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AEROSPACE MATERIAL SPECIFICATION

AMS 3590C
Superseding AMS 3590B

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PLASTIC SHEET, COPPER FACED
Paper Reinforced Phenolic Resin

1. SCOPE:

1.1 Form: This specification covers phenolic-resin-impregnated paper laminates in the form of sheets clad on one or both sides with electrolytically deposited copper foil.

1.2 Application: Primarily for use in etched printed circuits used in electrical and electronic equipment up to 120°C (250°F).

1.3 Classification: This specification covers two types of copper-clad paper/phenolic laminates as follows; the type supplied shall be as specified on the drawing or purchase order:

Type I - Copper clad on one face
Type II - Copper clad on both faces

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

REAFFIRMED

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2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D149 - Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D150 - A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials
ASTM D229 - Testing Rigid Sheet and Plate Materials Used for Electrical Insulation
ASTM D570 - Water Absorption of Plastics
ASTM D618 - Conditioning Plastics and Electrical Insulating Materials for Testing
ASTM D709 - Laminated Thermosetting Materials
ASTM D790 - Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D1825 - Etching and Cleaning Copper-Clad Electrical Insulating Materials and Thermosetting Laminates for Electrical Testing
ASTM D1867 - Copper-Clad Thermosetting Laminates for Printed Wiring
ASTM D3636 - Sampling and Judging Quality of Solid Electrical Insulating Materials

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

3. TECHNICAL REQUIREMENTS:

3.1 Material and Fabrication: The sheets shall be constructed of laminations of paper thoroughly impregnated with phenolic resin and properly cured. Face sheets of copper may be applied to one or both faces of the paper during the original curing of the laminate or in a subsequent operation.

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

3.1.2 Copper Faces: Shall be electrolytically deposited copper of not less than 99.50% purity.

3.2 Properties: Sheet shall conform to the following requirements; tests shall be performed on the sheet supplied and in accordance with specified test methods, insofar as practicable. Specimens shall be conditioned in accordance with ASTM D618, Procedure A, prior to being tested. For specimens requiring removal of copper faces before testing (See 4.5.1), the conditioning shall follow removal of the copper. For thicknesses not specified, the value for the next lower thickness shall be used when requirements vary with thickness.

3.2.1	Dielectric Strength:		ASTM D149 (See 4.5.1)
3.2.1.1	Perpendicular to Lamination, Stepwise Test, min		
	Nominal Thickness Inch / mm		
	0.031 / 0.75	450 V per mil (17.7 kV/mm)	
	0.062 / 1.55	300 V per mil (11.8 kV/mm)	
	0.125 / 3.15	220 V per mil (8.66 kV/mm)	
3.2.1.2	Parallel to Laminations, Stepwise Test, min		ASTM D149 (See 4.5.1)
	As received	60 kV per in. (2.35 kV/mm)	
	After 48 hr immersion in distilled water at 50°C ± 2 (122°F ± 4)	15 kV per in. (0.585 kV/mm)	
3.2.2	Dielectric Constant at 1 MHz, max	4.6	ASTM D150 (See 4.5.1)
3.2.3	Insulation Resistance, min	1000 megohm	4.5.2
3.2.4	Flexural Strength, Crosswise, min	10,500 psi (72.5 MPa)	ASTM D790 (See 4.5.1)
3.2.5	Compressive Strength, Flatwise, min	25,000 psi (170 MPa)	ASTM D299 (See 4.5.1)
3.2.6	Bond Strength, min		ASTM D1867
	As Received and After Solder Bath Resistance		
	Nominal Foil Thickness Inch / mm		
	0.0014 / 0.035	5 lb per in. (875 N/m) of width	
	0.0028 / 0.070	6 lb per in. (1050 N/m) of width	
3.2.7	Solder Bath Resistance	Pass	ASTM D1867 Etched Specimen
3.2.8	Solvent Resistance	No softening, blistering, or lifting of base laminate and residual surface adhesive	4.5.3

3.2.9	Heat Resistance	No blistering	4.5.4
3.2.10	Copper Porosity	No more than 3 resin spots spaced not less than 1 in. (25 mm) apart for each 18 x 18 in. (450 x 450 mm). No resin spot with an included area larger than 0.5 in. (12 mm) diameter circle.	4.5.5

3.2.11 Water Absorption in 24 hr, max — ASTM D570

Nominal Thickness Inch	mm	
0.031	0.75	1.3%
0.062	1.55	1.0%
0.125	3.15	0.75%

3.3 Quality: Sheet, as received by purchaser, 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 detrimental to usage of the sheet. Discoloration of the copper faces will be permissible. The bonded copper faces shall be smooth.

3.4 Tolerances: Unless otherwise specified, the following tolerances shall apply:

3.4.1 Length and Width: Shall not vary more than +1.0 in. (+25 mm), -0 from that ordered except where test specimens have been removed.

3.4.2 Thickness:

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

TABLE I

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

TABLE I (SI)

Nominal Thickness Millimetre	Tolerance, Millimetre Plus	Minus
0.035	0.010	0.005
0.070	0.018	0.008

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

3.4.2.2.1 Normal Thickness Tolerances:

TABLE II

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.
0.031	0.004	0.005	0.0045	0.0055
0.062	0.0055	0.0065	0.006	0.007
0.125	0.0085	0.0095	0.009	0.010

TABLE II (SI)

Nominal Thickness Millimetres	Tolerance, Millimetre, Plus and Minus			
	Copper on One Side Only		Copper on Both Sides	
	0.035 mm	0.070 mm	0.035 mm	0.070 mm
0.75	0.10	0.12	0.112	0.140
1.55	0.140	0.165	0.15	0.18
3.15	0.215	0.240	0.22	0.25

3.4.2.2.1.1 At least 90% of each 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 tolerance.

3.4.2.2.2 Close Thickness Tolerances:

TABLE III

Nominal Thickness Inch	Tolerance, Inch, Plus and Minus Either Copper Thickness on Either One or Two Sides
0.031	0.003
0.062	0.004
0.125	0.006

TABLE III (SI)

Nominal Thickness Millimetres	Tolerance, Millimetre, Plus and Minus Either Copper Thickness on Either One or Two Sides
0.75	0.08
1.55	0.10
3.15	0.15

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

3.4.3 Warp and Twist: Shall not exceed the following values for either thickness of copper, based on 36 in. (900 mm) length, determined in accordance with ASTM D229 or ASTM D709.

TABLE IV

Nominal Sheet Thickness		Maximum Deviation, Percent	
Inch	Millimetres	Copper On One Side Only	Copper On Both Sides
0.031 to 0.062, incl	0.75 to 1.55, incl	10	6
Over 0.062 to 0.125, incl	Over 1.55 to 3.15, incl	8	3
Over 0.125 to 0.250, incl	Over 3.15 to 6.25, incl	5	1.5

3.4.3.1 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 in. (mm) for the given length

D_{36} = maximum deviation in in. (mm) for 36 in. (900 mm) length (from Table IV)

L = the given length in in. (mm)

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of sheet shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.6. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the sheet conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for Ø dielectric constant (3.2.2), insulation resistance (3.2.3), bond strength (3.2.6), and tolerances (3.4) are classified as acceptance tests and shall be performed on each lot.

4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests Ø and shall be performed prior to or on the initial shipment of sheet to a purchaser, when a change in material or processing, or both, requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.2.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be as follows:

4.3.1 For Acceptance Tests: Sufficient sheet shall be taken at random from each lot to perform all required tests. The number of determinations for each requirement shall be as specified in the applicable test procedure or, if not specified therein, not less than three.

4.3.1.1 A lot shall be all sheet produced in a single production run from the same batches of raw materials under the same fixed conditions and presented for vendor's inspection at one time. Not more than 4 sq ft (0.37 m^2) shall be cut from each thickness in a shipment for testing. Ø The size of the portion of sheet removed shall be stated on the outside of the package. The unit of product for determining sample size for testing (See ASTM D3636) shall not exceed 150 lb (68 kg) of sheet. Sheet may be packaged and delivered in smaller quantities under the basic lot approval provided lot identification is maintained.

4.3.2 For Preproduction Tests: As agreed upon by purchaser and vendor.

4.4 Approval:

4.4.1 Sample sheet shall be approved by purchaser before sheet for production use is supplied, unless such approval be waived by purchaser. Results of tests on production sheet shall be essentially equivalent to those on the approved sample.

4.4.2 Vendor shall use ingredients, manufacturing procedures, processes, and methods of inspection on production sheet which are essentially the same as those used on the approved sample sheet. If necessary to make any change in ingredients, in type of equipment for processing, or in manufacturing procedures, vendor shall submit for reapproval a statement of the proposed changes in material or processing, or both, and, when requested, sample sheet. Production sheet made by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Test Methods:

4.5.1 Test Specimen Preparation: Specimens for dielectric strength (both directions), dielectric constant, flexural strength, and compressive strength shall have the copper facing removed in accordance with ASTM D1825.

4.5.2 Insulation Resistance:

4.5.2.1 Circuit Test Specimen: Test specimens the thickness of the sheet by 2.00 x 2.50 in. (50.0 x 62.5 mm) shall be made as shown in Fig. 1, or be the equivalent.

4.5.2.2 Specimen Preparation: Apply suitable resist to each test panel and develop Fig. 1 wiring pattern in accordance with best commercial practice. Remove unwanted copper in accordance with ASTM D1825 except that the 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 at least 1 hr in running water at 15° - 30°C (60° - 90°F) and 15 - 20 min. in running water at 75° - 90°C (170° - 190°F). Dry for 2 - 2-1/2 hr in a forced circulating-air oven maintained at 65° - 80°C (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 clean mixture of 90% by volume ethanol and 10% by volume distilled water. Air dry. Care should be exercised to avoid touching critical areas of the clean specimen with bare hands.

4.5.2.3 Insulation Resistance Measurement: Mount specimens in a circulating-air humidity chamber (provided with suitable specimen lead wire insulators on the chamber) maintained at a relative humidity of 92% ± 2 at 65°C ± 2 (150°F ± 4) and expose for 18 hr ± 1. Lower the relative humidity to 87% ± 2 while holding the temperature constant and stabilize the specimens at this condition for 2 - 2-1/4 hours. Apply 500 V direct current between terminal leads and maintain electrification time for at least 1 minute. Immediately thereafter, measure insulation resistance using a suitable megohm bridge (See 8.2). Measurements shall be performed while the relative humidity is at 87% ± 2.

4.5.3 Solvent Resistance: A 1 x 6 in. (25 x 150 mm) specimen, etched and rinsed in accordance with 4.5.1 and dried, shall be vapor degreased for at least 1/2 min., sprayed with recirculated degreaser solvent for at least 1-1/2 min., and examined.

4.5.4 Heat Resistance: Shall be determined in accordance with ASTM D1867 at 120°C ± 2 (250°F ± 4), holding the specimens at this temperature for 30 min. ± 1.

4.5.5 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 free of fingerprints, dust, etc. Examine in a dark room, using ultra-violet light, for fluorescent resin spots.

4.6 Reports:

4.6.1 The vendor of sheet shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance test requirements and stating that the sheet conforms to the other technical requirements of this specification. This report shall include the purchase order number, AMS 3590C, lot number, vendor's identification number, size, and quantity.

4.6.2 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 3590C, contractor or other direct supplier of sheet, supplier's identification number, part number, and quantity. When sheet for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of sheet to determine conformance to the requirements of this specification and shall include in the report either a statement that the sheet conforms or copies of laboratory reports showing the results of tests to determine conformance.

4.7 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the sheet may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the sheet represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Packaging and Identification:

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