosswise	4.7.4	4	1	A	Minimum p.s.i.	55,000	55,000	50,000	50,000	50,000	45,000	45,000	45,000	45,000
		4	1			45,000	45,000	40,000	40,000	40,000	35,000	35,000	35,000	35,000
Bonding strength	4.7.5	4	1	A	Minimum lbs.	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	2,000

¹ Short time.
² Step-by-step.
³ These ranges are for nominal thicknesses, subject to the tolerances specified in table III.
⁴ Not required.

TABLE VII. Qualification tests for type GRB

Property to be tested	Test paragraph	Number of specimens for each thickness	Tests per specimen	Conditioning (see 4.6)	Units of value	Yields required for each sample thickness		
						1/8 inch	1/16 inch	1/32 inch
Dielectric breakdown parallel to laminations, step-by-step test	4.7.3	1 1	1	A D-48/50	Minimum kv.	35.0	35.0	35.0
		3 4	1			30.0	30.0	30.0
Impact strength, tested edgewise: Cut lengthwise Cut crosswise	4.7.8	4 4	1 1	E-48/50	Minimum ft.-lbs. per inch	(*) (*)	7.0	7.0
		4 4	1 1			(*) (*)	5.5	5.5
Flexural strength, tested flatwise: Cut lengthwise Cut crosswise	4.7.4	4 4	1 1	A	Minimum p.s.i.	55,000	50,000	45,000
		4 4	1 1			45,000	40,000	35,000
Bonding strength	4.7.5	4 4	1 1	A D-48/50	Minimum lbs.	(*) (*)	(*) (*)	1,500
		4 4	1 1			(*) (*)	(*) (*)	1,500
Water absorption	4.7.6	4 4	1 1	Precondition at E-1/105; condition at D,-30/23	Maximum percent	0.38	0.30	0.20
		4 4	1 1			0.38	0.30	0.20
Dielectric constant at 1 megacycle	4.7.7	4 4	1 1	D-48/50	Maximum	(*) (*)	8.8	(*) (*)
		4 4	1 1			(*) (*)	9.045	(*) (*)
Dissipation factor at 1 megacycle	4.7.7	4 4	1 1	D-48/50	Maximum	(*) (*)	0.045	(*) (*)
		4 4	1 1			(*) (*)	0.045	(*) (*)
Volume resistivity	4.7.8	4 4	1 1	C-96/85/90	Minimum meg.-cm.	(*) (*)	100,000	(*) (*)
		4 4	1 1			(*) (*)	100,000	(*) (*)
Surface resistance	4.7.8	4 4	1 1	C-96/85/90	Minimum meg.	(*) (*)	1,000	(*) (*)
		4 4	1 1			(*) (*)	1,000	(*) (*)
Heat resistance: Cut lengthwise	4.7.10	4 4	1 1	E-1/160	Percent flexural strength retained (minimum)	(*) (*)	50	(*) (*)
		4 4	1 1			(*) (*)	50	(*) (*)

1 Short time.
 * Step-by-step.
 * Not required.

TABLE VIII. Periodic control tests for type GEB

Property to be tested	Test paragraph	Number of specimens for each thickness	Tests per specimen	Conditioning (see 4.6)	Unit of value	Values required for each sample thickness		
						1/8 inch	1/16 inch	1/32 inch
Dielectric breakdown parallel to laminations, step-by-step test	4.7.3	11	1	A	Minimum kv.	85.0	115.0	155.0
		14	1					
Flexural strength, tested flatwise: Cut lengthwise Cut crosswise	4.7.4	4	1	A	Minimum p.s.i.	55,000	50,000	45,000
		4	1			45,000	40,000	35,000
		4	1			(*)	(*)	1,500
Bonding strength	4.7.5	4	1	A	Minimum lbs.	(*)	(*)	(*)
Water absorption	4.7.6	4	1	Precondition at E-1/105; condition at D ₁ -34/23	Maximum percent	0.55	0.30	0.10
Heat resistance: Cut lengthwise	4.7.10	4	1	E-1/150	Percent flexural strength retained (minimum)	(*)	50	(*)

* Short time.
 † Step-by-step.
 ‡ Not required.

TABLE IX. Lot acceptance tests for type GFB

Property to be tested	Test paragraph	Number of specimens for each sample	Tests per specimen	Conditioning (see 4.8)	Unit of value	Values required for each sample thickness range ^a (inches)					
						0.031 to 0.044	0.044 to 0.057	0.057 to 0.125	0.125 to 0.250	0.250 to 0.400	0.400 to 0.600
Dielectric breakdown parallel to laminations, step-by-step test	4.7.2	1	1	A	Minimum kv.	35.0	35.0	35.0	35.0	35.0	35.0
		4	4			55,000	65,000	50,000	50,000	45,000	45,000
Flexural strength, tested likewise: Cut lengthwise Cut crosswise	4.7.4	4	1	A	Minimum p.s.i.	45,000	45,000	40,000	40,000	35,000	35,000
		4	1			(*)	(*)	(*)	(*)	(*)	(*)
Bonding strength	4.7.5	4	1	A	Minimum lbs.	(*)	(*)	(*)	(*)	(*)	3,600
Heat resistance: Cut lengthwise	4.7.10	4	1	E-1/150	Percent flexural strength retained (minimum)	(*)	(*)	50	(*)	(*)	(*)
						(*)	(*)	(*)	(*)	(*)	(*)

^a Short time.
^b Step-by-step.
 * These ranges are for nominal thicknesses, subject to the tolerances specified in table III.
 † Not required.

5 Inspection.

4.5.1 Lot acceptance examination. Each sheet of every lot shall be subjected to examination to determine compliance with section 3, except 3.1 and 3.2.2. Conformance with 3.2.1, 3.2.3, 3.2.4, 3.4, 3.5, 3.6 and 3.7 shall be determined by visual examination. Conformance with 3.2.5 shall be determined as specified in 4.7.9. Conformance with 3.3.1 shall be determined by means of a steel scale. Conformance with 3.3.2 shall be determined as specified in the American Society for Testing Materials Publication D229. If any of the sheets fails to conform to any of these requirements, such sheet shall be rejected.

4.5.2 Lot acceptance tests.

4.5.2.1 Lot acceptance tests shall be conducted on material selected from production lots offered under one or several contracts or orders.

4.5.2.2 A production lot shall consist of all sheets of the same type of a given machine run and of a particular thickness range as shown in tables VI and IX, as applicable, and offered for inspection at one time. (For instance, sheets of $1/16$ and $3/32$ inch thicknesses fall within one thickness range (0.032 to 0.094) and may be included in one production lot). A machine run shall consist of all of the material pressed from a coating operation in which the basic resin and filler and treating conditions are the same.

4.5.2.3 Sampling. Sample sheets shall be selected in accordance with table X and the required number of specimens shall be cut from each sample sheet as specified in table VI and IX, as applicable. All of the tests of tables VI and IX, as applicable, shall be performed on each specimen and the results on the specimens averaged for each sheet and compared with the requirements to determine conformance (see 6.2).

TABLE X. Sampling for lot acceptance tests

Lot size (sheets)	Sample (sheets)
15 and under	1
16 to 25	2
26 and over	3

4.5.2.4 Acceptance or rejection of lots. If any of the sample sheets tested fail any of the tests shown in tables VI and IX, as applicable, the entire lot shall be rejected.

4.6 Conditioning.

4.6.1 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, a prior temperature conditioning has been carried out.

4.6.2 Designation. Conditioning procedures shall be designated as follows:

- (a) A capital letter indicating the general condition of the specimen, that is, 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 whenever relative humidity is controlled.

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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 condi-

tion, 48 hours in distilled water at 50°C.

Condition E-48/50—Temperature condition, 48 hours at 50°C.

4.6.3 *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 XI.

TABLE XI. Conditioning time tolerances

Conditioning		Cooling		Comments
Condition	Time tolerance	Time	Time tolerance	
E-48/50	-0 hours +2 hours	16 hours or more	-0 hours	Cool in desiccator. Start test within ¼ hour after removing specimen from desiccator.
D-48/50 D-24/23	-0 hours +½ 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-1/105	-0 minutes +6 minutes	2 hours or more	-0 hours	See water-absorption test (see 4.7.6).
D ₁ -24/23	-0 hours +2 hours	.....	.....	See water-absorption test (see 4.7.6).
C-96/35/90	-0 hours +2 hours	.....	.....	Tests after humidity conditioning shall be made on specimens in the humidity chamber (see 4.7.8).

4.6.4 *Temperature tolerances.* The conditioning temperature tolerances shall be as follows:

Nominal temperature Degrees C.	Tolerance (±) Degrees C.
23	2
35	1
50	2
105	2

4.6.5 *Humidity tolerance.* Tolerance on the nominal relative humidity of 90 percent shall be ± 2 percent.

4.7 Test methods.

4.7.1 *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.

4.7.2 *Dielectric breakdown parallel to laminations (step-by-step).*

4.7.2.1 *Specimens.* The test specimens shall be 2 by 3 inches by the thickness of the sheet.

American standard tapered pins having a taper of $\frac{1}{4}$ per inch per foot shall be used. For test specimens having a thickness up to $\frac{1}{2}$ inch, inclusive, number 3 American standard tapered pins¹ 3 inches long and having a diameter at the large end of $\frac{3}{16}$ inch shall be used. Drill two $\frac{3}{16}$ -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 $1\frac{1}{2}$ inches from the small end of the hole. The electrodes shall be inserted after the conditioning of the test specimen. Spheres having a $\frac{1}{2}$ -inch diameter, when paced on the extremities of the tapered pins, will decrease the tendency to flashover.

4.7.2.2 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 uniform 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, determined as specified above, 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	Increase of increment in step-by-step method
Kilovolts	Kilovolts
12.5 or less	0.5
Over 12.5 to 25, inclusive	1.0
Over 25 to 50, inclusive.	2.5
Over 50 to 100, inclusive	5.0

¹ For information on tapered pins, see Kents Mechanical Engineers Handbook, 12th Edition, Design and Production, page 15-16. (This handbook may be obtained from John Wiley & Sons, Inc., 440-4th Ave., New York 16, N. Y.)

4.7.2.3 Report. The breakdown voltage shall be reported in kilowatts and the time

required to break each specimen shall be reported in seconds.

4.7.3 Impact strength (tested edgewise).

4.7.3.1 Specimens. Specimens of sheets in thicknesses of $\frac{1}{8}$ to $\frac{1}{2}$ inch, inclusive, shall be tested in sizes $2\frac{1}{2}$ inches by $\frac{1}{2}$ 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 ± 0.005 inch with a curvature at the bottom of the notch of 0.010 ± 0.002 inch radius. Different sets of specimens shall be cut lengthwise and crosswise of the sheet.

4.7.3.2 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 centerline 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.

4.7.3.3 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 specimens and the pendulum's initial energy, and shall be expressed in foot-pounds per inch of notch.

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4.7.4.1 *Specimens.* Specimens of sheet in thicknesses of $\frac{1}{32}$ to $\frac{1}{2}$ inch, 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 XII shall be used. Different sets of specimens shall be cut lengthwise and crosswise of the sheet.

TABLE XII. Dimensions of specimen and speed of test

Nominal specimen thickness	Width of specimen	Length of specimen	Span	Speed of test per minute
<i>Inch</i>	<i>Inch</i>	<i>Inches</i>	<i>Inches</i>	<i>Inch</i>
$\frac{1}{32}$	1	2 $\frac{1}{2}$	$\frac{1}{4}$	0.025
$\frac{1}{16}$	1	3	1	.026
$\frac{3}{32}$	1	3 $\frac{1}{2}$	1 $\frac{1}{2}$	.040
$\frac{1}{8}$	1	4	2	.053
$\frac{3}{16}$	$\frac{1}{2}$	5	3	.080
$\frac{1}{4}$	$\frac{3}{4}$	6	4	.106
$\frac{5}{16}$	$\frac{1}{2}$	8	6	.160
$\frac{1}{2}$	$\frac{1}{2}$	10	8	.213

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

4.7.4 *Flexural strength (tested flatwise).*

4.7.4.2 *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.

4.7.4.3 *Calculations.* The maximum fiber stress shall be calculated as follows:

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

Where:

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

4.7.5 *Bonding strength.*

4.7.5.1 *Specimens.* Specimens shall be 1 by 1 by $\frac{1}{2}$ inch in size.

4.7.5.2 *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.

4.7.5.3 *Report.* The bonding strength shall be reported in pounds.

4.7.6 *Water absorption.*

4.7.6.1 *Specimens.* The specimens shall be 3 inches by 1 inch by thickness.

4.7.6.2 *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_1). 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_2). 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 $\frac{1}{16}$ 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

the water-soluble matter.

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

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

4.7.7 Dielectric constant and dissipation factor (at 1 megacycle).

4.7.7.1 Specimens. The specimens for dielectric constant and dissipation factor tests at 1 megacycle frequency, perpendicular to laminations, shall be 4-inch diameter disks or 4-inch squares cut from sheets $\frac{1}{8}$ inch in thickness.

4.7.7.2 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 ± 5 percent and an accuracy of determination of dissipation factor of ± 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.

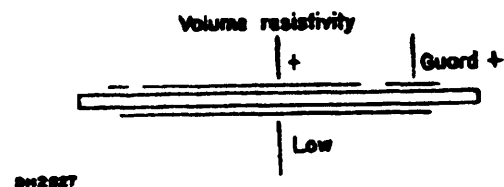
Note. For a complete discussion of theory, apparatus, electrodes, and calculation, refer to method D150 of ASTM Book Standards.

4.7.8 Volume resistivity and surface resistance.

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

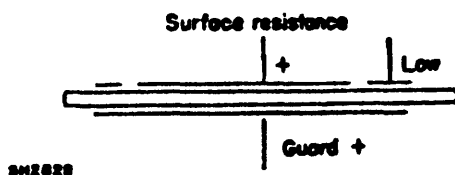
4.7.8.2 Procedure.

4.7.8.2.1 Volume resistivity. The test electrodes shall be made of conductive 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 $\frac{1}{4}$ inch wide shall be located concentrically with respect to the upper electrode and shall be spaced $\frac{1}{4}$ 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 volume 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.

4.7.8.2.2 Surface resistance. Surface resistance measurements shall be made on the same specimens as those used for volume resistivity. The test procedure shall be similar to that specified for volume resistivity, except that the potentials of the guard and bottom electrodes shall be interchanged 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.

4.7.8.3 *Calculations.* The volume resistivity shall be calculated as follows:

$$r = \frac{RA}{L}$$

Where:

r = volume resistivity in megohm-centimeters.

R = measured volume resistance in megohms.

A = area of guarded electrode in square centimeters.

L = average thickness of specimen in centimeters.

Surface resistance shall be reported in megohms.

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

4.7.10 *Heat resistance (type GEB only).* The method shall be the same as specified in 4.7.4 except that:

- (a) Specimens cut lengthwise of type GEB shall be given an additional conditioning of 1 hour at $150^{\circ} \pm 2^{\circ}\text{C}$. and then be tested at $150^{\circ} \pm 2^{\circ}\text{C}$.

The average of four such determinations divided by the average flexural strength cut

lengthwise determined as specified in 4.7.4 shall be multiplied by 100 and recorded as percent flexural strength retained.

5. PREPARATION FOR DELIVERY

5.1 Packaging.

5.1.1 *Level A.* The laminated plastic sheets shall be wrapped individually or interleaved, to protect sheets from abrasion, using not less than 25-pound basis weight kraft paper.

5.1.2 *Level C.* The laminated plastic sheets shall be packaged in accordance with the manufacturer's practice.

5.2 Packing.

5.2.1 *Level A.* Laminated plastic sheets, packaged as specified (see 6.2) shall be packed in overseas type, wood cleated fiberboard, nailed wood, wirebound, wood, corrugated or solid fiberboard, wood cleated veneer paper overlaid, or wood cleated plywood boxes conforming to Specification PPP-B-591, PPP-B-621, PPP-B-585, PPP-B-636 (class 3), MIL-B-10377, or PPP-B-601, respectively, at the option of the contractor. Shipping containers shall have case liners conforming to Specification MIL-L-10547. Case liners shall be closed and sealed in accordance with the appendix to Specification MIL-L-10547. Case liners for boxes conforming to Specification PPP-B-636 may be omitted provided all corners and edge seams and manufacturers joints of the boxes are sealed with a minimum of $1\frac{1}{2}$ inches width of pressure sensitive tape conforming to Specification PPP-T-76. Box closures shall be as specified in the applicable box specification or appendix thereto, except fiber boxes may be banded with tape conforming to type IV of Specification PPP-T-97 and the appendix thereto. The gross weight of wood boxes shall not exceed 200 pounds; fiberboard boxes shall not exceed the weight limitations of the applicable box specification.

5.2.2 *Level B.* Laminated plastic sheets, packaged as specified (see 6.2) shall be packed in domestic type wood cleated fiberboard, nailed wood, wirebound wood cleated plywood or wood cleated veneer paper overlaid boxes of class 2 fiber boxes conforming to Specification PPP-B-591, PPP-B-621, PPP-B-585, PPP-B-601, MIL-B-10377 or PPP-B-636, respectively, at the option of the contractor. Box closures shall be as specified in the applicable box specification or appendix thereto, except strapping of class 2 of Specification PPP-B-636 fiber boxes shall not be required. The gross weight of wood boxes shall not exceed 200 pounds; fiberboard boxes shall not exceed the weight limitations of the applicable box specification.

5.2.3 *Level C.* Laminated plastic sheets, packaged as specified (see 6.2) shall be packed in containers which will insure acceptance by common carrier and safe delivery at destination. Shipping containers shall comply to the Uniform Freight Classification Rules or other regulations as applicable to the mode of transportation.

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

6. NOTES

6.1 Intended use.

6.1.1 *Type GEE.* Type GEE material is intended for use in electronics applications requiring moisture resistance and high mechanical strength. The material is not intended for applications requiring arc and flame resistance.

6.1.2 *Type GEB.* Type GEB material is intended for use in applications similar to those for type GEE with the additional requirement that class B (130°C. operating temperature) temperature is involved.

6.2 *Ordering data.* Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Type required (see 1.2).
- (c) Sheet size and thickness required (see 3.3).
- (d) Whether sheets, smaller in dimensions than specified in the procurement document due to cutting specimens for lot acceptance tests, are acceptable (see 4.5.2.3).
- (e) Selection of applicable levels of packaging and packing (see 5.1 and 5.2).
- (f) Special marking, if required (see 5.3).

6.3 With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for opening of bids, been tested and approved for inclusion in Qualified Products List QPL-18177, whether or not such products have actually been so listed by that date. The attention of suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government, tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified product list is the Chief of the Bureau of Ships, Department of the Navy, Washington 25, D.C. and information pertaining to qualification of products may be obtained from that activity.

6.4 *Fabricated parts or equipment.* Requirements applicable to fabricated parts or equipment incorporating glass fiber base epoxy-resin, laminated material should be specified in separate specifications or as part of contracts or orders.

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6.5 Certain provisions of this specification are the subject of international standardization agreement (ABC NAVY-STD-17A). 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.

Notice. When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government

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