



AEROSPACE MATERIAL SPECIFICATION

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AMS 3590B

Superseding AMS 3590A

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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 (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

- 2.1 SAE Publications: Available from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

- 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 Electrical Insulating Materials at Commercial Power Frequencies

ASTM D150 - A-C Loss Characteristics and Dielectric Constant (Permittivity) 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 Plastics

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

- 2.3 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

SAE Technical Board rules provide that: "All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

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,
perpendicular to
laminations, Step-
wise Test, min

ASTM D149
(See 4.5.1)

Nominal Thickness

Inch (mm)

0.031 (0.79)

0.062 (1.57)

0.125 (3.18)

450 V per mil (17.7 kV/mm)

300 V per mil (11.8 kV/mm)

220 V per mil (8.66 kV/mm)

3.2.2 Dielectric Strength,
parallel to laminations,
Stepwise Test, min

ASTM D149
(See 4.5.1)

As received

60 kV per in. (2.34 kV/mm)

After 48 hr immersion
in distilled water at
50°C ± 2 (122°F ± 4)

15 kV per in. (0.585 kV/mm)

3.2.3 Dielectric Constant
at 1 MHz, max

4.6

ASTM D150
(See 4.5.1)

3.2.4 Insulation Resistance, min.

1000 megohm

4.5.2

3.2.5 Flexural Strength,
crosswise, min

10 500 psi (72.4 MPa)

ASTM D790
(See 4.5.1)

3.2.6 Compressive Strength,
flatwise, min

25 000 psi (172 MPa)

ASTM D229
(See 4.5.1)

3.2.7 Bond Strength, min

ASTM D1867

As Received and
After Solder Bath Resistance

Nominal Foil Thickness

Inch	(mm)	
0.0014	(0.036)	5 lb per in. (876 N/m) of width
0.0028	(0.071)	6 lb per in. (1051 N/m) of width

3.2.8 Solder Bath Resistance

Pass

ASTM D1867,
Etched
Specimen

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3.2.9 Solvent Resistance

No softening, blistering
or lifting of base
laminate and residual
surface adhesive

4.5.3

3.2.10 Heat Resistance

No blistering

4.5.4

3.2.11 Copper Porosity

No more than 3 resin
spots spaced no less
than 1 in. (25 mm) apart
for each 18 x 18 in.
(457 x 457 mm). No
resin spot with an
included area larger
than 0.5 in. (13 mm)
diameter circle

4.5.5

3.2.12 Water Absorption in 24 hr, max

ASTM D570

Nominal Thickness

Inch	(mm)	
0.031	(0.79)	1.3%
0.062	(1.57)	1.0%
0.125	(3.18)	0.75%

3.3 Quality: Sheet 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 will be permissible. The bonded copper faces shall be smooth.

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

3.4.1 Length and Width: Shall not vary more than +1.00 in. (+25.4 mm), -0.00 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
0.036	0.010	0.005
0.071	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	
	0.036 mm	0.071 mm	0.036 mm	0.071 mm
0.79	0.10	0.13	0.114	0.140
1.57	0.140	0.165	0.15	0.18
3.18	0.216	0.241	0.23	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 Tolerance:

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	

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TABLE III (SI)

Nominal Thickness Millimetres	Tolerance, Millimetres, Plus and Minus	
	Either Copper Thickness on Either One or Two Sides	
0.79	0.08	
1.57	0.10	
3.18	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. (914 mm) length, determined in accordance with ASTM D229 or ASTM D709.

TABLE IV

Ø	Nominal Sheet Thickness		Maximum Deviation, Percent	
	Inch	(Millimetres)	Copper On One Side Only	Copper On Both Sides
	0.031 to 0.062, incl	(0.79 to 1.57, incl)	10	6
	Over 0.062 to 0.125, incl	(Over 1.57 to 3.18, incl)	8	3
	Over 0.125 to 0.250, incl	(Over 3.18 to 6.35, 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 inches (millimetres) for the given length

D_{36} = maximum deviation in inches (millimetres) for 36 in. (914 mm) length (from Table IV)

L = the given length in inches (millimetres)

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of sheet shall supply all samples 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 perform such confirmatory testing as he deems necessary to ensure that the sheet conforms to the requirements of this specification.

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4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to dielectric constant (3.2.3), insulation resistance (3.2.4), bond strength (3.2.7), and tolerance (3.4) requirements are classified as acceptance tests.

4.2.2 Qualification Tests: Tests to determine conformance to all technical requirements of this specification are classified as qualification tests and may be the basis for approval of the sheet (See 4.4.1).

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

4.3 Sampling: Sufficient material shall be taken at random from each lot to perform all required tests. The number of specimens for each test shall be as specified in the applicable test procedure or, if not specified therein, not less than three. A lot shall be all sheet produced in a single production run from the same batches of raw materials and presented for vendor's inspection at one time. No more than 4 sq ft (0.37 m²) shall be cut from each thickness in a shipment for testing. The size of the portion of sheet removed shall be stated on the outside of the package.

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. 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 any change is necessary 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 and processing 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 Specimens: Test specimens the thickness of the sheet by 2.00 x 2.50 in. (50.8 x 63.5 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 4.5.1 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 60° - 90° F (16° - 32° C) and 15 - 20 min. in running water at 170° - 190° F (77° - 88° C). Dry for 2 - 2-1/2 hr in a forced circulating-air oven maintained at 150° - 180° F (66° - 82° C) 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.
- 4.5.2.3 Insulation Resistance Measurement: Mount test specimens in a circulating-air humidity chamber (provided with suitable specimen lead wire insulators on the chamber) maintained at a relative humidity of $92\% \pm 2$ at $149^{\circ} \text{F} \pm 4$ ($65^{\circ} \text{C} \pm 2$) and expose for $18 \text{ hr} \pm 1$. Lower the relative humidity to $87\% \pm 2$ 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 at least 1 minute. Immediately thereafter, measure insulation resistance using a megohm bridge (General Radio Type 544B or equivalent). Measurements shall be performed while the relative humidity is $87\% \pm 2$.
- 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 $120^{\circ} \text{C} \pm 2$ ($248^{\circ} \text{F} \pm 4$), 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 three copies of 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, material specification number and its revision letter, vendor's identification number, size, and quantity.
- 4.6.2 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 and its revision letter, 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 a statement that the sheet conforms, or shall include 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.