



# Standard Specification for Copper-Clad Thermosetting Laminates for Printed Wiring<sup>1</sup>

This standard is issued under the fixed designation D 1867; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last approval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This specification covers twelve grades of thermosetting laminate with copper foil bonded to one or both surfaces. These combination forms are intended primarily for use in fabrication of printed (etched) wiring or circuit boards.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

### 2.1 ASTM Standards:

D 709 Specification for Laminated Thermosetting Materials<sup>2</sup>

D 1711 Terminology Relating to Electrical Insulation<sup>2</sup>

D 3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials<sup>3</sup>

D 5109 Test Methods for Copper-Clad Thermosetting Laminates for Printed Wiring Boards<sup>3</sup>

### 2.2 Other Standards:

MIL-P-13949 Plastic Sheet, Laminated, Metal Clad (for Printed Wiring Boards)<sup>4</sup>

NEMA Publication Number LI-1<sup>5</sup>

<sup>1</sup> This specification is under the jurisdiction of the ASTM Committee D09 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D09.07 on Flexible and Rigid Insulating Materials.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 10.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 10.02.

<sup>4</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

<sup>5</sup> Available from National Electrical Manufacturers Association, 2101 L St., N.W., Washington, DC 20037.

## 3. Terminology

3.1 For definitions of terms used in this standard, refer to Terminology D 1711.

## 4. Classification

4.1 *Base Laminate Grades*—Where applicable, the dielectric material forming the base of the copper-clad laminate of the types listed in Table 1 and Table 2 shall conform to the property requirements of that specific grade shown in Specification D 709.

4.2 *Copper Foil Surfaces*—The surfaces shall be copper foil, either rolled or electrodeposited, having a minimum purity of 99.50 % (silver considered as equal to copper). The thickness tolerances of the copper foil shall conform to the requirements of Table 3.

4.3 *Thickness Tolerance Classes*—Copper-clad laminates are available in two classes of thickness tolerance. Class I represents those tolerances of standard manufacturing practice. Class II represents a closer tolerance product than Class I. Any specified class shall conform to the requirements shown in Table 4.

4.3.1 For sheets of laminate equal to or greater than 18 by 18 in. (approximately 2.3 ft<sup>2</sup>) at least 90 % of all thickness test measurements made upon any sheet of laminate shall be within the limits specified in Table 4. For metric size sheets this 90 % requirement shall apply to sheet sizes of 0.5 by 0.5 m or 0.25 m<sup>2</sup> area.

4.3.2 The deviation of any single thickness test measurement value (see Practice D 3636) from the nominal overall thickness listed in Table 4 shall not exceed 125 % of the tolerance listed in Table 4.

4.3.3 Any overall laminate thickness not listed in Table 4 shall meet the tolerance requirements of the next highest nominal thickness listed in Table 4.

4.3.4 For cut panels (for example, laminate sheets cut to area less than 2.3 ft<sup>2</sup> or less than 0.25 m<sup>2</sup>) at least 98 % of all thickness test measurements shall be within the specified overall laminate thickness tolerance values of Table 4.

**TABLE 1 Base Laminate Grades**

NOTE 1— A cross reference table of grade designations (see Table 2) appears here for reference purposes only. The ASTM grades shown are most closely associated with the NEMA and the military grades listed in this table. There is no requirement, stated or implied, in this ASTM specification that the ASTM grade must meet the specification requirements of the NEMA or the military standards listed.

ASTM Grade	Type
XXXX	Paper base, phenolic resin
XXXPC	Paper base, phenolic resin
FR-2	Paper base, phenolic resin, flammability rated
FR-3	Paper base, epoxy resin, flammability rated
FR-4	Glass woven fabric base, epoxy resin, general purpose, flammability rated
FR-5	Glass woven fabric base, epoxy resin, temperature resistant, flammability rated
FR-6	Random glass fiber base, polyester resin, flammability rated
G-10	Glass woven fabric base, epoxy resin, general purpose
G-11	Glass woven fabric base, epoxy resin, temperature resistant
CEM-1	Glass woven cloth surfaces, cellulose paper core, epoxy resin, flammability rated
CEM-3	Glass woven cloth surfaces, non-woven glass core, flammability rated
CFR-1	Glass polyester non-woven fabric base, epoxy resin, flammability rated

**TABLE 2 Grade Cross References**

ASTM Grade	NEMA LI-1 Grade	MIL-P-13949 Grade
XXXX	XXXX	PP
XXXPC	XXXPC	PP
FR-2	FR-2	...
FR-3	FR-3	PX
FR-4	FR-4	GF
FR-5	FR-5	GH
FR-6	FR-6	...
G-10	G-10	GE
G-11	G-11	GB
CEM-1	CEM-1	...
CEM-3	CEM-3	...
CFR-1	...	CF

**TABLE 3 Copper Foil Thickness<sup>A</sup>**

Nominal Weight, oz/ft <sup>2</sup>	Nominal Thickness, in.	Thickness Tolerance, in.	
		Plus	Minus
1/2	0.0007	0.00007	0.00007
1	0.0014	0.0004	0.0002
2	0.0028	0.0007	0.0003
3	0.0042	0.0004	0.0004
4	0.0056	0.0006	0.0006
5	0.0070	0.0007	0.0007

<sup>A</sup> Conversion factor: 0.001 in. = 0.0254 mm; 1 oz/ft<sup>2</sup> = 0.305 kg/m<sup>2</sup>.

## 5. Ordering Information

5.1 Orders for copper-clad laminates shall specify the grade of laminate base (see 4.1); the type of copper foil (either rolled or electrodeposited); the nominal weight of the copper foil (see 4.2); one- or two-side cladding; nominal overall laminate thickness; and the thickness tolerance class (see 4.3).

## 6. Detailed Requirements

6.1 The laminate shall meet the requirements shown in Table 5.

**TABLE 4 Thickness Tolerance of Copper-Clad Sheet, ± in.<sup>A</sup>**

Nominal Overall Laminate Thickness, in. <sup>B</sup>	Class I			Class II	
	Grades			Grades	
	XXXX, XXXPC FR-2, FR-3	FR-4, FR-5 CEM-1, CEM-3 FR-6, G-10, G-11	FR-4 FR-5 G-10 G-11 CFR-1	XXXX XXXPC FR-2 FR-3	FR-4 FR-5 G-10 G-11 CFR-1
	1 oz, 1 Side	1 oz, 2 Sides 2, 3, 4, 5 oz 1 or 2 Sides	All Weights 1 or 2 Sides	All Weights 1 or 2 Sides	All Weights 1 or 2 Sides
1/32	0.004	0.0045	0.0065	0.003	0.004
3/64	0.005	0.0055	0.0075	0.0035	0.005
1/16	0.0055	0.006	0.0075	0.004	0.005
3/32	0.007	0.0075	0.009	0.005	0.007
1/8	0.0085	0.009	0.012	0.006	0.009
5/32	0.0095	0.010	0.015	0.007	0.010
3/16	0.010	0.011	0.019	0.008	0.012
7/32	0.011	0.012	0.021	0.009	0.012
1/4	0.012	0.012	0.022	0.009	0.012
CFR-1					
0.0085	NA <sup>C</sup>	NA	NA	NA	0.0015
0.015	NA	NA	NA	NA	0.002
0.020	NA	NA	NA	NA	0.002
0.030	NA	NA	NA	NA	0.003

<sup>A</sup> Conversion factor: 0.001 in. = 0.0254 mm; 1 oz = 28.349 g.

<sup>B</sup> CFR-1 laminate thickness as listed is without copper foil in accordance with MIL-P-13949. Tolerance values for CFR-1 apply to the dielectric layer only.

<sup>C</sup> Not applicable.

## 7. Warp or Twist

7.1 The warp or twist of copper-clad laminate shall meet the requirements of Table 6. The maximum values shown in Table 6 are percentage values applicable only to sheet sizes as manufactured and to sheets cut such that neither length nor width is less than 18 in. (457 mm). The values shown are percentages based upon 36-in. (914-mm) dimension sheets.

## 8. Blistering

8.1 No blistering shall occur due to exposure of specimens of the material to air at the temperatures and times shown in Table 7. This requirement applies to copper-clad specimens and to laminate from which all of the copper has been etched.

## 9. Workmanship and Surface Requirements

### 9.1 Grades XXXP, XXXPC, FR-2 and FR-6 Only:

9.1.1 Copper surfaces shall be free from defects which may affect serviceability of the laminate. Such defects in copper surfaces include blisters, wrinkles, cracks, dents, and scratches.

9.1.2 The copper shall not contain any pin holes having average diameter greater than 0.015 in. (0.381 mm).

9.1.3 Pin holes in the copper exceeding average diameter 0.005 in. (0.127 mm) shall not be present in concentration exceeding one per ft<sup>2</sup>.

9.1.4 The number of inclusions in copper which are larger than 0.020 in. (0.508 mm) in length shall be limited in a single ft<sup>2</sup> of laminate and in any single sheet of approximately 0.5 m<sup>2</sup> size. The limits are:

9.1.4.1 5 in any one ft<sup>2</sup>, and

9.1.4.2 10 in any one 0.5 m<sup>2</sup> size sheet.

9.1.5 The unclad laminate surface shall have a semi-gloss or dull finish.