



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

This standard is issued under the fixed designation D1867; 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 reapproval. 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:<sup>2</sup>

D709 Specification for Laminated Thermosetting Materials

D1711 Terminology Relating to Electrical Insulation

D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials

D5109 Test Methods for Copper-Clad Thermosetting Laminates for Printed Wiring Boards

### 2.2 Other Standards:

MIL-P-13949 Plastic Sheet, Laminated, Metal Clad (for Printed Wiring Boards)<sup>3</sup>

NEMA Publication Number LI-1<sup>4</sup>

## 3. Terminology

3.1 For definitions of terms used in this standard, refer to Terminology D1711.

<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.

Current edition approved May 1, 2007. Published June 2007. Originally approved in 1961. Last previous edition approved in 2001 as D1867 – 01. DOI: 10.1520/D1867-07.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

<sup>4</sup> Available from National Electrical Manufacturers Association, 2101 L St., N.W., Washington, DC 20037.

## 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 D709.

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 D3636) 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.

## 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).

\*A Summary of Changes section appears at the end of this standard

**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
XXXP	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

**TABLE 2 Grade Cross References**

ASTM Grade	NEMA LI-1 Grade	MIL-P-13949 Grade
XXXP	XXXP	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	...

**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>.

**6. Detailed Requirements**

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

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

Nominal Overall Laminate Thickness, in.	Class I			Class II	
	Grades			Grades	
	XXXP, XXXPC FR-2, FR-3		FR-4, FR-5 CEM-1, CEM-3 FR-6, G-10, G-11	XXXP XXXPC FR-2 FR-3	FR-4 FR-5 G-10 G-11
	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

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

<sup>B</sup> Not applicable.

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.

9.2 Grades FR-3, FR-4, FR-5, CEM-1, CEM-3, G-10, and G-11:

9.2.1 Copper surfaces shall be free from defects which may affect serviceability. Such defects include blisters, wrinkles, and cracks. The copper surfaces shall be free from other defects as required in 9.2.2.

9.2.2 Pits are small holes occurring as imperfections that do not penetrate entirely through the copper foil. Dents are depressions in the copper foil that do not significantly decrease the thickness of the copper foil. Pits and dents are limited by a point count system in which the maximum total allowable point count for pits and dents is 35 per ft<sup>2</sup> (377/m<sup>2</sup>). Pits and dents carry various point counts depending upon the longest dimension of the pit or dent. Table 8 provides point count values for various dimensions.

9.2.3 Pinholes are small holes occurring as imperfections that penetrate entirely through the copper foil. A pinhole having an area equivalent to a 0.005-in. (0.127-mm) diameter