



IPC-4101D-WAM1

Specification for Base Materials for Rigid and Multilayer Printed Boards

Developed by the Laminated Prepreg Materials Subcommittee (3-11) of
the Printed Board Base Materials Committee (3-10) of IPC

Supersedes:

IPC-4101D - April 2014
IPC-4101C - August 2009
IPC-4101B with
Amendments 1 & 2 - April 2007
IPC-4101B with
Amendment 1 - February 2007
IPC-4101B - June 2006
IPC-4101A with
Amendment 1 - June 2002
IPC-4101A - December 2001
IPC-4101 - December 1997
IPC-L-108
IPC-L-109
IPC-L-112
IPC-L-115
IPC-AM-361

Users of this standard are encouraged to participate in the
development of future revisions.

Contact:

IPC
3000 Lakeside Drive, Suite 309S
Bannockburn, Illinois
60015-1249
Tel 847 615.7100
Fax 847 615.7105

Table of Contents

1 SCOPE	1	3.4	Qualification Testing	7
1.1 Classification	1	3.4.1	Qualification Testing of Laminate	11
1.1.1 Specification Sheet Description	1	3.4.2	Qualification Testing of Prepreg	11
1.1.2 Nominal Laminate Thickness	1	3.5	Verification of Manufacturer's Quality System	11
1.1.3 Metal Cladding Type and Nominal Weight/Thickness	2	3.6	Conflict	11
1.1.3.1 Metal Cladding Type	2	3.7	Materials	11
1.1.3.2 Nominal Weight/Thickness	2	3.7.1	Metal Cladding	11
1.1.4 Thickness Tolerance (Laminate)	2	3.7.2	Reinforcement Fabric	11
1.1.5 Surface Quality Class	2	3.7.3	Resin Systems	11
1.1.6 Reinforcement Style	2	3.8	General Requirements	11
1.1.7 Prepreg Parameters	2	3.8.1	Fabricated Sheets and Panels	11
1.1.8 Color	4	3.8.1.1	Fabricated Laminate Sheet Material	11
1.1.8.1 Contrast Agents	4	3.8.1.2	Fabricated Laminate Panel Material	11
1.2 Dimensions and Tolerances	4	3.8.1.3	Fabricated Prepreg Panels	11
1.2.1 Metric and Imperial Measurements	4	3.8.1.4	Fabricated Prepreg Rolls	12
2 APPLICABLE DOCUMENTS	4	3.8.2	Inspection Lot	12
2.1 IPC	4	3.8.2.1	Inspection Lot for Laminate	12
2.2 National Conference of Standards Laboratories (NCSL)	6	3.8.2.2	Inspection Lot for Prepreg	12
2.3 International Standards	6	3.8.2.3	Preparation of Samples	12
2.4 Underwriters Laboratories (UL)	6	3.8.2.4	Etching Process and Etchant Removal for Copper Foil Specimens	12
2.5 European Union	6	3.8.2.5	Standard Laboratory Conditions	12
2.6 ASTM International	6	3.8.3	Visual Properties	12
3 REQUIREMENTS	6	3.8.3.1	Laminate Visual Properties	12
3.1 Terms and Definitions	6	3.8.3.1.1	Foil Indentations	12
3.1.1 Qualification Assessment	6	3.8.3.1.2	Wrinkles	12
3.1.2 Quality Conformance Testing	6	3.8.3.1.3	Scratches	13
3.1.3 Supplier's Quality System	6	3.8.3.1.4	Plastic Surface Finish of Metal-Clad Single-Sided Base Material	13
3.1.4 Process Control Testing	6	3.8.3.1.5	Surface Finish of Foil after Curing – Except Double Treat	13
3.1.5 Self Declaration	6	3.8.3.1.6	Surface and Subsurface Imperfections	13
3.1.6 Quality Assessment Data	7	3.8.3.2	Prepreg Visual Properties	13
3.1.7 Sample Qualification	7	3.8.3.2.1	Inclusions	13
3.1.8 Production Data	7	3.8.3.2.2	Impregnation Imperfections	13
3.1.9 Customer Test Data	7	3.8.4	Dimensional	14
3.1.10 Internal Assessment	7	3.8.4.1	Length and Width	14
3.1.11 Individual Customer Audit	7	3.8.4.1.1	Length and Width of Laminate	14
3.1.12 Independent Third Party Assessment	7	3.8.4.1.2	Length and Width of Prepreg	14
3.1.13 Epoxy, Multifunctional	7	3.8.4.1.3	Prepreg Roll Width	14
3.1.14 Epoxy, Difunctional	7	3.8.4.1.4	Prepreg Roll Length	14
3.1.15 AABUS	7	3.8.4.2	Thickness	14
3.2 Specification Sheets	7	3.8.4.2.1	Class A, B and C Laminate Materials	14
3.3 Manufacturer Quality Profile	7			

3.8.4.2.2	Class D Laminate Materials	14	3.10.1.1	Flammability	18
3.8.4.2.3	Class K, L and M Laminate Materials	15	3.10.1.2	Thermal Stress	18
3.8.4.2.4	Thickness Tolerance of Laminate Materials	15	3.10.1.3	Solderability	18
3.8.4.3	Bow and Twist of Laminate Materials	15	3.10.1.4	Chemical Resistance (Optional Test)	19
3.8.4.3.1	Sheets and Panels with Both Dimensions ≥ 300 mm [11.81 in]	15	3.10.1.5	Metal Surfaces Cleanability	19
3.8.4.3.2	Panels with One or Both Dimensions < 300 mm [11.81 in]	15	3.10.1.6	Glass Transition Temperature (T_g) (Optional Test)	19
3.9	Physical Requirements	15	3.10.1.7	Delta T_g (Optional Test)	19
3.9.1	Physical Requirements of Laminate Materials	15	3.10.1.8	Decomposition Temperature (Optional Test)	19
3.9.1.1	Peel Strength	15	3.10.1.9	Time to Delaminate (TMA) (Optional Test)	19
3.9.1.1.1	Peel Strength after Thermal Stress	16	3.10.2	Chemical Requirements of Prepreg Materials	20
3.9.1.1.2	Peel Strength at Elevated Temperature	16	3.10.2.1	Flammability	20
3.9.1.1.3	Peel Strength after Process Chemicals (Optional Test)	16	3.10.2.2	Chemical Resistance (Optional Test)	20
3.9.1.2	Dimensional Stability	16	3.10.2.3	Presence of Dicyandiamide (Dicy) (Optional Test)	20
3.9.1.3	Flexural Strength	16	3.11	Electrical Requirements	20
3.9.1.4	Flexural Strength at Elevated Temperature	17	3.11.1	Electrical Requirements of Laminate Materials	20
3.9.1.5	Thermal Conductivity [=] $w/(m^{\circ}K)$	17	3.11.1.1	Permittivity	20
3.9.1.6	Coefficient of Thermal Expansion (CTE) (Optional Test)	17	3.11.1.2	Loss Tangent	20
3.9.1.7	Z-Axis CTE / Total Expansion (Optional Test)	17	3.11.1.3	Volume Resistivity	20
3.9.1.8	Fracture Toughness (Optional Test)	17	3.11.1.4	Surface Resistivity	20
3.9.2	Physical Requirements of Prepreg Materials	17	3.11.1.5	Arc Resistance	20
3.9.2.1	Resin Content	17	3.11.1.6	Dielectric Breakdown	20
3.9.2.1.1	Resin Content Percent (RC) (by Treated Weight)	17	3.11.1.7	Electric Strength	20
3.9.2.1.2	Resin Content Percent (RC) (by Burn-Off)	17	3.11.2	Electrical Requirements of Prepreg Materials	20
3.9.2.1.3	Treated Weight Total (TW)	17	3.11.2.1	Permittivity	20
3.9.2.1.4	Variation Within a Panel	17	3.11.2.2	Loss Tangent	20
3.9.2.2	Flow Parameter	17	3.11.2.3	Electric Strength	20
3.9.2.2.1	Resin Flow Percent (MF)	18	3.12	Environmental Requirements	20
3.9.2.2.2	Scaled Flow Thickness (SC)	18	3.12.1	Environmental Requirements of Laminate Materials	20
3.9.2.2.3	No Flow (NF)	18	3.12.1.1	Moisture Absorption	20
3.9.2.2.4	Rheological Flow (RE)	18	3.12.1.2	Fungus Resistance	21
3.9.2.2.5	Delamination (DL)	18	3.12.1.3	Pressure Vessel (Optional Test)	21
3.9.2.2.6	Inherent Cure (PC)	18	3.12.1.4	Total Halogen Content (Optional Test)	21
3.9.2.2.7	Cure Time (GT) (Optional Test)	18	3.12.1.5	Conductive Anodic Filament (CAF) Growth (Optional Test)	21
3.9.2.2.8	Volatile Content (VC) (Optional Test)	18	3.12.2	Environmental Requirements of Prepreg Materials	21
3.9.2.2.9	Thermal Conductivity (Prepreg Reference)	18	3.12.2.1	Fungus Resistance	21
3.10	Chemical Requirements	18	3.12.2.2	Conductive Anodic Filament (CAF) Growth (Optional Test)	21
3.10.1	Chemical Requirements of Laminate Materials	18	3.13	Substitutability	21

3.13.1	Permissible Substitutions of Specification Sheet Materials	21	6	NOTES	25
3.13.2	Substitutability of Classes of Pits and Dents	21	6.1	Ordering Information	25
3.13.3	Substitutability of Classes of Thickness Tolerance	21	6.1.1	Ordering Data for Laminate Materials	25
3.13.4	Remarking of Substituted Laminates	21	6.1.2	Ordering Data for Prepreg Materials	25
3.14	Marking	21	6.2	New Materials	25
3.14.1	Marking Laminate Materials	21	7	KEYWORDS	26
3.14.2	Marking Prepreg Materials	22	7.1	Keyword Search Terms (Electronic/Soft Copy Searches)	26
3.14.3	Marking of Shipping Containers	22	7.2	Segmented Keyword Search Terms and All Specification Sheets that Use the Specific Keywords for Searching	26
3.15	Workmanship	22	7.3	Keyword Search Terms for All Specification Sheets	26
3.16	Material Safety	22		Figures	
3.17	Prepreg Shelf Life	22		Figure 3-1 Thickness Measurements for Laminates	15
4	QUALITY ASSURANCE PROVISIONS	22		Tables	
4.1	Quality System	22	Table 1-1	Metal Cladding Types	2
4.2	Responsibility for Inspection	22	Table 1-2	Copper Foil Weight and Thickness	3
4.2.1	Test Equipment and Inspection Facilities	23	Table 3-1	Reference Information and Test Frequency of Laminate	8
4.3	Qualification Testing	23	Table 3-2	Reference Information and Test Frequency of Prepreg	10
4.3.1	Samples	23	Table 3-3	Point Value for Longest Dimensions of Indentation	12
4.3.2	Frequency	23	Table 3-4	Surface Quality Classification	13
4.3.3	Laminator Qualification Profile	23	Table 3-5	Permissible Variation in Length and Width of Laminates	14
4.3.4	Changes in Composition	23	Table 3-6	Permissible Variation in Length and Width of Prepregs	14
4.3.5	Qualification Data Retention	23	Table 3-7	Thickness and Tolerances for Laminates	16
4.4	Quality Conformance Inspection	23	Table 3-8	Permissible Bow and Twist for Laminates, %	16
4.4.1	Frequency	23	Table 3-9	Flammability Requirements	19
4.4.2	Acceptance Criteria	24	Table 3-10	Permissible Laminate Substitutions for Specification Sheets /21, /24, /26 and /30	21
4.4.3	Rejected Lots	24	Table 4-1	Quality Conformance Plan for Monthly, Quarterly and Annual Tests – Laminate	23
4.4.4	Conformance Data Retention	24	Table 4-2	Quality Conformance Plan for Monthly, Quarterly and Annual Tests – Prepreg	23
4.4.5	Certificate of Conformance	24			
4.5	Statistical Process Control (SPC)	24			
5	PREPARATION FOR DELIVERY	24			
5.1	Packaging Materials	24			
5.2	Authorized Distributors	24			

Specification for Base Materials for Rigid and Multilayer Printed Boards

1 SCOPE

This specification covers the requirements for base materials, herein referred to as laminate or prepreg, to be used primarily for rigid or multilayer printed boards for electrical and electronic circuits.

1.1 Classification The system shown below identifies clad and unclad laminate or prepreg base materials. The specification sheets serve as a cross-reference connecting the outlined callout system in this document to previously used systems.

Example for laminate base materials where this specification is referenced:

- L Material Designator (see 1.1.1)
- 25 Specification Sheet Number (see 1.1.1)
- 1500 Nominal Laminate Thickness (see 1.1.2)
- C1/C1 Metal Cladding Type and Nominal Weight/Thickness (see 1.1.3)
- A Thickness Tolerance Class (see 1.1.4)
- A Surface Quality Class (see 1.1.5)

Example for prepreg base materials where this specification is referenced:

- P Material Designator (see 1.1.1)
- 25 Specification Sheet Number (see 1.1.1)
- E7628 Reinforcement Style (see 1.1.6)
- TW Resin Content Method (see 1.1.7)
- RE Flow Parameter Method (see 1.1.7)
- VC Optional Prepreg Method (see 1.1.7)

1.1.1 Specification Sheet Description At the end of this document is a series of specification sheets. Each specification sheet outlines requirements for both laminate and prepreg for each product grade. The specification sheets are organized by a specific reinforcement type, resin system, and/or construction and are provided with a specification sheet number for ordering purposes. For convenience, the laminate and prepreg requirements for materials of the like composition are on the same specification sheet. Material Designator “L” indicates laminate material and Material Designator “P” indicates prepreg material as shown in designation examples in 1.1. When certifying to multiple specification sheets, the strongest performance requirements **shall** apply.

The headings for each specification sheet include reference definitions for the material, which cover the reinforcements, resin systems, flame retardants, and fillers used, as well as its other known identifications and glass transition temperature, T_g . The specific line items within the specification sheets are the requirements that material **shall** meet in order to be certified to this specification.

Specification sheets have no cancellation date. When no revision of IPC-4101 is called out, the latest revision of IPC-4101 **shall** apply. If previous revisions are used, then the specification sheet and revision **shall** be called out.

1.1.2 Nominal Laminate Thickness The nominal thickness is identified by four digits. For all substrates covered by this document, thicknesses may be specified or measured either over the cladding or over the dielectric (see 1.1.4 and 3.8.4.2). For metric specification, the first digit represents whole millimeters, the second represents tenths of millimeters, etc. For orders requiring Imperial units, the four digits indicate the thickness in ten-thousandths of an inch. In the example shown in 1.1, 1500 designates a laminate with thickness of 1.5 mm [0.0591 in], which would be specified as 0591 when using Imperial units.