AERONAUTICAL
MATERIAL SPECIFICATIONS

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AMS 3601A

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PLASTIC SHEET, COPPER FACED
Glass Fabric Reinforced Epoxy Resin

1. ACKNOWLEDGMENT: A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

2. APPLICATION: Primarily for use in etched, printed circuits used in electrical and electronic equipment where low moisture absorption and superior bond strength are required.

3. MATERIAL AND FABRICATION: The sheets shall be constructed of laminations of glass fabric thoroughly impregnated with an epoxy resin and properly cured. Face sheets of copper may be applied to one or both faces during the original cure of the laminate or in a subsequent operation.

4. TECHNICAL REQUIREMENTS:

4.1 General:

4.1.1 Color: Unless otherwise specified, the color of the plastic laminate shall be natural.

4.1.2 Copper Faces: The facing material shall be electrolytically deposited copper of not less than 99.50% purity.

4.2 Properties: Unless otherwise specified, the product shall conform to the following requirements; tests shall be performed on the product supplied and in accordance with listed ASTM methods, insofar as practicable. Specimens shall be conditioned Ø in accordance with ASTM D618-54, Procedure A, prior to testing. For specimens requiring removal of copper faces prior to testing, the conditioning shall be performed after such removal.

4.2.1	Flexural Strength, flatwise, min		
Ø	at 77 F, psi	50,000	ASTM D790-49T
	at 300 F, % of value at 77 F	50	(See Note 1)
4.2.2	Compressive Strength, edgewise, psi, min	30,000	ASTM D229-49 (See Note 1)
4.2.3	Water Absorption in 24 hr, %, max		ASTM D570-54T
	Nominal Thickness, in. (See Note 2)		(See Note 1)
	0.031	0.50	
Ø	0.062	0.30	
	0.125	0.18	

4.2.4	Dielectric Strength, when specified, perpendicular to laminations, step by step, v per mil, min		ASTM D149-55T (See Note 1)
	Nominal Thickness, in. (See Note 2)		
Ø	0.031	600	
Ø	0.062	500	
	0.125	425	
4.2.5	Dielectric Strength parallel to laminations, step by step, kv per in., min		ASTM D229-49, Tentative Revision June 1951, Section 27c
Ø	As received	45	(See Note 1)
	After 48 hr immersion in distilled water at 122 F ± 4	30	
Ø4.2.6	Dielectric Constant at 1 megacycle, max	5.2	ASTM D150-54T (See Note 1)
Ø4.2.7	Power Factor at 1 megacycle, max	0.020	ASTM D150-54T (See Note 1)
Ø4.2.8	Arc Resistance, sec	100	ASTM D495-56T
Ø4.2.9	Solder Bath Resistance	Pass	See Note 3
4.2.10	Bond Strength, lb per in. width, min		See Note 4
	Nominal Foil Thickness, in.		
	0.0014 As received	7	
	After solder float	7	
Ø	0.0028 As received	8	
	After solder float	8	
Ø4.2.11	Insulation Resistance, megohms, min	1000	See Note 5
Ø4.2.12	Solvent Resistance	Pass	See Note 6
Ø4.2.13	Heat Resistance	Pass	See Note 7
Ø4.2.14	Copper Porosity	Pass	See Note 8

Note 1. Removal of Copper: Prior to testing, specimens shall be immersed in vigorously aerated 40 deg Baumé ferric chloride solution at 75 - 100 F until unwanted
Ø copper is removed. Solution shall be renewed when time of removal exceeds 15 min. per 0.0014 in. thickness of copper. After removal of copper, specimens shall immediately be rinsed for 1 hr in running water at 60 - 90 F.

ØNote 2. For thicknesses not specified, use the value for the next lower thickness.

Note 3. Solder Bath Resistance: Three etched specimens 1 in. square by the thickness of the material shall be tested. The specimens shall be dipped in liquid flux (rosin in alcohol) and then floated on the surface of a bath of molten solder, with the copper face to be tested down. The solder shall be at a temperature of 490 F ± 10. After 20 sec, the specimen shall be removed from the solder bath and examined. The material shall not soften, split, blister, or delaminate. For material with copper on both sides, three specimens shall be tested for each side.

Note 4. Bond Strength: The strength of the bond between the copper foil and the base laminate shall be determined at 70 - 85 F in accordance with the following procedure on specimens as received and on specimens which have been floated on molten solder in accordance with Note 3. Etch four 1 x 4 specimens, two in the lengthwise direction and two in the crosswise direction, in accordance with Note 1. Grasp the test specimen, on each end, between the thumbs and forefingers and flex each side of the specimen 5 times. During flexing, the center of the specimen shall deflect at least 1/4 in. beyond the ends (flexing of specimens over 0.093 in. thick is not required). The copper foil shall be peeled back from one end of the specimen for approximately 2 in., with the line of peel perpendicular to the edge of the specimen. The specimen shall be supported in a horizontal plane with the peeled copper strip down between two solid supports adjusted to provide a 3/4 in. span. The end of the peeled strip shall then be clamped between two rubber-faced jaws. The jaws shall cover the full width of the strip and shall be clamped parallel to the line of peel. The load shall be applied to the gripping tab, starting with no load, at a uniform rate not to exceed 2 in. per minute. The direction of the load applied to the tab shall not deviate from the perpendicular by more than 5 degrees. The load required to produce separation of the copper foil from the base material shall be recorded as the bond strength. The full width of the strip shall peel, otherwise the results shall be discarded and the test repeated. For sheets that are copper faced on both sides, eight specimens shall be tested, four on each side.

An alternate method of test follows: The specimen shall be supported in a horizontal plane with the peeled copper strip down between two solid supports adjusted to provide a 3/4 in. span. The end of the peeled strip shall then be clamped between rubber-faced jaws to which is attached a light container. The total weight of the clamp and the container shall not exceed 1 pound. The jaws shall cover the full width of the strip and shall be clamped parallel to the line of peel. Sand (or equivalent) shall be poured into the container at a rate of approximately 2 lb per min. until the strip begins to peel, and the container shall then be weighed. The full width of the strip shall peel, otherwise the results shall be discarded and the test repeated. For sheets that are copper faced on both sides, eight specimens shall be tested, four on each side.

Note 5. Insulation Resistance:

(a) Test Specimens, Circuit: Three test specimens 2 in. x 2½ in. by the thickness of the material shall be made as shown in Figure 1, or be the equivalent.

(b) Test Specimen, Preparation: Apply suitable resist to each test panel and develop Figure 1 wiring pattern in accordance with best commercial practice. Remove unwanted copper in accordance with Note 1 except final rinse shall be for 15-20 minutes. Immediately remove iron salts by immersing the wet panel in 10% oxalic acid at room temperature for 5 - 10 min., with occasional agitation. Rinse panel for 1 hr in running water at 60 - 90 F and 15 - 20 min. in running water at 170 - 190 F. Dry for 2 - 2-1/2 hr in
Ø a forced circulating air oven maintained at 150 - 180 F and cool in a desiccator to room temperature and approximately 50% relative humidity. Drill necessary holes and solder lead wires into the holes using a pencil-type soldering iron or gun and water-white, unactivated rosin flux, filling the hole with a plug of solder. Remove excess flux and other contaminants by rinsing in a clean mixture of 90% ethanol and 10% distilled water by volume. Air dry. Care should be exercised to avoid touching critical areas of the clean specimen with bare hands.

(c) Insulation Resistance Measurement: Mount test specimens in a circulating-air humidity chamber (provided with suitable specimen lead wire insulators on the chamber) maintained at 92% + 2 RH and 149 F + 4 and expose for 18 hr ± 1. Lower the humidity to 87% ± 2 RH while holding the temperature constant and stabilize the specimens at this condition for 2 - 2-1/4 hours. Apply 500 v DC between terminal leads and maintain electrification time for 1 minute. Immediately thereafter, measure insulation resistance using a megohm bridge (General Radio Type 544B or equivalent). Measurements shall be performed while the RH is 87% ± 1.

Note 6. Solvent Resistance: A 1 x 6 in. specimen etched and rinsed in accordance with Note 1 and dried shall be trichlorethylene vapor degreased for 1/2 min., sprayed
Ø with recirculated degreaser solvent for 1-1/2 min., and examined. The base laminate and residual surface adhesive shall show no delamination, softening, blistering, or lifting.

Note 7. Heat Resistance: A 6 x 6 in. test specimen shall be supported vertically, on a non-metallic rack, in a horizontal-flow, air-circulating oven at 350 F ± 10 for
Ø 1/2 hour. The plane of the test specimen shall be parallel to the air flow. At the end of this period remove the specimen from the oven and immediately examine. There shall be no evidence of blistering.

Note 8. Copper Porosity: One half of a standard size sheet shall be vapor degreased and air dried. Lightly scrub the copper surfaces with a slurry of pumice and water, rinse thoroughly, and air dry. Handle board so that the copper surfaces are
Ø free of fingerprints, dust, etc. Examine in a dark room, using ultra-violet light, for fluorescent resin spots. There shall be not more than 3 resin spots, spaced no less than 1 in. apart, for each 18 x 18 in. area of copper. No resin spot shall have an included area greater than that of a 1/2 in. diameter circle.

5. QUALITY: The product shall be uniform in quality and condition and free from blisters, cracks, holes, cuts, wrinkles, delamination, unbonded areas, corrosion, excess bonding material, and other imperfections. Discoloration of the copper faces shall not be considered objectionable. The bonded copper faces shall be of such smoothness as to present no visible evidence of the underlying glass fabric weave.

6. SIZES AND TOLERANCES:

6.1 Length and Width: Shall not vary more than +1.0 in., -0 from that ordered except where test specimens have been removed; no more than 4 sq ft shall be cut from each thickness in a shipment for testing, and the size of the portion of material removed shall be stated on the outside of the package.

6.2 Thickness:

6.2.1 Copper face standard thicknesses and tolerances shall be as follows:

Nominal Thickness Inch	Tolerance, Inch	
	Plus	Minus
0.0014	0.0004	0.0002
0.0028	0.0007	0.0003

6.2.2 Sheet Thickness: The total thickness of the finished sheet, including copper faces, shall be in accordance with the following; unless otherwise specified, material conforming to the normal thickness tolerances shall be furnished. When other thicknesses are specified, use the tolerance for the next greater thickness.

6.2.2.1 Normal Thickness Tolerances:

6.2.2.1.1

Nominal Thickness Inch	Tolerance, Inch, Plus and Minus			
	Copper on One Side Only		Copper on Both Sides	
	0.0014 in.	0.0028 in.	0.0014 in.	0.0028 in.
Ø				
0.031	0.0055	0.0065	0.0065	0.0075
0.062	0.0065	0.0075	0.0075	0.0085
0.125	0.011	0.012	0.012	0.013

6.2.2.1.2 At least 90% of the sheet shall be within the tolerance given and at no point shall the thickness vary from the nominal thickness by a value greater than 125% of the specified tolerances.

6.2.2.2 Close Thickness Tolerances:

Nominal Thickness Inch	Tolerance, Inch, Plus and Minus			
	Copper on One Side Only		Copper on Both Sides	
	0.0014 in.	0.0028 in.	0.0014 in.	0.0028 in.
Ø				
0.031	0.004	0.005	0.005	0.006
0.060	0.006	0.006	0.006	0.006
0.125	0.006	0.007	0.007	0.008

Ø6.2.2.2.1 Specified tolerances shall be furnished over 100% of the area of the sheet.

6.2.3 Warp and Twist: Shall not exceed the following values, based on 36 in. length, when determined in accordance with ASTM D229-49 or D709-55T:

Nominal Sheet Thickness Inch	Maximum Deviation, Inches	
	Copper on One Side Only Both Thicknesses	Copper on Both Sides Both Thicknesses
0.031 to under 0.060	3.60	1.80
0.060 to under 0.125	1.80	0.90
0.125 to 0.250, incl	0.72	0.36

6.2.3.1 When it is desired to compare the actual deviation for any length with the permissible deviation for that length, the following formula may be used:

$$D = 0.00077 \times D_{36} \times L^2$$

Where:

D = permissible deviation from the straightedge in inches for the given length.
D_{36} = maximum deviation in inches for 36 in. length (from table above).
L = the given length in inches.

7. REPORTS:

7.1 Unless otherwise specified, the vendor of the product shall furnish with each shipment three copies of a report stating that the product meets the requirements of this specification. This report shall include the purchase order number, material specification number, vendor's identification number, size, thickness, and quantity.

7.2 Unless otherwise specified, the vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

8. IDENTIFICATION: Unless otherwise specified, each sheet shall be marked on one corner with AMS 3601A, sheet thickness, normal or close thickness tolerance, copper foil thickness, manufacturer's identification, and month and year of manufacture. The characters shall be applied using a suitable marking fluid and shall not be obliterated by normal handling.

9. PACKAGING:

9.1 Packaging shall be accomplished in such a manner as to ensure that the product, during shipment and storage, will not be permanently distorted, and will be protected against damage from exposure to weather or any normal hazard.

9.2 Each package shall be permanently and legibly marked to give the following information: