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# IPC-4103

## Specification for Base Materials for High Speed/ High Frequency Applications

### **IPC-4103**

January 2002

A specification developed by IPC

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Supersedes IPC-L-125A  
July 1992

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# Specification for Base Materials for High Speed/ High Frequency Applications

Developed by the High Speed/High Frequency Base Materials  
Subcommittee (D-23) of the High Speed/High Frequency Committee  
(D-20) of IPC

***Supersedes:***

IPC-L-125A - July 1992

IPC-L-125

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

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## Acknowledgment

Any Specification involving a complex technology draws material from a vast number of sources. While the principal members of the High Speed/High Frequency Base Materials Subcommittee (D-23) of the High Speed/High Frequency Committee (D-20) are shown below, it is not possible to include all of those who assisted in the evolution of this specification. To each of them, the members of the IPC extend their gratitude.

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# Specification for Base Materials for High Speed/High Frequency Applications

## 1 GENERAL

**1.1 Scope** This specification covers the requirements for high speed/high frequency base materials, herein referred to as laminate or bonding layer, to be used primarily for the fabrication of rigid or multilayer printed boards for high speed/high frequency electrical and electronic circuits. This specification applies to material thickness defined in the specification sheets as measured over the dielectric only.

**1.2 Classification** The system shown below identifies clad and unclad laminate or bonding layer base materials. A cross-reference list, which connects the outlined call-out system in this document to previously used systems, is shown in the specification sheet section.

*Example for laminate base materials where IPC-4103 is referenced:*

4103	-	L	01	C
Specification Number	Specification Revision	Material Designator (see 1.2.1)	Specification Sheet (see 1.2.1)	Dielectric Permittivity Range (see 1.2.2)
1	1500	A	A	C1/C1
Dielectric Permittivity Tolerance (see 1.2.3)	Nominal Laminate Thickness (see 1.2.4)	Thickness Tolerance (see 1.2.5)	Surface Quality (see 1.2.6)	Metal Cladding Type and Nominal Weight/Thickness (see 1.2.7)

*Example for bonding layer base materials where IPC-4103 is referenced:*

4103	-	B	01	C
Specification Number	Specification Revision	Material Designator (see 1.2.1)	Specification Sheet (see 1.2.1)	Dielectric Permittivity Range (see 1.2.2)
E0106	P	TW	RE	VC
Reinforcement Style (see 1.2.8)	Resin Type (see 1.2.9)	Resin Content Column A (see 1.2.10)	Flow Parameter Column B (see 1.2.10)	Optional Bonding Layer Method (see 1.2.10)

**1.2.1 Specification Sheet Description** At the end of this document is a series of specification sheets. Each sheet outlines requirements for both laminate and bonding layers 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. The laminate and bonding layer requirements for materials of the like composition are on the same specification sheet for convenience. Material Designator “L” indicates laminate material and Material Designator “B” indicates bonding layer material as shown in the above designation examples. A bonding layer may be a thermoset or thermoplastic film or thermoplastic or thermoset prepreg.

**1.2.2 Dielectric Permittivity** The nominal permittivity is identified by a letter designation (A, B, C, D, E, F or X) as indicated on the applicable specification sheet.

**1.2.3 Dielectric Permittivity Tolerance** The permittivity tolerance is identified by a number designation (1, 2, 3, 4, 5, or X). See 3.11.1.1 and Table 3-8.

**1.2.4 Nominal Laminate Thickness** The nominal thickness is identified by four digits. For all substrates covered by this document, thickness is specified or measured over the dielectric (see 3.8.4.2). For metric specification, the first digit represents whole millimeters, the second represents tenths of millimeters, etc. The four digits indicate the thickness in whole millimeters. In the example shown in 1.2, 1500 is designated for the English usage of 0590.

**1.2.5 Thickness Tolerance, Laminate** The class of thickness tolerance for laminate base material is identified by either A, B, C, D, E, F, G, H, or X as agreed upon between user and supplier (see 3.8.4.2 and Table 3-6).

**1.2.6 Surface Quality Class** The class of surface quality is identified by either A, B, C, D, or X as agreed upon between user and supplier (see 3.8.3.1.1).

**1.2.7 Metal Cladding Type, Nominal Weight** The type and nominal weight or thickness of the metallic cladding for laminate base material is identified by five designators, with the first and fourth designators indicating type of cladding, the third designator being a slash mark to differentiate sides of the base material, and the second and fifth designators indicating the nominal weight or thickness of the metallic cladding.

**1.2.7.1** The types of metallic cladding and the designators representing them are shown in Table 1-1. This table is provided as a reference only. The referee document is the latest version of IPC-CF-148A, IPC-4562, or IPC-CF-152 as appropriate. Cladding types C and R, and H and S,

respectively, may be used interchangeably as agreed upon between user and supplier.

**Table 1-1 Metal Cladding Types**  
(For Reference Only)

A – Copper, wrought, rolled (IPC-4562, Grade 5)
B – Copper, rolled (treated)
C – Copper, electrodeposited (IPC-4562, Grade 1)
D – Copper, electrodeposited, double treat (IPC-4562, Grade 1)
G – Copper, electrodeposited, high ductility (IPC-4562, Grade 2)
H – Copper, electrodeposited, high temperature elongation (IPC-4562, Grade 3)
J – Copper, electrodeposited, annealed (IPC-4562, Grade 4)
K – Copper, wrought, light cold rolled (IPC-4562, Grade 6)
L – Copper, wrought, annealed (IPC-4562, Grade 7)
M – Copper, wrought, rolled, low temperature annealable (IPC-4562, Grade 8)
P – Copper, electrodeposited, high temperature elongation, double treat (IPC-4562, Grade 3)
R – Copper, reverse treated electrodeposited (IPC-4562, Grade 1)
S – Copper, reverse treated electrodeposited, high temperature elongation (IPC-4562)
T – Copper, copper foil parameters as dictated by contract or purchase order
U – Aluminum
Y – Copper invar copper
N – Nickel
O – Unclad
X – Other, as agreed between user and supplier

**1.2.7.2** The weight or thickness of metallic cladding and the designators representing them are listed in Table 1-2. This table is provided as a reference only. The referee document is the latest version of IPC-CF-148A, IPC-4562, or IPC-CF-152 as appropriate.

**1.2.8 Reinforcement Style** The reinforcement type and style of the bonding layer is indicated by five digits based on the chemical type and style. Typical examples of reinforcement designators are shown below:

“E0106” represents E-glass reinforcement style 106 per IPC-EG-140A.

“S0313” represents S-glass reinforcement style 313 per IPC-SG-141.

“A3080” represents aramid reinforcement style 3080 per IPC-A-142.

“Q0525” represents quartz reinforcement style 525 per IPC-QF-143.

Reinforcement properties such as thickness, construction, and weight are established in accordance with the reinforcement style designations of the appropriate material specification. If the bonding layer does not have a reinforcement, use “00000” (five zeros) in this field.

**1.2.9 Resin Type** The resin type of the bonding layer shall be indicated by a “S” for thermosetting resins or a “P” for thermoplastic resin.

**1.2.10 Bonding Layer Parameters** A variety of test procedures can be used to specify and determine fitness for use of bonding layers in multilayer board applications.

**Table 1-2 Copper Foil Weight and Thickness**  
(For Reference Only)

Foil Designator	Common Industry Terminology (CIT)	Area Weight g/m <sup>2</sup> [oz/ft <sup>2</sup> ]	Nominal Thickness μm [mils]
E	5 μm	45.1 [0.148]	5.1 [0.20]
Q	9 μm	75.9 [0.249]	8.5 [0.34]
T	12 μm	106.8 [0.350]	12.0 [0.47]
H	1/2 oz	152.5 [0.500]	17.1 [0.68]
M	3/4 oz	228.8 [0.750]	25.7 [1.01]
1	1 oz	305.0 [1]	34.3 [1.35]
2	2 oz	610.0 [2]	68.6 [2.70]
3	3 oz	915.0 [3]	102.9 [4.05]
4	4 oz	1220.0 [4]	137.2 [5.40]
5	5 oz	1525.0 [5]	171.5 [6.75]
6	6 oz	1830.0 [6]	205.7 [8.10]
7	7 oz	2135.0 [7]	240.0 [9.45]
10	10 oz	3050.0 [10]	342.9 [13.50]
14	14 oz	4270.0 [14]	480.1 [18.90]

Table 1-3 outlines some of the available tests to characterize a bonding layer material. All the tests may not be applicable to all bonding layers. The specification for a bonding layer may consist of one test method from Column A, one test method from Column B and one method from Column C as shown below with the corresponding designators. If no test method is chosen for any column, zero-zero (00) **shall** be the designator. The choice of the test methods **shall** be as agreed upon between the user and supplier and supplied as part of the ordering information. The nominal value and tolerances for the individual tests **shall** be as specified on the purchase order or by other agreement between the user and supplier.

**1.2.11 Color** Unless otherwise specified, all laminates and bonding layers are supplied in the natural (undyed/unpigmented) color. If the user requires another color, it **shall** be specified on the purchase order.

**1.2.11.1 Contrast Agents** Contrast agents, which may be added to a natural color resin system to enhance processing, such as tinting agents for contrast in automatic



**Table 1-3 Bonding Layer Testing Parameters**

Column A Resin Content Method	Column B Flow Parameter Method	Column C Optional Bonding Layer Method
RC – PerCent Resin Content	MF – PerCent Resin Flow	VC – Volatile Content
TW – Treated Weight	SC – Scaled Flow	DY – Dicy Inspection
00 – None specified	NF – No Flow	GT – Gel Time
	RE – Rheology Flow	CT – Conductivity, Thermal
	PC – PerCent Cure	CE – Conductivity, Electrical
	DH – Delta H	00 – None Specified
	00 – None Specified	

optical inspection, **shall** not adversely affect the performance, properties, or functionality of the laminate or bonding layer and **shall** be considered as the natural color.

**1.3 Dimensions and Tolerances** All dimensions and tolerances specified herein are applicable only to the end product. Dimensions are expressed in millimeters unless otherwise specified. Reference information is shown in parentheses.

**1.4 Interpretation** “**Shall**,” the imperative form of the verb, is used throughout this standard whenever a requirement is intended to express a provision that is mandatory. Deviation from a “**shall**” requirement may be considered if sufficient data is supplied to justify the exception.

The words “should” and “may” are used whenever it is necessary to express non-mandatory provisions. “Will” is used to express a declaration of purpose.

To assist the reader, the word “**shall**” is presented in bold characters.

## 2 APPLICABLE DOCUMENTS

The following is a list of applicable documents referenced in the specification. The current revision at the time of order **shall** be used as a part of this specification unless agreed upon by user and supplier.

### 2.1 IPC<sup>1</sup>

**IPC-T-50** Terms and Definitions for Interconnecting and Packaging Electronic Circuits

**IPC-MP-88** Implementation of Metric Policy

**IPC-QS-95** General Requirements for Implementation of ISO-9000 Quality Systems

**IPC-EG-140A** Specification for Finished Fabric Woven from “E” Glass for Printed Boards

**IPC-SG-141** Specification for Finished Fabric Woven from “S” Glass for Printed Boards

**IPC-A-142** Specification for Finished Fabric Woven from Aramid for Printed Boards

**IPC-QF-143** Specification for Finished Fabric Woven from Quartz (Pure Fused Silica) for Printed Boards

**IPC-CF-148A** Resin Coated Metal for Printed Boards

**IPC-CF-152** Composite Metallic Materials Specification for Printed Wiring Boards

**IPC-TM-650** Test Methods Manual<sup>2</sup>

2.1.5 Surface Examination, Unclad and Metal-Clad Material

2.1.9 Surface Scratch Examination Metal-Clad Foil

2.1.10 Visual Inspection for Undissolved Dicyandiamide

2.2.18 Determination of Thickness of Laminates by Mechanical Measurement

2.2.19.1 Length, Width and Perpendicularity of Laminate and Bonding film Panels

2.3.1.1 Chemical Cleaning of Metal-Clad Laminates

2.3.4.2 Chemical Resistance of Laminates, Prepreg and Coated Foil Products, by Solvent Exposure

2.3.4.3 Chemical Resistance of Core Materials to Methylene Chloride

2.3.6 Etching, Ammonium Persulfate Method

2.3.7 Etching, Ferric Chloride Method

2.3.7.1 Cupric Chloride Etching Method

2.3.10 Flammability of Laminate

2.3.16 Resin Content of Prepreg by Burn-Off

2.3.16.1 Resin Content of Prepreg by Treated Weight

2.3.16.2 Treated Weight of Prepreg

2.3.17 Resin Flow Percent of Prepreg

2.3.17.2 Resin Flow of “No Flow” Prepreg

2.3.18 Gel Time, Prepreg Materials

2.3.19 Volatile Content of Prepreg

1. IPC, 2215 Sanders Road, Northbrook, IL 60062

2. Current and revised IPC Test Methods are available through IPC-TM-650 subscription and on the IPC Web site ([www.ipc.org/html/testmethods.htm](http://www.ipc.org/html/testmethods.htm)).

- 2.4.4 Flexural Strength of Laminates (at Ambient Temperature)
- 2.4.4.1 Flexural Strength of Laminates (at Elevated Temperature)
- 2.4.8 Peel Strength of Metallic Clad Laminates
- 2.4.8.2 Peel Strength of Metallic Clad Laminates at Elevated Temperature (Hot Fluid Method)
- 2.4.8.3 Peel Strength of Metallic Clad Laminates at Elevated Temperature (Hot Air Method)
- 2.4.13.1 Thermal Stress of Laminates
- 2.4.22.1 Bow and Twist, Laminate
- 2.4.24 Glass Transition Temperature and Z-Axis Thermal Expansion by TMA
- 2.4.25 Glass Transition Temperature and Cure Factor by DSC  
*Note:* Test Method 2.4.25 also describes the delta glass transition temperature test (Delta  $T_g$ )
- 2.4.38 Prepreg Scaled Flow Testing
- 2.4.39 Dimensional Stability, Glass Reinforced Thin Laminates
- 2.4.41 Coefficient of Linear Thermal Expansion of Electrical Insulating Materials
- 2.4.41.1 Coefficient of Thermal Expansion by the Vitreous Silica (Quartz) Dilatometer Method
- 2.4.41.2 Coefficient of Thermal Expansion Strain Gage Method
- 2.5.1 Arc Resistance of Printed Wiring Materials
- 2.5.5.2 Dielectric Constant and Dissipation Factor of Printed Wiring Board Materials - Clip Method
- 2.5.5.3 Permittivity (Dielectric Constant) and Loss Tangent (Dissipation Factor) of Materials (Two Fluid Cell Method)
- 2.5.5.5 Stripline Test for Permittivity (Dielectric Constant and Dissipation Factor) at X-Band
- 2.5.5.6 Non-Destructive Full Sheet Resonance Test for Permittivity of Clad Laminates
- 2.5.6 Dielectric Strength of Rigid Printed Wiring Material
- 2.5.6.2 Electric Strength of Printed Wiring Material
- 2.5.17.1 Volume and Surface Resistivity of Dielectric Materials
- 2.6.1 Fungus Resistance, Printed Wiring Materials
- 2.6.2.1 Water Absorption, Metal-Clad Plastic Laminates
- 2.6.16 Pressure Vessel Method for Glass Epoxy Laminate Integrity
- IPC-QL-653** Qualification of Facilities that Inspect/Test Printed Boards, Components, and Materials
- IPC-1730** Laminator's Qualification Profile
- IPC-4110** Specification and Characterization Methods for Nonwoven Cellulose Based Paper Reinforcement
- IPC-4121** Guidelines for Selecting Core Constructions for Multilayer Printed Wiring Board Applications
- IPC-4130** Specification and Characterization Methods for Nonwoven "E" Glass Mat
- IPC-4411** Specification and Characterization Methods for Nonwoven Para-Aramid Reinforcement
- IPC-4562** Metal Foil for Printed Wiring Applications
- IPC-6018** Microwave End Product Board Inspection and Test
- IPC-9191** General Guidelines for Implementation of Statistical Process Control (SPC)
- 2.2 Joint Industry Standards<sup>1</sup>**
- J-STD-003** Solderability Test Methods For Printed Wiring Boards
- J-STD-004** Requirements for Soldering Fluxes
- 2.3 National Conference of Standards Laboratories<sup>3</sup>**
- ANSI/NCSL Z540-1-1994** American National Standard for Calibration - Calibration Laboratories & Measuring and Test Equipment - General Requirements
- 2.4 Federal Specifications<sup>4</sup>**
- QQ-A-250** Aluminum and Aluminum Alloy Plate Sheet
- QQ-B-626** Brass, Leaded and Unleaded Rod, Shapes, Forgings and Flat Product with Finished Edges (Bar, Flat Wire and Strip)
- QQ-C-576** Copper Flat Products with Slit, Slit and Edge-Rolled, Sheared, Sawed or Machined Edges (Plates, Bar, Sheet and Strip)
- 2.5 ASQ<sup>5</sup>**
- ASQ Q90** Quality Management and Quality Assurance Standards - Guidelines for Selection and Use

3. ANSI, 655 15th Street N.W., Suite 300, Washington, DC 20005-5794

4. Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094

5. ASQ, 611 East Wisconsin Avenue, P.O. Box 3066, Milwaukee, Wisconsin 53201-3066

**ASQ Q92** Quality Systems Model for Quality Assurance in Production and Installation

## 2.6 ASTM<sup>6</sup>

**ASTM B152** Standard Specification for Copper Sheet, Strip, Plate and Rolled Bar

**ASTM D149** Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

## 2.7 International Standards<sup>7</sup>

**ISO 10012-1** Quality Assurance Requirements for Measuring Equipment, Part 1 - Metrological Confirmation System for Measuring Equipment

## 3 REQUIREMENTS

**3.1 Terms and Definitions** The definition of terms **shall** be in accordance with IPC-T-50 and the following.

**3.1.1 Qualification Assessment** Qualification Assessment is a form of risk reduction between a buyer and a source for laminates and bonding films. The laminator **shall** produce an assessment of its capabilities and sources of verification for the buyer to evaluate. The buyer must then review this assessment and determine whether the information and verification provided constitutes an acceptable level of risk. The more verification of self declaration parameters provided, the lower the risk factor associated with utilizing a new laminator. There is no minimum level of Qualification Assessment Verification required by this standard, and it is between the buyer and laminator to determine the extent of verification applicable to their requirements. If the risk assessment is determined to be unacceptably high, increasing the verification requirements may reduce the risk. The cost associated with reducing this risk varies with the type of verification that is determined to be necessary.

**3.1.2 Quality Conformance Testing** Quality Conformance testing is performed on a regular basis following qualification testing as determined by the Manufacturer's Quality System. This is done to demonstrate that the supplier is continually meeting the finished product requirements of this specification and the applicable specification sheet for each base material. In the absence of a documented Manufacturer's Quality System, the conformance testing **shall** be conducted in accordance with the frequency as specified in Table 3-4 for laminates and Table 3-5 for bonding films.

**3.1.3 Manufacturers Quality System** The Manufacturer's Quality System is an organized entity within the laminator's operation that administers the documentation system, steering committee, lines of responsibilities, etc., as described in IPC-9191.

**3.1.4 Process Control Testing** Testing performed for the purpose of nominalizing the critical steps of the manufacturer's internal process.

**3.1.5 Self Declaration** The first level of Qualification Assessment is Self Declaration. A completed IPC-1730 contains a profile of a manufacturer's site capability, processing and test equipment, technology specifics, quality program, manufacturing history, company information, and data verification sources. Self Declaration is the laminator's view of its products and process capabilities to meet the customer's requirements, the requirements of the standard, and the applicable associated specification sheet(s) (see 3.3).

**3.1.6 Quality Assessment Data** The data contained in the Self Assessment is compiled and analyzed for performance characteristics of laminates or bonding films. The performance data may be based on information from a variety of both internal and external sources.

**3.1.7 Sample Qualification** Verification by Sample Qualification signifies that a manufacturer was capable of producing a product with a given set of parameters at a point in time when the Qualification sample was manufactured. Sample Qualification Testing of laminate and bonding film performance characteristics **shall** be performed at a facility that has demonstrated compliance of IPC-QL-653.

**3.1.8 Production Data** Production data is normal performance data from manufacturing runs generated as a quality assurance function. This data can be compiled, analyzed, and reported as support for product compliance to this standard by the laminator.

**3.1.9 Customer Test Data** Customer test data is normal performance data generated at incoming inspection by the customer. This data can be compiled, analyzed, and reported as support for product compliance to this standard by the laminator.

**3.1.10 Internal Assessment** Internal Assessments consist of periodic supplier verification of data contained in the Quality Profile section of the Self Declaration.

6. ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428

7. ISO, 3 Rue de Varembe, Case Postale 56, CH-1211 Geneva, Switzerland

**3.1.11 Individual Customer Audit** The Individual Customer Audit is an evaluation of the laminator's facility to compare the current Management Quality System versus the Self Declaration and the requirements of this document. The analysis, summary, and necessary corrective actions, at the discretion of the customer, may become part of the laminator's Self Declaration.

**3.1.12 Independent Third Party Assessment** Assessments are performed by a third party assessor, which is generally procedural in nature. Examples of third party assessors are ISO Registrars, Malcolm Baldrige, Underwriters' Laboratories, Canadian Standards Agency, IECQ, DSCC, etc.

**3.2 Specification Sheets** The individual item requirements **shall** be as specified herein and in accordance with the applicable specification sheets. Where there is no specification sheet available, the individual requirements **shall** be as specified in complementary documents such as master drawings or ordering data sheets (see 6.1). In the event of any conflict between requirements of this specification sheet and a complementary document, the latter **shall** govern.

**3.3 Manufacturers Quality Profile** Suppliers of laminates and bonding films **shall** assess their manufacturing capability and complete the Laminator Qualification Profile IPC-1730. The laminator **shall** maintain an up to date IPC-1730 document available for review by users. The IPC-1730 document **shall** be reviewed and updated on a minimum two year basis. The Laminator's Qualification Profile **shall** be made available for review upon request.

**3.4 Qualification Testing** Laminate and bonding layer materials furnished under this specification **shall** be qualified as described in Table 3-4 for laminates and Table 3-5 for bonding layers. The supplier **shall** retain on file data, which supports the material meets the requirements of this standard using the test methods described herein. Qualification testing **shall** be performed to demonstrate the supplier's ability to meet all of the requirements of each applicable specification sheet for each base material. Materials listed on a QPL for MIL-S-13949 as of 30 November 1998 are considered to be qualified to the extent of the original qualification and consistent with 3.4.1 and provided the test information is available for review.

**3.4.1 Qualification Testing Laminate** Qualification of laminates **shall** require test data for both thin and thick materials as applicable. One set of test information for the thinnest thickness tested **shall** qualify the manufacturer for thin laminate materials from that thickness up to and including 0.76 mm [0.030 in]. One set of test information for a laminate  $\geq 0.76$  mm [0.030 in] **shall** qualify the manufacturer for thick laminate materials.

**3.4.2 Qualification Testing Bonding Layer** Qualification of the bonding layer comprised of the thinnest reinforcement style automatically qualifies by extension all the thicker reinforcement styles for a given specification sheet.

**3.5 Verification of Manufacturer's Quality System** The verification of the Manufacturer's Quality System, as outlined in the Self Declaration in IPC-1730, may be conducted to reduce risk to the buyer. The verification can be accomplished via several methods, including Internal Assessment, Individual Customer Audit, and/or Third Party Assessment.

**3.6 Conflict** In the event of conflict, the following order of precedence **shall** apply:

1. Purchase order
2. Master drawing (see 6.1.1-D or 6.1.2-D)
3. This specification (specification sheets take precedence over body of test)
4. Applicable documents (see Paragraph 2)

### 3.7 Materials

**3.7.1 Metal Cladding** Metal cladding **shall** meet the requirements of IPC-4562, IPC-CF-148A, IPC-CF-152, or as agreed upon between user and supplier. For alternate metal claddings not covered by industry standards, requirements **shall** be as agreed upon between user and supplier.

**3.7.2 Reinforcement Fabric** Construction of the reinforcement fabrics **shall** be in accordance with IPC-EG-140A, IPC-SG-141, IPC-4110, IPC-4411, IPC-4130, IPC-A-142, and IPC-QF-143. For alternate reinforcement types not covered by industry standards, requirements **shall** be as agreed upon between user and supplier.

**3.7.3 Resin System** Resin systems used to produce laminate and bonding layer materials under this specification **shall** be as specified in the individual specification sheets (see 1.2.1). For alternate resin systems not covered by industry standards, requirements **shall** be as agreed upon between user and supplier.

**3.7.4 Fillers** Fillers are used in certain systems as called out in the applicable specification sheet. For alternate fillers not covered by industry standards, requirements **shall** be as agreed upon between user and supplier.

**3.8 General Requirements/Acceptability** Laminate or bonding layer base materials **shall** be considered acceptable if they meet the minimum requirements listed below and in the applicable specification sheet, or as agreed upon between user and supplier. If no property requirement is

specified, the default is listed in Table 3-1 below. Requirements only apply to the working area defined in 3.8.1.1 below through 3.8.1.4, unless otherwise specified. Both sides of double-sided laminate base material **shall** be evaluated for those requirements that are impacted by the metal/base material relationships. See specific test methods for applicability.

**Table 3-1 Default Requirements**

Property	Default Grade/Class/Range	Reference
Thickness	A	Table 3-6
Permissible Variation in Length and Width	Grade A	Table 3-2 or Table 3-3
Foil Indentations	Class A	3.8.3.1.1
Dimensional Stability	Range B	3.9.1.2
Warp and Twist	Class A	Table 3-7

**Note:** When tests are performed by the procuring activity, the bonding layer should be properly stored and should be tested as soon as possible after receipt (not to exceed five (5) days).

### 3.8.1 Fabricated Sheets and Panels

**3.8.1.1 Fabricated Laminate Sheet Material** A fabricated sheet **shall** be any size with an area  $\geq 0.55 \text{ m}^2$  [5.92 ft<sup>2</sup>]. The working area of a fabricated sheet is considered to be the area inside a 25 mm [0.984 in] border around the perimeter of the sheet.

**3.8.1.2 Fabricated Laminate Panels Material** A fabricated panel **shall** be any size with an area  $< 0.55 \text{ m}^2$  [5.92 ft<sup>2</sup>]. The working area of a fabricated panel is considered to be the area inside a 13 mm [0.512 in] border around the perimeter of the panel.

**3.8.1.3 Fabricated Bonding Layer Panels** Fabricated panels are cut-to-size pieces of a bonding layer that are nominally (length times width, excluding considerations of tooling holes or other cut-outs)  $< 0.55 \text{ m}^2$  [5.92 ft<sup>2</sup>]. The working border **shall** be the area excluding a 15 mm [0.591 in] border.

**3.8.1.4 Fabricated Bonding Layer Rolls** Bonding layer rolls are continuous lengths of a bonding layer that are rolled for the purposes of inventory and custom fabrication by the user. The working area of the bonding layer **shall** exclude the outer  $25 \text{ mm} \pm 5 \text{ mm}$  [0.984 in  $\pm$  0.20 in] edge. No more than 5% of the nominal roll length **shall** be unsuitable for panel fabrication, which includes splices, areas sampled for testing, and non-splice breaks in the continuous length of the bonding layer. The length of the roll may be compensated to replace that bonding layer unsuitable for panel fabrication as agreed upon between user and supplier.

### 3.8.2 Inspection Lot

**3.8.2.1 Inspection Lot Laminate** An inspection lot **shall** meet the following criteria:

- A. Material covered by a single specification sheet and the same metal cladding type.
- B. One press load or 200 sheets, whichever is greater. The 200 sheets must be comprised of consecutive press loads of the same specification sheet and the same metal cladding type.

**3.8.2.2 Inspection Lot Bonding Layer** An inspection lot of a bonding layer **shall** be one master roll of reinforcement as provided by the supplier or one master roll of a non-reinforced film. Splices provided by the reinforcement supplier are not considered to be a change in the master roll. Each master roll **shall** be inspected at the beginning and at the end as a minimum. A significant parameter change to the impregnation process **shall** require an additional inspection point.

**3.8.2.3 Preparation of Samples** Unless otherwise specified herein, samples and test specimens **shall** be prepared in accordance with standard in-house procedures. If a referee method is required, it **shall** be as agreed upon between user and supplier.

**3.8.2.4 Etching Process And Etching Removal for Copper Clad Specimens** Unless otherwise specified, any standard procedure may be used. However, IPC-TM-650, Test Methods 2.3.6, 2.3.7, or 2.3.7.1 **shall** be used as a referee.

**3.8.2.5 Standard Laboratory Conditions** Unless otherwise specified herein, all inspections **shall** be performed in accordance with the test and laboratory conditions specified in IPC-QL-653.

### 3.8.3 Visual Properties

**3.8.3.1 Laminate Visual Properties** The specimen **shall** be tested in accordance with Table 3-4 for laminates. Unless otherwise specified, the working area of the specimen **shall** be examined with normal or corrected 20/20 vision. The worst 50.8 mm x 50.8 mm [2.000 in x 2.000 in] area **shall** be examined at 10X magnification. Visual inspection may be carried out under ambient temperature and humidity conditions.

**3.8.3.1.1 Metal Foil Indentations** Indentations **shall** be located visually using 20/20 vision. The longest dimension of each foil indentation in a specimen **shall** be measured with a suitable reticule on a minimum 4X magnifier, with referee inspections at 10X. The following point value system **shall** be used to determine point count for any 300 mm x 300 mm [11.81 in x 11.81 in] area:

Longest Dimension	Point Value
<0.26 mm [0.0102 in] .....	1
0.26 mm to 0.50 mm [0.0102 in to 0.0197 in] .....	2
0.51 mm to 0.75 mm [0.0200 in to 0.0295 in] .....	4
0.76 mm to 1.00 mm [0.0299 in to 0.0394 in] .....	7
>1.00 mm [0.0394 in] .....	30

Class of metal foil indentations **shall** be as specified (see 1.2.6 and 6.1.1-F). The class **shall** be determined by a point count when examined in accordance with point value versus longest dimension chart shown below and the provisions below.

There **shall** be no adherent material in an indentation nor exposure of base laminate. Indentations with a depth of less than 0.013 mm [0.00051 in] shall not be included in the point count. Requirements for foil indentations do not apply to copper that has been treated on both sides, nor to the exterior 25 mm [0.984 in] border on full-size sheets and 13 mm [0.512 in] border on cut panels. Class A applies, unless otherwise specified. The point count allowance for each grade **shall** be prorated for inspection areas less than 300 mm x 300 mm [11.81 in x 11.81 in] but shall not be reduced to less than half.

**Class A** The total point count **shall** be 29 maximum for any 300 mm x 300 mm [11.81 in x 11.81 in] area. Fiber indentations over 6.4 mm [0.252 in] long **shall** not exceed two in any 300 mm x 300 mm [11.81 in x 11.81 in] area.

**Class B** The total point count **shall** be 17 maximum for any 300 mm x 300 mm [11.81 in x 11.81 in] area. Fiber indentations over 6.4 mm [0.252 in] long **shall** not exceed one in any 300 mm x 300 mm [11.81 in x 11.81 in] area.

**Class C** The total point count **shall** be 5 maximum for any 300 mm x 300 mm [11.81 in x 11.81 in] area. There **shall** be no foil indentations with a maximum dimension >0.50 mm [>0.0197 in].

**Class D** The total point count **shall** be 0 (zero) for any 300 mm x 300 mm [11.81 in x 11.81 in] area. Foil indentations  $\geq 125 \mu\text{m}$  [ $\geq 0.0049$  in] **shall** not be acceptable. Resin spots **shall** be 0 (zero) as inspected with normal or corrected 20/20 vision. If Class D is specified, other quality related features are also required of this quality class per IPC-4562.

**Class X** Requirements **shall** be as agreed upon between user and supplier (see 6.1.1-J).

**3.8.3.1.2 Wrinkles** There **shall** be no metal-clad wrinkles, as seen under normal or corrected 20/20 vision of the sheet or panel.

**3.8.3.1.3 Scratches** Scratches are not permitted where any part of the defect is  $\geq 20\%$  of the nominal foil thickness (for example 3.4  $\mu\text{m}$  for 17  $\mu\text{m}$  copper) or occur more than

five scratches per 300 mm x 300 mm [11.81 in x 11.81 in]. Any scratch with a depth of less than 5% of the nominal foil thickness **shall** not be counted regardless of length. Acceptability criterion for scratch length between the two previously indicated ranges is a maximum of 100 mm [3.937 in].

**3.8.3.1.4 Plastic Surface Finish of Metal Clad One Sided Laminate** The plastic surface on the non-clad side of base materials **shall** be as produced by the curing or lamination process. There should be no evidence of resin-starved or scorched areas.

**3.8.3.1.5 Surface Finish of Foil After Curing Except for Double Treat** Unless otherwise specified (see 6.1.1), discoloration of the copper surface as a result of the curing or lamination process **shall** be acceptable.

**3.8.3.1.6 Surface and Subsurface Imperfections** The etched panels **shall** be inspected to verify that no subsurface imperfections in excess of those shown below are present. The panels **shall** be inspected using an optical apparatus or aid that provides a minimum magnification of 4x. Referee magnification **shall** be accomplished at 10x. Lighting conditions of inspection **shall** be appropriate to the type, grade and thickness being inspected or as agreed between user and supplier.

Surface and subsurface imperfections (such as weave texture, resin saturation, scorching, voids, foreign inclusions) **shall** be acceptable provided the imperfections meet the following:

- The reinforcement fiber is not cut or exposed.
- There is not more than one piece of residual surface metal after metal removal per 0.5 m<sup>2</sup> [5.4 ft<sup>2</sup>] of surface examined and this piece does not have an area greater than that of circle 0.125 mm [0.0049 in] in diameter. Encapsulated metallic particles of any size are not allowed.
- The imperfections do not propagate as a result of thermal stress.
- The foreign inclusions are translucent.
- Opaque foreign matter are  $\leq 13$  mm [ $\leq 0.512$  in] in length and average no more than one per 300 mm x 300 mm [11.81 in x 11.81 in] area inspected.
- Opaque foreign other than fibers **shall** not exceed the 0.50 mm [0.0197 in]. Opaque foreign inclusions <0.13 mm [ $<0.00512$  in] **shall** not be counted. Opaque foreign inclusions between 0.50 mm and 0.13 mm [0.0197 in and 0.00512 in] inclusive **shall** average no more than two spots per 300 mm x 300 mm [11.81 in x 11.81 in] area inspected.
- Voids are  $\leq 0.075$  mm [ $\leq 0.00295$ ] in the longest dimension and do not occur in void clusters any more than three voids in a 3.2 mm [0.126 in] circle.

**3.8.3.2 Bonding Layer Visual Properties** The specimen **shall** be tested in accordance with Table 3-5 for bonding layers. Bonding layer visual inspection is conducted with normal or corrected 20/20 vision.

**3.8.3.2.1 Inclusions** Metallic inclusions are not acceptable. Inclusions or foreign material that are nonmetallic **shall** be acceptable, provided they are ≤0.50 mm [≤0.0197 in] in the longest dimension and occur no more frequently than two per 300 mm x 300 mm [11.81 in x 11.81 in] of surface for the panel size inspected or a 610 mm [24.02 in] by the width of the sample.

**3.8.3.2.2 Impregnation/Coating Imperfections** Imperfections in impregnation or coating **shall** be acceptable provided the criteria are met as shown below.

- A) Overall bonding layer thickness increases from reinforcement imperfections is maximum 99%.
- B) Dewetted areas (measured in at least two dimensions) are maximum 2.3 mm [0.0906 in].
- C) Pin-holed areas are maximum 0.65 mm [0.0256 in].
- D) Reinforcement distortion maximum (variation in pick line) per 300 mm [11.81 in] distance is 25 mm [0.984 in].
- E) Creases with exposed reinforcement are maximum <15 mm [<0.591 in].
- F) Silver streaks, cigar voids (non-wetted fibers) are not present.
- G) Brown streaks (binder marks) are agreed upon between user and supplier.

**3.8.4 Dimensional** Length, width, thickness, and other dimensional characteristics **shall** be measured with equipment capable of accuracy to verify the requirements of this specification.

**3.8.4.1 Length and Width** When tested in accordance with Table 3-4 or Table 3-5 as applicable, the material **shall** meet the length and width requirements specified below.

**3.8.4.1.1 Length and Width, Laminate** For laminate base materials, the manufacturer’s standard sizes between 0.45 m and 3.6 m [17.7 in and 141.7 in] in length and

**Table 3-3 Permissible Variation in Length and Width of Bonding Layers**

	Panel Size in mm [in]		
	<305 [<12]	305 to 610 [12 to 24]	>610 [>24]
Grade A	± 1.6 [± 0.063]	± 3.2 [± 0.126]	± 6.4 [± 0.252]
Grade B	± 0.8 [± 0.0315]	± 1.6 [± 0.063]	± 3.2 [± 0.126]

between 0.45 m and 1.5 m [17.7 in and 59.1 in] in width **shall** be acceptable. The length and width may vary no more than 25 mm [0.984 in] over or under the standard size. Unless specific dimensions are specified, standard size metal-clad laminates from which test specimens have been cut **shall** be acceptable. When smaller sizes are cut from standard sizes, the permissible variations from the specified length or width **shall** be as specified in Table 3-2, or as agreed upon between user and supplier. Adjacent edges must be perpendicular within 0.075 mm [0.00295 in] per 25 mm [0.984 in] for laminate.

**3.8.4.1.2 Length and Width, Bonding Layers** The length and width of bonding layer sheets **shall** be as specified in the procurement document (see 6.1.2-H). The permissible variations from the specified length or width **shall** be as specified in Table 3-3, or as agreed upon between user and supplier. Adjacent edges **shall** be perpendicular within 0.13 mm [0.005 in] per 25 mm [0.984 in].

**3.8.4.1.3 Bonding Layer Roll Width** For bonding layer base materials the width of the rolls **shall** be as specified in the procurement document (see 6.1.2-H). The width of the material **shall** be within +6.4/-0.0 mm [+0.250/-0.0 in] of the specified value.

**3.8.4.1.4 Bonding Layer Roll Length** The length of the bonding layer rolls **shall** be as specified in the procurement document (see 6.1.2-H). The length **shall** be within ± 1% of the value specified.

**3.8.4.2 Thickness**

**3.8.4.2.1 Thickness Class Laminates** For Class A, B, C, D, E, F, G and H materials, the thickness of the laminate base material without the metal cladding **shall** be measured per IPC TM-650, Method 2.2.18 (see Figure 3-1).

**Table 3-2 Permissible Variation in Length and Width of Laminates**

	Panel Size in mm [in]			Sheet Size in mm [in]
	<300 [<11.81]	300 to 600 [11.81 to 23.62]	>600 [>23.62]	
Grade A	± 0.80 [± 0.0315]	± 1.60 [± 0.06299]	± 3.20 [± 0.12598]	+ 25.0, -0.0 [+0.9843, -0.0]
Grade B	± 0.50 [± 0.0197]	± 0.80 [± 0.0315]	± 1.60 [± 0.06299]	+ 13.0, -0.0 [+0.5118, -0.0]

**Table 3-4 Reference Information and Testing Frequency of Laminates**

This Table is applicable for Qualification Testing and where a documented Manufacturer's Quality System is absent for Conformance Testing

Tests	Requirement Paragraph	Test Method <sup>1</sup>	Qualification Testing	Conformance Testing	Conformance Testing Frequency	Specimens per Sheet Sampled
<b>General</b>						
Visuals	3.8.3.1	2.1.5	X	X	Audit <sup>2</sup>	
Surface Finishes	3.8.3.1.1 through 3.8.3.1.6	2.1.5 2.1.9	X		Audit <sup>2</sup>	
Surface/Subsurface Imperfections	3.8.3.1.6		X	X	Lot	3
Dimensional <sup>6</sup>	3.8.4	2.2.19.1	X	X	Audit <sup>2</sup>	
Bow/Twist	3.8.4.3	2.4.22 2.4.22.1	X	X	Lot	1
<b>Physical</b>						
Peel Strength After Thermal Stress	3.9.1.1.1	2.4.8	X	X	Lot	4 <sup>5</sup>
Peel Strength At Elevated Temperature <sup>4</sup>	3.9.1.1.2	2.4.8 2.4.8.2 2.4.8.3	X	X	3 Months	4 <sup>5</sup>
Peel Strength After Exposure to Process Solutions <sup>3,4</sup>	3.9.1.1.3	2.4.8	X	X	3 Months	4 <sup>5</sup>
Dimensional Stability <sup>10</sup>	3.9.1.2	2.4.39	X	X	1 Months	3
Flexural Strength	3.9.1.3	2.4.4	X	X	12 Months	6 <sup>7</sup>
<b>Chemical</b>						
Flammability <sup>9</sup>	3.10.1.1	2.3.10	X	X	1 Months	3
Thermal Stress, Etched	3.10.1.2	2.4.13.1	X	X	Lot	2
Thermal Stress, Unetched	3.10.1.2	2.4.13.1	X	X	Lot	2
Solderability	3.10.1.3	J STD-003 Edge Dip	X	X	3 Months	3
Chemical Resistance <sup>3</sup>	3.10.1.4	2.3.4.3	X	X	Lot	1
Metal Surface Cleanability <sup>3</sup>	3.10.1.5	2.3.1.1	X	X	Lot	1
Tg <sup>3</sup>	3.10.1.6	2.4.24 2.4.25	X	X	Lot	1
Delta Tg <sup>3,4</sup>	3.10.1.7	2.4.25		X	Lot	1
Average X/Y/Z CTE <sup>3,4</sup>	3.10.1.8	2.4.41 2.4.41.1	X	X	1 Month	1
<b>Electrical</b>						
Permittivity	3.11.1.1	2.5.5.3 2.5.5.5 2.5.5.6	X	X	Lot	1
Loss Tangent	3.11.1.2	2.5.5.3 2.5.5.5	X	X	Lot	1
Volume Resistivity	3.11.1.3	2.5.17.1	X	X	12 Months	3
Surface Resistivity	3.11.1.4	2.5.17.1	X	X	12 Months	3
Dielectric Breakdown	3.11.1.5	2.5.6	X	X	3 Months	3 <sup>6</sup>
Electric Strength	3.11.1.6	2.5.6.2	X	X	3 Months	3



**Table 3-4 Reference Information and Testing Frequency of Laminates (continued)**

This Table is applicable for Qualification Testing and where a documented Manufacturer's Quality System is absent for Conformance Testing

Tests	Requirement Paragraph	Test Method <sup>1</sup>	Qualification Testing	Conformance Testing	Conformance Testing Frequency	Specimens per Sheet Sampled
<b>Environmental</b>						
Moisture Absorption	3.12.1.1	2.6.2.1	X	X	3 Months	4
Fungus Resistance	3.12.1.2	2.6.1	X			1
Pressure Vessel <sup>3,4</sup>	3.12.1.3	2.6.16		X	Lot	3

Lot Size	Sample Size	Acceptance Number
<50	5	0
51 to 90	7	0
91 to 150	11	0
151 to 280	13	0
281 to 500	16	0
501 to 1,200	19	0
1201 to 3,200	23	0
>3201	29	0

<sup>1</sup> All methods are from IPC-TM-650 unless otherwise noted.  
<sup>2</sup> Table for audit of visuals and dimensions shown below. <sup>3</sup> Optional tests as agreed upon between user and supplier.  
<sup>4</sup> Note applicable to specific material only.  
<sup>5</sup> One lengthwise and one crosswise specimen for each side – four total for double-sided.  
<sup>6</sup> One additional sample will be prepared for initial voltage reading for step-by-step testing.  
<sup>7</sup> Three lengthwise and three crosswise specimen.  
<sup>8</sup> The supplier **shall** use a statistical sampling plan to assure conformance to dimensional requirements.  
<sup>9</sup> Flammability, applies only to laminates ≥0.50 mm [≥0.020 in], thin laminate will qualify bonding film and/or rigid laminate.  
<sup>10</sup> Nominal value to be agreed upon between user and supplier.

**3.8.4.2.2 Thickness Tolerance Laminates** For Class A, B, C, and D laminates the thickness tolerance within the working area of the laminate sheet or cut-to-size panel **shall** be in accordance with Table 3-6. The thickness outside the working area of the laminate sheet or cut-to-size panel supplied by the supplier **shall** not vary from the nominal by a value >125% of the specified tolerance. For Class E, F, G, and H laminates the thickness tolerance over 100% of the laminate sheet or cut-to-size panel **shall** be in accordance with Table 3-6.

**3.8.4.3 Bow and Twist Laminate** When specimens are tested in accordance with Table 3-4, permissible bow and twist **shall** be as defined in Table 3-7. This requirement does not apply to single sided laminates, double-sided laminates with a dielectric thickness <0.76 mm [<0.030 in] or laminates with unequal cladding of ≥0.065 mm [≥0.00256 in] thickness difference between the two sides.

**3.8.4.3.1 Sheets and Panels with Both Dimensions ≥300 mm [≥11.81 in]** Fabricate a 300 mm x 300 mm [11.81 in x 11.81 in] specimen from a sheet or panel in a manner that will not impart additional bow or twist to the specimen.

(For example, when shearing, test specimen sheared edges **shall** be those on the shear deck side of each cut).

**3.8.4.3.2 Panel with One or Both Dimensions <300 mm [<11.81 in]** If both dimensions are <300 mm [<11.81 in], use an as-received panel as the test specimen. If one dimension is >300 mm [>11.81 in], cut back to 300 mm [11.81 in].

**3.9 Physical Requirements**

**3.9.1 Physical Requirements Laminate Materials**

**3.9.1.1 Peel Strength** When specimens are tested in accordance with Table 3-4, peel strength for all copper types **shall** meet the requirements of 3.9.1.1.1 through 3.9.1.1.3. For non-copper metallic foils, adhesion test methods and values **shall** be as agreed upon by user and supplier. All foil weights may be plated up to 35 μm [0.00137 in] and the peel strength inspected using the original specified value.

**3.9.1.1.1 Peel Strength after Thermal Stress** When specimens are tested in accordance with Table 3-4, the minimum average peel strength following thermal stress **shall** be as indicated in the applicable specification sheet.

**Table 3-5 Reference Information and Testing Frequency of Bonding Layer Material**

This Table is applicable for Qualification Testing and where a documented Manufacturer's Quality System is absent for Conformance Testing.

Tests	Requirement Paragraph	Test Method <sup>1</sup>	Qualification Testing	Conformance Testing	Conformance Testing Frequency	Specimens per Sheet Sampled
<b>General</b>						
Visuals	3.8.3.2	2.1.5	X	X	Lot	1
Dimensions <sup>6</sup>	3.8.4.1		X	X	Audit	
<b>Physical</b>						
Resin Content Method <sup>2</sup>	3.9.2.1					
by Burn Off <sup>2</sup>	3.9.2.1.1	2.3.16	X	X	Lot	1
by Treated Weight <sup>2</sup>	3.9.2.1.2	2.3.16.1		X	Lot	1
by Treated Weight Total <sup>2</sup>	3.9.2.1.3	2.3.16.2		X	Lot	1
Flow Parameter Method <sup>3, 11</sup>	3.9.2.2					
Resin Flow Percent <sup>3, 11</sup>	3.9.2.2.1	2.3.17	X	X	Lot	1
Scaled Flow Thickness <sup>3, 11</sup>	3.9.2.2.2	2.4.38	X	X	Lot	1
No Flow <sup>11</sup>	3.9.2.2.3	AABUS <sup>7</sup>	X	X	Lot	1
Rheological Flow <sup>11</sup>	3.9.2.2.4	AABUS <sup>7</sup>		X	Lot	1
Delta H	3.9.2.2.5	AABUS <sup>7</sup>		X	Lot	1
Optional Methods	3.9.2.3					
Gel Time <sup>4</sup>	3.9.2.3.1	2.3.18	X	X	Lot	1
Percent Cure	3.9.2.3.2	AABUS <sup>7</sup>		X	Lot	1
Volatile Content <sup>4</sup>	3.9.2.3.3	2.3.19	X	X	Lot	1
Conductivity, Thermal <sup>5</sup>	3.9.2.3.4	AABUS <sup>7</sup>	X	X	3 Month	AABUS <sup>7</sup>
Conductivity, Electrical <sup>5</sup>	3.9.2.3.5	AABUS <sup>7</sup>	X	X	3 Month	AABUS <sup>7</sup>
<b>Chemical</b>						
Flammability <sup>8,9</sup>	3.10.2	2.3.10	X	X	1 Month	3
Chemical Resistance <sup>4,9</sup>	3.10.3.1	2.3.4.2		X	Lot	
Presence of Dicy <sup>4</sup>	3.10.3.2	2.1.10	X	X	Lot	
<b>Electrical</b>						
Permittivity <sup>9</sup>	3.11.2.1	2.5.5.5	X	X	Lot	3
Loss Tangent <sup>9</sup>	3.11.2.2	2.5.5.5	X	X	Lot	3
Electric Strength <sup>9</sup>	3.11.2.3	2.5.6.2	X	X	3 Month	3
<b>Environmental</b>						
Fungus Resistance <sup>9,10</sup>	3.12.2.1	2.6.1	X			1

<sup>1</sup> All methods are from IPC-TM-650 unless otherwise noted.

<sup>2</sup> For qualification purposes, Resin Content **shall** be in accordance with Resin Content Percent by Burn Off. For conformance testing, Resin Content may be determined by using IPC-TM-650, Test Methods 2.3.16, 2.3.16.1, 2.3.16.2.

<sup>3</sup> For bonding layer types other than No Flow bonding layer, either Resin Flow percent or Scaled Flow Thickness may be Specified for qualification and conformance testing. Flow is not applicable to a thermoplastic bonding layer.

<sup>4</sup> Optional tests as agreed upon between user and supplier.

<sup>5</sup> Note applicable to specific material only.

<sup>6</sup> The supplier **shall** use a statistical sampling plan to assure conformance to dimensional requirements.

<sup>7</sup> AABUS = As Agreed Upon Between User and Supplier.

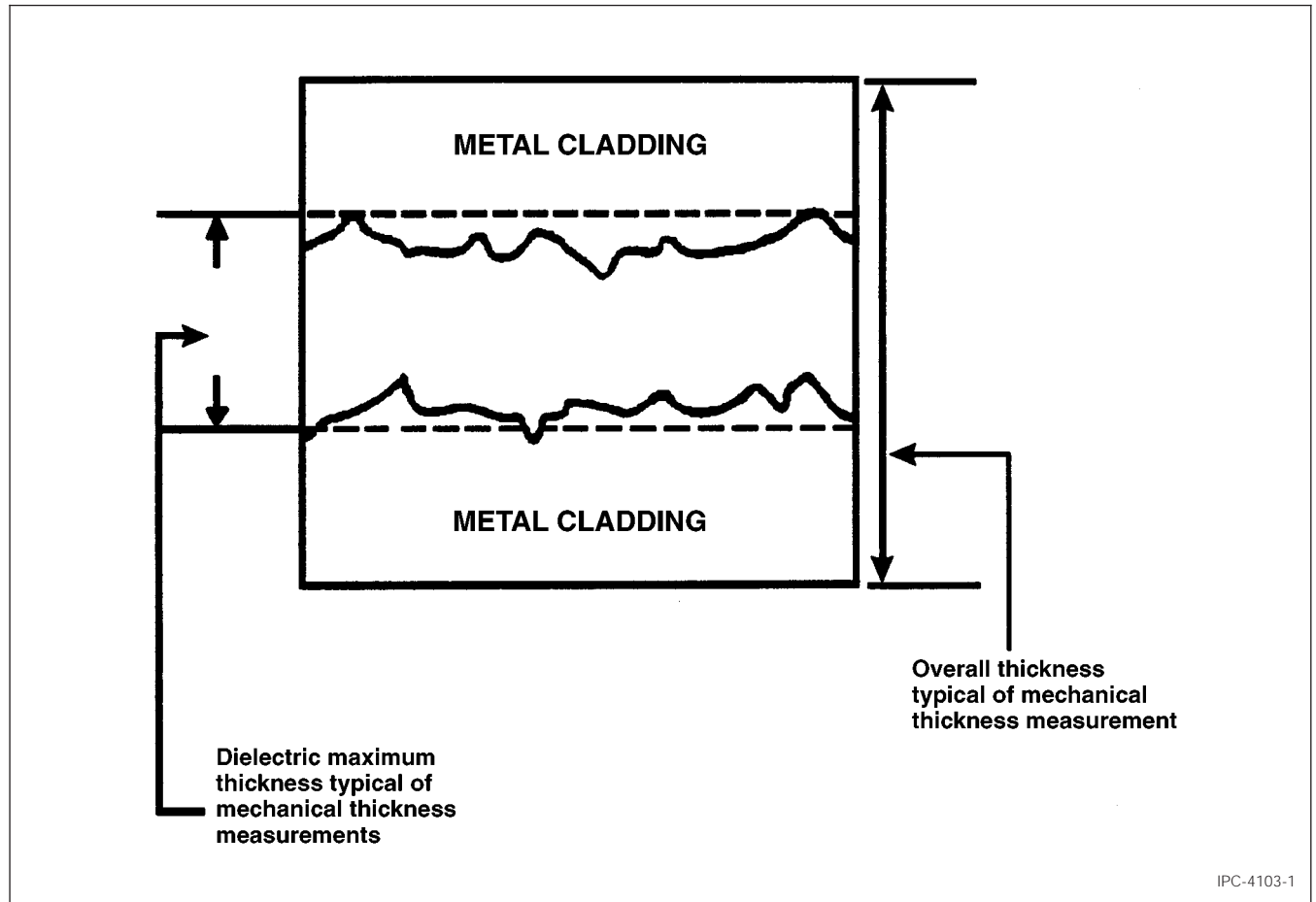
<sup>8</sup> Flammability, thin laminate will qualify Bonding layer and/or Rigid Laminate.

<sup>9</sup> Test to be conducted after pressing the bonding film into a laminate. If the same bonding film is used to make thin core laminates, testing of the laminate only is required.

<sup>10</sup> Qualification only

<sup>11</sup> Not applicable for thermoplastic bonding layers

<sup>12</sup> Not applicable for film bonding layers



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Figure 3-1 Thickness Measurement

Table 3-6 Thickness Tolerance for Laminates in mm [in]

Nominal Thickness of Laminate, Dielectric Only, mm [in]	Class A/E	Class B/F	Class C/G	Class D/H
0.050 to 0.119 [0.001969 to 0.004685]	± 0.025 [± 0.000984]	± 0.020 [± 0.000787]	± 0.015 [± 0.000591]	± 0.010 [± 0.000394]
0.120 to 0.164 [0.004724 to 0.006457]	± 0.040 [± 0.00157]	± 0.025 [± 0.000984]	± 0.020 [± 0.000787]	± 0.015 [± 0.000591]
0.165 to 0.299 [0.006496 to 0.01177]	± 0.050 [± 0.00196]	± 0.040 [± 0.00157]	± 0.025 [± 0.000984]	± 0.020 [± 0.000787]
0.300 to 0.499 [0.01181 to 0.01965]	± 0.065 [± 0.00256]	± 0.050 [± 0.00196]	± 0.040 [± 0.00157]	± 0.030 [± 0.00118]
0.500 to 0.785 [0.01969 to 0.03091]	± 0.075 [± 0.00295]	± 0.065 [± 0.00256]	± 0.050 [± 0.00196]	± 0.040 [± 0.00157]
0.786 to 1.039 [0.03094 to 0.04091]	± 0.100 [± 0.00394]	± 0.075 [± 0.00295]	± 0.050 [± 0.00196]	± 0.040 [± 0.00157]
1.040 to 1.674 [0.04094 to 0.06591]	± 0.125 [± 0.00492]	± 0.090 [± 0.00354]	± 0.050 [± 0.00196]	± 0.040 [± 0.00157]
1.675 to 2.564 [0.06594 to 0.10094]	± 0.180 [± 0.00709]	± 0.100 [± 0.00394]	± 0.075 [± 0.00295]	± 0.065 [± 0.00256]
2.565 to 3.579 [0.10098 to 0.14091]	± 0.230 [± 0.00906]	± 0.125 [± 0.00492]	± 0.090 [± 0.00354]	± 0.075 [± 0.00295]
≥3.580 [≥0.14094]	± 0.300 [± 0.01181]	± 0.150 [± 0.00591]	± 0.100 [± 0.00394]	± 0.090 [± 0.00354]

**Table 3-7 Laminate Bow and Twist, Maximum Percentage**

Laminate Thickness mm [in]	Panel Size	Class A	Class B
0.50 to 0.75 [0.0197 to 0.0295]	Double Sided $\leq 200$ [ $\leq 7.874$ ]	1.0	0.75
	Double Sided $> 200$ to 300 [ $> 7.874$ to 11.81]	1.5	1.0
0.76 to 1.67 [0.0300 to 0.0657]	Double Sided $\leq 200$ [ $< 7.874$ ]	0.75	0.50
	Double Sided $> 200$ to 300 [ $> 7.874$ to 11.81]	1.0	0.75
$> 1.67$ [ $> 0.0657$ ]	Double Sided $\leq 200$ [ $\leq 7.874$ ]	0.75	0.50
	Double Sided $> 200$ to 300 [ $> 7.874$ to 11.81]	1.0	0.75

**3.9.1.1.2 Peel Strength at Elevated Temperature** When specimens are tested in accordance with Table 3-4, the specimens **shall** meet the requirements of the applicable specification sheet.

**3.9.1.1.3 Peel Strength after Process Solutions (Optional)** When specimens are tested in accordance with Table 3-4, the minimum average peel strength after process solutions **shall** be as indicated in the applicable specification sheet.

**3.9.1.2 Dimensional Stability** When specimens are tested in accordance with Table 3-4, the nominal dimensional stability **shall** be as agreed upon between user and vendor. The tolerance **shall** be Range B unless otherwise specified on the purchase order or by other agreement between the user and vendor:

- RANGE A  $\pm 3.0$  mm per m [mils per in].
- RANGE B  $\pm 5.0$  mm per m [mils per in].
- RANGE C  $\pm 7.5$  mm per m [mils per in].
- RANGE X. Unspecified, not Applicable, or as agreed upon between user and supplier.

**3.9.1.3 Flexural Strength** The metal cladding of the specimens **shall** be completely removed by etching in accordance with 3.8.2.4. When specimens are tested in accordance with Table 3-4, the average minimum flexural strength **shall** be as indicated in the applicable specification sheet.

### 3.9.2 Physical Requirements, Bonding Layer Materials

**3.9.2.1 Resin Content Method** The quantity of resin on a particular reinforcement **shall** be specified by resin content or treated weight total.

**3.9.2.1.1 Resin Content Percent (by Burn-off)** When specimens are tested in accordance with Table 3-5, the percentage of resin content **shall** be as indicated on the applicable specification sheet, or as agreed upon between user and supplier.

**3.9.2.1.2 Resin Content Percent (by Treated Weight)** When specimens are tested in accordance with Table 3-5, the percentage of resin content shall be as indicated on the applicable specification sheet or as agreed upon between

user and supplier. In the case of dispute, the referee test method will be in accordance with IPC-TM-650, Test Method 2.3.16 (see 3.9.2.1.1).

**3.9.2.1.3 Treated Weight Total** When specimens are tested in accordance with Table 3-5, the total treated weight of the resin and reinforcement combined **shall** be as indicated on the applicable specification sheet, or as agreed upon between user and supplier.

**3.9.2.1.4 Variation Within a Panel** Resin content variation is no greater than that specified in the applicable specification sheet, or as agreed upon between user and supplier.

**3.9.2.2 Resin Flow Parameter Method** The amount that the resin will flow under certain controlled conditions **shall** be specified by resin flow (MF), scaled flow (SC), no flow (NF), rheological properties (RE), delta H (DH), or percent cure (PC) as indicated on the procurement document, or as agreed upon between user and supplier.

**3.9.2.2.1 Resin Flow Percent** When specimens are tested in accordance with Table 3-5, the nominal resin flow percent **shall** be as indicated on the procurement document. The tolerance of the resin flow percent measurement **shall** meet the requirements of the applicable specification sheet, or as agreed upon between user and supplier.

**3.9.2.2.2 Scaled Flow Thickness** When specimens are tested in accordance with Table 3-5, the nominal per ply thickness **shall** be as indicated on the procurement document. The per ply thickness **shall** not vary from the nominal thickness more than specified on the applicable specification, sheet or as agreed upon between user and supplier.

**3.9.2.2.3 Resin Flow for No Flow Type Bonding Layers** When specimens are tested in accordance with Table 3-5, the nominal resin flow percent or no flow shall be as indicated on the procurement document. The resin flow percent or no flow **shall** not vary from the nominal value more than specified on the applicable specification sheet, or as agreed upon between user and supplier.

**3.9.2.2.4 Rheological Flow** When specimens are tested in accordance with Table 3-5, the nominal rheological flow and tolerance **shall** be as indicated in the procurement document, or as agreed upon between user and supplier.

**3.9.2.2.5 Delta H** When specimens are tested in accordance with Table 3-5, the nominal delta H and tolerance **shall** be as indicated in the procurement document, or as agreed upon between user and supplier.

**3.9.2.3 Optional Tests** Other tests can be used to characterize a bonding film. The results of these tests **shall** be within the variation specified on the applicable specification sheet or as agreed upon between user and supplier.

**3.9.2.3.1 Gel Time** When specimens are tested in accordance with Table 3-5, the nominal gel time **shall** be as indicated on the procurement document. The gel time **shall** not vary from the nominal gel time more than specified on the applicable specification sheet, or as agreed upon between user and supplier.

**3.9.2.3.2 Cure Percent** When specimens are tested in accordance with Table 3-5, the nominal cure percent and tolerance **shall** be as indicated in the procurement document, or as agreed upon between user and supplier.

**3.9.2.3.3 Volatile Content** When specimens are tested in accordance with Table 3-5, the volatile content **shall** not exceed the maximum as indicated on the applicable specification sheet, or as agreed upon between user and supplier.

**3.9.2.3.4 Conductivity, Thermal** When specimens are tested in accordance with Table 3-5, the thermal conductivity **shall** be as agreed upon between user and supplier.

**3.9.2.3.5 Conductivity, Electrical** When specimens are tested in accordance with Table 3-5, the electrical conductivity **shall** be as agreed upon between user and supplier.

### 3.10 Chemical Requirements

#### 3.10.1 Chemical Requirements, Laminate

**3.10.1.1 Flammability** When specimens are tested in accordance with Table 3-4, the maximum average and individual observed burn times **shall** be as indicated in the applicable specification sheet.

**3.10.1.2 Thermal Stress** When specimens are tested in accordance with Table 3-4, the specimens **shall** exhibit no evidence of blistering, delamination, wrinkling or cracking.

**3.10.1.3 Solderability** When laminates are tested as specified in Table 3-4, the metal-clad surfaces **shall** not exhibit nonwetting or more than 5% dewetting. Prior to testing, specimens **shall** be cleaned as follows: Specimens 75 mm x 75 mm [2.95 in x 2.95 in] **shall** be cut, wiped with isopropyl alcohol, and immersed in a 20% by volume solution of hydrochloric acid, technical grade, 5.6°C

Baume, maintained at 21°C ± 5°C [69.8°F ± 9°F] for a period of 15 seconds. The specimens **shall** be rinsed with a cold water spray rinse for 5 seconds and blown dry with filtered, oil free, compressed air.

**3.10.1.4 Chemical Resistance (Optional)** When specimens are tested in accordance with Table 3-4, the weight gain following chemical exposure **shall** be as agreed upon between the user and supplier.

**3.10.1.5 Metal Surface Cleanability** When specimens are tested in accordance with Table 3-4, the material **shall** meet the metal surfaces cleanability requirements as agreed upon between the user and supplier.

**3.10.1.6 Glass Transition Temperature (Optional)** When specimens are tested in accordance with Table 3-4, the T<sub>g</sub> **shall** meet the values as agreed upon between the user and supplier.

**3.10.1.7 Delta Glass Transition Temperature (Optional)** When specimens are tested in accordance with Table 3-4, the delta T<sub>g</sub> **shall** meet the values as agreed upon between the user and supplier.

**3.10.1.8 Average Coefficient of Thermal Expansion (CTE) (Optional)** When specimens are tested in accordance with Table 3-4, the CTE in the x, y and z directions **shall** meet the values specified on the applicable specification sheet or as agreed upon between the user and supplier.

#### 3.10.2 Chemical Requirements, Bonding Layer

**3.10.3 Flammability** When laminated specimens are tested in accordance with Table 3-5, the maximum average and individual observed burn times **shall** be as indicated in the applicable specification sheet. The bonding layer must be laminated to produce a minimum thickness of 0.50 mm [0.0197 in].

**3.10.3.1 Chemical Resistance (Optional)** When specimens are tested in accordance with Table 3-5 the weight gain following chemical exposure **shall** be as agreed upon between the user and supplier.

**3.10.3.2 Presence of Dicyandiamide (Optional)** When specimens are tested in accordance with Table 3-5, the amount of acceptable dicy crystals **shall** be as agreed upon between the user and supplier.

### 3.11 Electrical Requirements

#### 3.11.1 Electrical Requirements, Laminate

**3.11.1.1 Dielectric Permittivity** When specimens are tested in accordance with Table 3-4, the nominal dielectric permittivity **shall** be as indicated in the applicable specification sheet and specified in 1.2.2. The tolerance around that nominal is defined in Table 3-8 below.

**Table 3-8 Dielectric Permittivity Tolerance**

Designation	Dielectric Permittivity Tolerance
1	± 0.02
2	± 0.04
3	± 0.05
4	± 0.25
5	± 0.50
X	as agreed between user and supplier

**3.11.1.2 Dielectric Loss Tangent** When specimens are tested in accordance with Table 3-4, the maximum dielectric loss tangent **shall** be as indicated in the applicable specification sheet.

**3.11.1.3 Volume Resistivity** When specimens are tested in accordance with Table 3-4, the minimum volume resistivity **shall** be as indicated in the applicable specification sheet.

**3.11.1.4 Surface Resistivity** When specimens are tested in accordance with Table 3-4, the minimum surface resistivity **shall** be as indicated in the applicable specification sheet.

**3.11.1.5 Dielectric Breakdown** When specimens are tested in accordance with Table 3-4, the dielectric breakdown **shall** be as indicated in the applicable specification sheet.

**3.11.1.6 Electric Strength** When specimens are tested in accordance with Table 3-4, the electric strength **shall** be as indicated in the specification sheet.

**3.11.2 Electrical Requirements, Bonding Layer** Electrical properties **shall** be tested on specimens cut from fully cured 2-ply samples of a minimum size of 900 cm<sup>2</sup> [0.97 ft<sup>2</sup>] that have been prepared in accordance with the manufacturers recommendations.

**3.11.2.1 Dielectric Permittivity** When specimens are tested in accordance with Table 3-5, the average dielectric permittivity **shall** be as indicated in the applicable specification sheet.

**3.11.2.2 Dielectric Loss Tangent** When specimens are tested in accordance with Table 3-5, the average dielectric loss tangent **shall** be as indicated in the applicable specification sheet.

**3.11.2.3 Electric Strength** When specimens are tested in accordance with Table 3-5, the minimum electric strength **shall** be as indicated in the specification sheet.

## 3.12 Environmental Requirements

### 3.12.1 Environmental Requirements, Laminate

**3.12.1.1 Moisture Absorption** When the required thickness specimens are tested in accordance with Table 3-4, the average moisture absorption **shall** be as indicated in the applicable specification sheet. The required thickness specimens are 0.5 mm to 0.6 mm [0.020 in to 0.024 in] for <0.76 mm [<0.030 in] laminates and 1.5 mm to 1.6 mm [0.0591 in to 0.0630 in] for ≥0.76 mm [≥0.030 in] laminates.

**3.12.1.2 Fungus Resistance** When tested in accordance with Table 3-4, the specimen **shall** resist fungus growth.

**3.12.1.3 Pressure Vessel (Optional)** When tested in accordance with Table 3-4, the specimens **shall** be evaluated using the criteria as agreed upon between the user and supplier.

### 3.12.2 Environmental Requirements, Bonding Layer

**3.12.2.1 Fungus Resistance** When tested for qualification in accordance with Table 3-5, the specimen **shall** resist fungus growth.

## 3.13 Visual and Dimensional Requirements, Laminates

**3.13.1 Substitutability of Grades of Metal Foil Indentations** Laminates inspected, certified, or marked to a tighter grade of metal foil indentations **shall** be substitutable for laminates ordered to a lower grade of metal foil indentations.

**3.13.2 Substitutability of Classes of Thickness Tolerance** Laminates inspected, certified, or marked to a tighter class of thickness tolerance **shall** be substitutable for laminates ordered to a lower class of thickness tolerance.

**3.13.3 Remarking of Substituted Laminates** Substituted laminates provided under the provisions of the foregoing requirements need not be remarked to lesser grades or classes unless specified by the purchase order. Lot or date codes **shall** not be changed.

## 3.14 Marking

**3.14.1 Marking, Laminates** Laminate sheets or cut-to-size panels **shall** be marked as specified in the ordering data. When applicable, the need for marking, location of the marking, information presented in the marking, and the type of marking **shall** be specified. Types of acceptable markings are:

- A) Ink of non-corrosive types that **shall** remain legible during normal handling, but readily removable prior to fabrication, which will not affect the physical or electrical properties of the base material.
- B) Labels that can be of a character that remain securely affixed and legible during normal handling.
- C) A metal embossing stamp or engraver.

**3.14.2 Marking Bonding Layer** Bonding layer sheets or panels **shall** have a label attached to the unit package. Bonding layer rolls **shall** have a label securely attached to the compatible protective bag enveloping the roll and a label attached to the inside mandrel at both ends.

**3.14.3 Marking of Shipping Containers** Laminate and bonding layer sheets or cut-to-size panels **shall** have a shipping label attached to the packing container. All labels **shall** be of such a character as to remain securely affixed and legible during normal handling. Location of the label and the type of marking **shall** be as specified in the drawing or ordering data, or, if not specified, **shall** be the supplier's standard labeling and marking. The following information is to be included.

- A. Specification number and type of material
- B. Manufacturer material designation and lot number
- C. Quantity unit of issue and dimensions
- D. Gross weight
- E. Date packed (date of packing for shipment to customer or warehouse)
- F. Contract number, manufacturers source code number, when applicable
- G. Manufacturers name and address
- H. Date of manufacture (date when the material was impregnated)
- I. Bonding film Parameters (to include as a minimum the resin content or treated weight, resin flow or scaled flow, and gel time as applicable)

**3.15 Workmanship** Laminate and bonding layer base materials **shall** be manufactured and processed in such a manner as to be uniform in quality and **shall** be free from defects, except as specified elsewhere in this document, that will affect processability and/or product life and serviceability.

**3.16 Material Safety** Laminate and bonding layer base materials supplied to this specification **shall** have available a Material Safety Data Sheet (M.S.D.S.) and other additional safety information as appropriate available upon request.

**3.17 Bonding Layer Shelf Life** Unless otherwise specified, bonding layers supplied **shall** be capable and certified

to meet all the requirements specified when stored either as per Condition 1 for not less than 180 days after receipt of the shipment by the user, per Condition 2 for not less than 90 days after receipt of the shipment by the user, or as agreed upon between the user and supplier.

Condition 1: <4.5°C [<40.1°F]

Condition 2: 21°C ± 2°C [69.8°F ± 3.6°F],

Relative Humidity 30% to 50%

Bonding layer exceeding the shelf life age requirements prior to shipment to the user must be retested and recertified by the supplier or authorized distributor before the bonding layer can be sold as material in compliance with and certified to this specification. For purposes of retest and recertification by the supplier or authorized distributor for sale as certified material, shelf life begins at the date of manufacture of the bonding layer. The bonding layer should be stored in the absence of a catalytic environment such as UV light or excessive radiation.

## 4 QUALITY ASSURANCE PROVISIONS

**4.1 Quality System** A quality system **shall** be documented to support the conformance testing frequency selected by the laminate and bonding film manufacturer.

**4.2 Responsibility for Inspection** Unless otherwise specified in the purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the purchase order, the supplier may use his own or any other facility suitable for the performance of the inspection requirements herein.

**4.2.1 Test Equipment and Inspection Facilities** Testing and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspection **shall** be established and maintained by the supplier in accordance with IPC-QL-653. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment **shall** be in accordance with ANSI/NCSL Z540-1-1994 or ISO 10012-1.

### 4.3 Qualification Testing

**4.3.1 Samples** When required under the provisions of Table 3-4 for laminates and Table 3-5 for bonding layers, sample sheets **shall** be selected from normal production for each manufacturer's brand type for which qualification is sought. The number of samples required per sheet **shall** also be as specified in Table 3-4 or Table 3-5. The number of specimens required for the individual test methods **shall** be cut from the sheets and inspected as specified.

**4.3.2 Sampling Frequency** Each material (as outlined in the specification sheets) **shall** undergo qualification once. The supplier, upon demand, **shall** provide sufficient data, as determined by the Manufacturer's Quality System, that the supplied material is qualified to this standard. A record of those materials qualified to this standard **shall** be listed in the Self Declaration form provided by the supplier in IPC-1730.

**4.3.3 Laminator's Qualification Profile** The manufacturer **shall** verify on a periodic basis that the information contained in the Laminators Qualification Profile, IPC-1730, accurately reflects overall capability. Maximum period is two years.

**4.3.4 Changes in Composition** Any changes to the chemical composition must be evaluated by the supplier as to the effect on performance properties or processing characteristics. It is the responsibility of the supplier to communicate product changes that have the potential to change performance properties or processing characteristics with the user.

**4.3.5 Qualification Data Retention** The qualification data **shall** be maintained by the supplier for the commercial life of the product plus two (2) years.

#### 4.4 Quality Conformance Inspection

**4.4.1 Quality Conformance Inspection** Quality Conformance Inspection **shall** be as documented in the laminate and bonding film supplier's Manufacturing Quality System. If a documented quality system does not exist, conformance testing **shall** be conducted in accordance with Table 3-4 for laminates and Table 3-5 for bonding layers. Additional testing required by the user must be included in the purchase order.

**4.4.1.1 Sampling Frequency** The frequency of conformance testing **shall** be as specified in the Manufacturers Quality System or as specified in Table 3-4 for laminates or Table 3-5 for bonding layers or by the purchase order. Where lot is indicated in Table 3-4, only 1 sheet is to be randomly selected from each lot for testing. Where "lot" is indicated for Table 3-5 for bonding layers, the sample shall be selected as specified in 3.8.2.2. Additional samples may be taken to satisfy the terms of the purchase order. When a period of one month or greater is indicated in Table 3-4, the sampling plan **shall** be as described in Table 4-1 for laminate and Table 4-2 for bonding film materials.

**4.4.1.2 Acceptance Criteria** The acceptance number for all tests conducted on a lot, monthly, quarterly and annual basis will be zero (0). No failure **shall** be allowed for any specimen tested as indicated in Table 4-1 and Table 4-2.

**Table 4-1 Sampling Plan for One Month or Over Testing for Laminates**

Total Number of Laminated Sheets Produced During Each Sampling Period	Number of Samples Pulled	Acceptance Number
≤200	1	0
201 to 1000 inclusive	2	0
1,001 to 10,000 inclusive	3	0
≥10,001	4	0

**Table 4-2 Sampling Plan for One Month or Over Testing for Bonding Layer Material**

Total Linear Dimension of Bonding Layer Produced During Each Sampling Period	Number of Samples Pulled	Acceptance Number
≤730 m [≤2395 ft]	1	0
731 m to 20,000 m [2398 ft to 65617 ft] inclusive	2	0
≥20,001 m [≥65620 ft]	3	0

**4.4.1.3 Rejected Lots** If an inspection lot is rejected, the supplier may rework it to correct the defects, or screen out the defective units and resubmit for reinspection. Resubmitted lots **shall** be inspected using tightened inspection. Such lots **shall** be separate from new lots, and **shall** be clearly identified as reinspected lots while the material is within the manufacturer's facility. If the defect cannot be screened out, the supplier **shall** sample additional lots, and make processing corrections as necessary. If the additional lots inspected show the same defect, it **shall** be the supplier's responsibility to contact the user(s) regarding the problem.

**4.4.1.4 Conformance Data** Quality conformance data **shall** be maintained for a minimum of three (3) years from the date of test.

**4.5 Statistical Process Control (SPC)** SPC utilizes systematic statistical techniques to analyze a process or its outputs. The purposes of these analyses are to take appropriate actions to achieve and improve process capability. The primary goal of SPC is to continually reduce variations in processes, products, or services in order to provide product meeting or exceeding real or important customer requirements.

Implementation of SPC **shall** be in accordance with IPC-9191. Depending on the progress made in implementing SPC on a particular product, an individual supplier may demonstrate compliance to specification with any of the following:

- Quality Conformance Evaluations
- End-Product Control
- In-Process Product Control
- Process Parameter Control

An individual supplier may choose to use a combination of the four assurance techniques listed above to prove compliance.



**Example:**

A product with 15 characteristics may meet specifications by Quality Conformance Evaluations on two characteristics, in-process product evaluations on five characteristics and process parameter control for five characteristics. The remaining three characteristics meet specification by a combination of in-process control and quality conformance evaluations. Evidence of compliance to the specification at the level of SPC implementation claimed is auditable by the customer or appointed third party. Requirements are dynamic in nature and are based on what is accepted in the worldwide market. Requirements may be stated as a reduction of variation around a target value, as opposed to just meeting the specification, drawing, etc.

**5 PREPARATION FOR DELIVERY**

**5.1 Packaging Material** Laminate and bonding film base materials **shall** be packed in a manner that will afford adequate protection against corrosion, deterioration, and physical damage during shipment and storage.

**5.2 Authorized Distributors** The laminate and bonding film base material manufacturer may authorize distributors to act as sales and/or fabrication and inspection agents. The manufacturer **shall** be responsible for assuring that materials processed by authorized agents meet the applicable requirements of this specification. Authorized distributors **shall** be responsible for the requirements of 3.8.3, 4.2, 4.2.1, 5.1.6.1 as applicable, and as determined by the manufacturer's level of authorization. The type and frequency of audits **shall** be as determined by the Manufacturer's Quality System.

**6 NOTES****6.1 Ordering Information**

**6.1.1 Ordering Data, Laminate Purchase orders should specify the following:**

- A. Title, number, and revision letter of the specification.
- B. Specification sheet number and revision level.
- C. Specific exemptions to the specifications, if any.
- D. Title, number, and date of any applicable drawing.
- E. Information for preparation of delivery, if applicable (see Paragraph 5.)
- F. Part Classification (see 1.2) identification and marking instructions.
- G. Production inspection, if applicable (see 4.4.1).
- H. Nominal thickness, width, and length of material (see 3.8.4).

- I. The range of tolerance around the nominal dimensional stability.
- J. All exceptions as agreed upon between user and supplier.
- K. Description of any test method not found in IPC-TM-650 or deviations from specified test methods.
- L. Request for certification, if applicable.
- M. Request for a test data report and desired test methods, if applicable.

**6.1.2 Ordering Data, Bonding Layer** Purchase orders should specify the following:

- A. Title, number, and revision letter of the specification.
- B. Specification sheet number and revision level.
- C. All exceptions as agreed upon between user and supplier.
- D. Title, number, and date of any applicable drawing.
- E. Information for preparation of delivery, if applicable (see Paragraph 5).
- F. Part Classification (see 1.2) identification and marking instructions.
- G. Production inspection, if applicable (see 4.4.1).
- H. Nominal thickness, width, and length of material (see 3.8.4).
- I. Grade of property requirements, if other than A, if applicable.
- J. Column A resin content parameter and nominal value (see 1.2.9).
- K. Column B resin flow parameter and nominal value (see 1.2.9).
- L. Column C other bonding film parameters if applicable (see 1.2.9).
- M. Description of any test method not found in IPC-TM-650 or deviations from specified test methods.
- N. Request for certification, if applicable.
- O. Request for a test data report and desired test methods, if applicable.

**6.2 New Materials** Users and material developers are encouraged to supply information on new materials for review by the IPC Base Materials Committee. Users who wish to invoke this specification for metal-clad materials not listed, **shall** list a L+zero (L0) for the specification sheet number for laminate materials and a B+zero (B0) for the specification sheet number for bonding layer materials.

## Summary of Specification Sheets

Specification Sheet #	Reinforcement	Resin System	Filler	Permittivity Range	ID Reference
IPC-4103/01	Woven E-Glass	PTFE	None	2.45 - 2.65	MIL-13949/8, Type GT
IPC-4103/02	Woven E-Glass	PTFE	None	2.40 - 2.60	MIL-13949/9, Type GX
IPC-4103/03	Non-Woven E-Glass	PTFE	None	2.15 - 2.35	MIL-13949/6, Type GP
IPC-4103/04	Non-Woven E-Glass	PTFE	None	2.15 - 2.35	MIL-13949/7, Type GR
IPC-4103/05	Woven E-Glass	PTFE	None	2.15 - 2.35	MIL-13949/14, Type GY
IPC-4103/06	With or Without Woven or Non-Woven E-Glass	PTFE	Ceramic	3.00 Maximum	N/A
IPC-4103/07	With or Without Woven or Non-Woven E-Glass	PTFE	Ceramic	5.0 - 7.0	N/A
IPC-4103/08	With or Without Woven or Non-Woven E-Glass	PTFE	Ceramic	7.5 - 11.0	N/A
IPC-4103/09	Woven E-Glass	PTFE	None	2.70 - 3.60	N/A
IPC-4103/10	Woven E-Glass	Hydrocarbon	Ceramic	3.25 - 3.45	N/A
IPC-4103/11	Woven E-Glass	Hydrocarbon	Ceramic	3.40 - 3.60	N/A
IPC-4103/12	Woven E-Glass Face Sheets, Non-Woven E-Glass Core	Polyester	Kaolin	3.00 - 4.50	CRM-5
IPC-4103/13	Woven E-Glass Face Sheets, Non-Woven E-Glass Core	Polyester	Kaolin	3.00 - 3.50	CRM-5
IPC-4103/14	Woven E-Glass	Polyester	None	3.00 - 4.00	N/A
IPC-4103/15	None	Thermoplastic	None	1.98 - 2.35	N/A
IPC-4103/16	Woven or Non-Woven E-Glass	PTFE	Ceramic	3.00 - 4.90	N/A

## Revision Date: January 2002

<b>SPECIFICATION SHEET</b>					
Specification Sheet #	:	IPC-4103/01			
Reinforcement	:	Woven E-Glass			
Resin System	:	PTFE			
Filler	:	None			
Permittivity Range	:	2.45 – 2.65			
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz			
Nominal Permittivity	:	A – 2.45, B – 2.50, C – 2.55, D – 2.60, E – 2.65, X – AABUS*			
ID Reference	:	MIL-13949/8, Type GT			
Glass Transition Range	:	N/A			
<b>LAMINATE REQUIREMENTS</b>					
Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150°C [221°F] 3. After Process Solutions C. All other foil – composite	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10 <sup>6</sup> – 10 <sup>5</sup>	– 10 <sup>6</sup> 10 <sup>5</sup>	MΩ-cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10 <sup>4</sup> – 10 <sup>3</sup>	– 10 <sup>4</sup> 10 <sup>3</sup>	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.20	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>6</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>6</sup> Hz, maximum	0.005	0.005	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	82 [11,900] 69 [10,000]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288°C [550°F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum (Laminate & bonding layer as laminated)	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability (Laminate & bonding layer as laminated) A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8
<b>BONDING LAYER REQUIREMENTS</b>					
Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.	
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A	
2. Reinforcement		N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A	
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A	

\*AABUS = As agreed upon between user and supplier.

Revision Date: January 2002

**SPECIFICATION SHEET**

Specification Sheet #	:	IPC-4103/02
Reinforcement	:	Woven E-Glass
Resin System	:	PTFE
Filler	:	None
Permittivity Range	:	2.40 – 2.60
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz
Nominal Permittivity	:	A – 2.40, B – 2.45, C – 2.50, D – 2.55, E – 2.60, X – AABUS*
ID Reference	:	MIL-13949/9, Type GX
Glass Transition Range	:	N/A

**LAMINATE REQUIREMENTS**

Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150°C [221°F] 3. After Process Solutions C. All other foil – composite	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10 <sup>6</sup> – 10 <sup>5</sup>	– 10 <sup>6</sup> 10 <sup>5</sup>	MΩ-cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>4</sup> – 10 <sup>3</sup>	– 10 <sup>4</sup> 10 <sup>3</sup>	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.20	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.0025	0.0025	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	82 [11,900] 69 [10,000]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288°C [550°F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

**BONDING LAYER REQUIREMENTS**

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement		N/A		
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

## Revision Date: January 2002

**SPECIFICATION SHEET**

Specification Sheet #	:	IPC-4103/03
Reinforcement	:	Non-Woven E-Glass
Resin System	:	PTFE
Filler	:	None
Permittivity Range	:	2.15 – 2.35
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz
Nominal Permittivity	:	A – 2.15, B – 2.20, C – 2.25, D – 2.30, E – 2.33, F – 2.35, X – AABUS*
ID Reference	:	MIL-13949/6, Type GP
Glass Transition Range	:	N/A

**LAMINATE REQUIREMENTS**

Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150°C [221°F] 3. After Process Solutions C. All other foil – composite	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10 <sup>6</sup> – 10 <sup>5</sup>	– 10 <sup>6</sup> 10 <sup>5</sup>	MΩ-cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>4</sup> – 10 <sup>3</sup>	– 10 <sup>4</sup> 10 <sup>3</sup>	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.30	0.30	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	30	30	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>6</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>6</sup> Hz, maximum	0.0010	0.0010	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	55 [7980] 41 [5950]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
9. Thermal Stress 10 S at 288°C [550°F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

**BONDING LAYER REQUIREMENTS**

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement		N/A		
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

Revision Date: January 2002

**SPECIFICATION SHEET**

Specification Sheet #	: IPC-4103/04
Reinforcement	: Non-Woven E-Glass
Resin System	: PTFE
Filler	: None
Permittivity Range	: 2.15 – 2.35
Permittivity Test Frequency	: 10 <sup>6</sup> or 10 <sup>10</sup> Hz
Nominal Permittivity	: A – 2.15, B – 2.20, C – 2.25, D – 2.30, E – 2.33, F – 2.35, X – AABUS*
ID Reference	: MIL-13949/7, Type GR
Glass Transition Range	: N/A

**LAMINATE REQUIREMENTS**

Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150°C [221°F] 3. After Process Solutions C. All other foil – composite	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10 <sup>6</sup> – 10 <sup>5</sup>	– 10 <sup>6</sup> 10 <sup>5</sup>	MΩ-cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>4</sup> – 10 <sup>3</sup>	– 10 <sup>4</sup> 10 <sup>3</sup>	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.10	0.10	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	30	30	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.0015	0.0015	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	24 [3480] 24 [3480]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288°C [550°F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

**BONDING LAYER REQUIREMENTS**

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement		N/A		
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

Revision Date: January 2002

<b>SPECIFICATION SHEET</b>					
Specification Sheet #	:	IPC-4103/05			
Reinforcement	:	Woven E-Glass			
Resin System	:	PTFE			
Filler	:	None			
Permittivity Range	:	2.15 – 2.35			
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz			
Nominal Permittivity	:	A – 2.15, B – 2.17, C – 2.20, D – 2.30, E – 2.33, F – 2.35, X – AABUS*			
ID Reference	:	MIL-13949/14, Type GY			
Glass Transition Range	:	N/A			
<b>LAMINATE REQUIREMENTS</b>					
Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum					
A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz.	AABUS*	AABUS*	N/mm [lb/inch]	2.4.8	3.9.1.1
B. Standard profile copper foil				2.4.8.2	3.9.1.1.1
1. After Thermal Stress	0.71 [3.98]	0.71 [3.98]		2.4.8.3	3.9.1.1.2
2. At 150°C [221°F]	0.71 [3.98]	0.71 [3.98]			3.9.1.1.3
3. After Process Solutions	0.71 [3.98]	0.71 [3.98]			
C. All other foil – composite	AABUS*	AABUS*			
2. Volume Resistivity, minimum					
A. C-96/35/90	10 <sup>6</sup>	–	MΩ-cm	2.5.17.1	3.11.1.3
B. After moisture resistance	–	10 <sup>6</sup>			
C. At elevated temperature E-24/150	10 <sup>5</sup>	10 <sup>5</sup>			
3. Surface Resistivity, minimum					
A. C-96/35/90	10 <sup>4</sup>	–	MΩ	2.5.17.1	3.11.1.4
B. After moisture resistance	–	10 <sup>4</sup>			
C. At elevated temperature E-24/125	10 <sup>3</sup>	10 <sup>3</sup>			
4. Moisture Absorption, maximum	0.20	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.0015	0.0015	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum					
A. Length direction	–	41 [5950]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
B. Cross direction	–	35 [5080]			
9. Thermal Stress 10 s at 288°C [550°F], minimum					
A. Unetched	Pass Visual	Pass Visual	s	2.4.13.1	3.10.1.2
B. Etched	Pass Visual	Pass Visual			
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability					
A. Average burn time, maximum	5	5	s	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	10		2.3.10	3.10.1.1
12. CTE, average maximum					
X,Y Axes	–	–	ppm/°C	2.4.41	3.10.1.8
Z Axis	–	–		2.4.41.1	
<b>BONDING LAYER REQUIREMENTS</b>					
Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.	
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A	N/A
2. Reinforcement		N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

Revision Date: January 2002

<b>SPECIFICATION SHEET</b>					
Specification Sheet #	:	IPC-4103/06			
Reinforcement	:	With or Without Woven or Non-Woven E-Glass			
Resin System	:	PTFE			
Filler	:	Ceramic			
Permittivity Range	:	3.00 maximum			
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz			
Nominal Permittivity	:	A – 2.80, B – 2.85, C – 2.90, D – 2.92, E – 2.93, F – 2.94, X – AABUS*			
ID Reference	:	N/A			
Glass Transition Range	:	N/A			
<b>LAMINATE REQUIREMENTS</b>					
Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum					
A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz.	AABUS*	AABUS*		2.4.8	3.9.1.1
B. Standard profile copper foil			N/mm [lb/inch]	2.4.8.2	3.9.1.1.1
1. After Thermal Stress	0.71 [3.98]	0.71 [3.98]		2.4.8.3	3.9.1.1.2
2. At 150°C [221°F]	0.71 [3.98]	0.71 [3.98]			3.9.1.1.3
3. After Process Solutions	0.71 [3.98]	0.71 [3.98]			
C. All other foil – composite	AABUS*	AABUS*			
2. Volume Resistivity, minimum					
A. C-96/35/90	10 <sup>6</sup>	–	MΩ-cm	2.5.17.1	3.11.1.3
B. After moisture resistance	–	10 <sup>6</sup>			
C. At elevated temperature E-24/150	10 <sup>5</sup>	10 <sup>5</sup>			
3. Surface Resistivity, minimum					
A. C-96/35/90	10 <sup>4</sup>	–	MΩ	2.5.17.1	3.11.1.4
B. After moisture resistance	–	10 <sup>4</sup>			
C. At elevated temperature E-24/125	10 <sup>3</sup>	10 <sup>3</sup>			
4. Moisture Absorption, maximum	0.13	0.13	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	30	30	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.003	0.003	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum					
A. Length direction	–	5.5 [798]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
B. Cross direction	–	5.5 [798]			
9. Thermal Stress 10 s at 288°C [550°F], minimum					
A. Unetched	Pass Visual	Pass Visual	s	2.4.13.1	3.10.1.2
B. Etched	Pass Visual	Pass Visual			
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability					
A. Average burn time, maximum	5	5	s	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	10		2.3.10	3.10.1.1
12. CTE, average maximum					
X, Y Axes	–	25	ppm/°C	2.4.41	3.10.1.8
Z Axis	–	35		2.4.41.1	
<b>BONDING LAYER REQUIREMENTS</b>					
Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.	
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A	N/A
2. Reinforcement		N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.



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<b>SPECIFICATION SHEET</b>					
Specification Sheet #	:	IPC-4103/07			
Reinforcement	:	With or Without Woven or Non-Woven E-Glass			
Resin System	:	PTFE			
Filler	:	Ceramic			
Permittivity Range	:	5.0 – 7.0			
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz			
Nominal Permittivity	:	A – 6.00, B – 6.15, X – AABUS*			
ID Reference	:	N/A			
Glass Transition Range	:	N/A			
<b>LAMINATE REQUIREMENTS</b>					
Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150°C [221°F] 3. After Process Solutions C. All other foil – composite	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10 <sup>3</sup> – 10 <sup>3</sup>	– 10 <sup>3</sup> 10 <sup>3</sup>	MΩ-cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>3</sup> – 10 <sup>3</sup>	– 10 <sup>3</sup> 10 <sup>3</sup>	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.35	0.35	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.0030	0.0030	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	28 [4060] 21 [3050]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288°C [550°F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8
<b>BONDING LAYER REQUIREMENTS</b>					
Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.	
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A	N/A
2. Reinforcement		N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

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**SPECIFICATION SHEET**

Specification Sheet #	:	IPC-4103/08
Reinforcement	:	With or Without Woven or Non-Woven E-Glass
Resin System	:	PTFE
Filler	:	Ceramic
Permittivity Range	:	7.5 – 11.0
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz
Nominal Permittivity	:	A – 9.8, B – 10.0, C – 10.2, D – 10.5, E – 10.8, X – AABUS*
ID Reference	:	N/A
Glass Transition Range	:	N/A

**LAMINATE REQUIREMENTS**

Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150°C [221°F] 3. After Process Solutions C. All other foil – composite	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10 <sup>3</sup> – 10 <sup>3</sup>	– 10 <sup>3</sup> 10 <sup>3</sup>	MΩ-cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>3</sup> – 10 <sup>3</sup>	– 10 <sup>3</sup> 10 <sup>3</sup>	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.35	0.35	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.0035	0.0035	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	28 [4060] 21 [3050]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288°C [550°F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

**BONDING LAYER REQUIREMENTS**

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement		N/A		
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

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<b>SPECIFICATION SHEET</b>					
Specification Sheet #	:	IPC-4103/09			
Reinforcement	:	Woven E-Glass			
Resin System	:	PTFE			
Filler	:	With or Without Ceramic			
Permittivity Range	:	2.70 – 3.60			
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz			
Nominal Permittivity	:	A – 2.75, B – 2.95, C – 3.00, D – 3.20, E – 3.50, X – AABUS*			
ID Reference	:	N/A			
Glass Transition Range	:	N/A			
<b>LAMINATE REQUIREMENTS</b>					
Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum					
A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz.	AABUS*	AABUS*	N/mm [lb/inch]	2.4.8	3.9.1.1
B. Standard profile copper foil				2.4.8.2	3.9.1.1.1
1. After Thermal Stress	0.71 [3.98]	0.71 [3.98]		2.4.8.3	3.9.1.1.2
2. At 150°C [221°F]	0.71 [3.98]	0.71 [3.98]			3.9.1.1.3
3. After Process Solutions	0.71 [3.98]	0.71 [3.98]			
C. All other foil – composite	AABUS*	AABUS*			
2. Volume Resistivity, minimum					
A. C-96/35/90	10 <sup>6</sup>	–	MΩ-cm	2.5.17.1	3.11.1.3
B. After moisture resistance	–	10 <sup>6</sup>			
C. At elevated temperature E-24/125	10 <sup>5</sup>	10 <sup>5</sup>			
3. Surface Resistivity, minimum					
A. C-96/35/90	10 <sup>4</sup>	–	MΩ	2.5.17.1	3.11.1.4
B. After moisture resistance	–	10 <sup>4</sup>			
C. At elevated temperature E-24/125	10 <sup>3</sup>	10 <sup>3</sup>			
4. Moisture Absorption, maximum	0.20	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	ε <sub>r</sub> ≥3.0 0.005 ε <sub>r</sub> <3.0 0.003	ε <sub>r</sub> ≥3.0 0.005 ε <sub>r</sub> <3.0 0.003	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum					
A. Length direction	–	82 [11,900]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
B. Cross direction	–	69 [10,000]			
9. Thermal Stress 10 s at 288°C [550°F], minimum					
A. Unetched	Pass Visual	Pass Visual	s	2.4.13.1	3.10.1.2
B. Etched	Pass Visual	Pass Visual			
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability					
A. Average burn time, maximum	5	5	s	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	10		2.3.10	3.10.1.1
12. CTE, average maximum					
X,Y Axes	–	–	ppm/°C	2.4.41	3.10.1.8
Z Axis	–	–		2.4.41.1	
<b>BONDING LAYER REQUIREMENTS</b>					
Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.	
1. Shelf Life, minimum (Condition 1/Condition 2)	AABUS*	N/A	N/A	N/A	N/A
2. Reinforcement	IPC-EG-140A				
3. Volatile content maximum	N/A	N/A	N/A	N/A	N/A
4. Minimum Bonding Temperature	AABUS*	°C	AABUS*	N/A	N/A
5. Maximum Process Temperature	AABUS*	°C	AABUS*	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

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**SPECIFICATION SHEET**

Specification Sheet #	:	IPC-4103/10
Reinforcement	:	Woven E-Glass
Resin System	:	Hydrocarbon
Filler	:	Ceramic
Permittivity Range	:	3.25 – 3.45
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz
Nominal Permittivity	:	A – 3.25, B – 3.38, X – AABUS*
ID Reference	:	N/A
Glass Transition Range	:	N/A

**LAMINATE REQUIREMENTS**

Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150°C [221°F] 3. After Process Solutions C. All other foil – composite	AABUS  0.54 [3.01] 0.54 [3.01] 0.54 [3.01] AABUS	AABUS  0.54 [3.01] 0.54 [3.01] 0.54 [3.01] AABUS	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>6</sup> – 10 <sup>5</sup>	– 10 <sup>6</sup> 10 <sup>5</sup>	MΩ-cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>4</sup> – 10 <sup>3</sup>	– 10 <sup>4</sup> 10 <sup>3</sup>	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.25	0.25	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	34	34	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.004	0.004	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	310 [44,970] 228 [33,070]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288°C [550°F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	N/A N/A	N/A N/A	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

**BONDING LAYER REQUIREMENTS**

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement		N/A		
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

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<b>SPECIFICATION SHEET</b>					
Specification Sheet #	:	IPC-4103/11			
Reinforcement	:	Woven E-Glass			
Resin System	:	Hydrocarbon			
Filler	:	Ceramic			
Permittivity Range	:	3.40 – 3.60			
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz			
Nominal Permittivity	:	A – 3.48, B – 3.58, X – ABBUS*			
ID Reference	:	N/A			
Glass Transition Range	:	N/A			
<b>LAMINATE REQUIREMENTS</b>					
Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum					
A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz.	AABUS	AABUS	N/mm [lb/inch]	2.4.8	3.9.1.1
B. Standard profile copper foil				2.4.8.2	3.9.1.1.1
1. After Thermal Stress	0.54 [3.01]	0.54 [3.01]		2.4.8.3	3.9.1.1.2
2. At 150°C [221°F]	0.54 [3.01]	0.54 [3.01]			3.9.1.1.3
3. After Process Solutions	0.54 [3.01]	0.54 [3.01]			
C. All other foil – composite	AABUS	AABUS			
2. Volume Resistivity, minimum					
A. C-96/35/90	10 <sup>5</sup>	–	MΩ-cm	2.5.17.1	3.11.1.3
B. After moisture resistance	–	10 <sup>5</sup>			
C. At elevated temperature E-24/125	10 <sup>4</sup>	10 <sup>4</sup>			
3. Surface Resistivity, minimum					
A. C-96/35/90	10 <sup>3</sup>	–	MΩ	2.5.17.1	3.11.1.4
B. After moisture resistance	–	10 <sup>3</sup>			
C. At elevated temperature E-24/125	10 <sup>2</sup>	10 <sup>2</sup>			
4. Moisture Absorption, maximum	0.25	0.25	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	30	30	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.006	0.006	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum					
A. Length direction	–	310 [44,970]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
B. Cross direction	–	228 [33,070]			
9. Thermal Stress 10 s at 288°C [550°F], minimum					
A. Unetched	Pass Visual	Pass Visual	s	2.4.13.1	3.10.1.2
B. Etched	Pass Visual	Pass Visual			
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability					
A. Average burn time, maximum	5	5	s	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	10		2.3.10	3.10.1.1
12. CTE, average maximum					
X,Y Axes	–	–	ppm/°C	2.4.41	3.10.1.8
Z Axis	–	–		2.4.41.1	
<b>BONDING LAYER REQUIREMENTS</b>					
Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.	
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A	N/A
2. Reinforcement		N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

Revision Date: January 2002

**SPECIFICATION SHEET**

Specification Sheet #	: IPC-4103/12
Reinforcement	: Woven E-Glass Face Sheets, Non-Woven E-Glass Core
Resin System	: Polyester
Filler	: Kaolin
Permittivity Range	: 3.0 – 4.5
Permittivity Test Frequency	: 10 <sup>6</sup> or 10 <sup>10</sup> Hz
Nominal Permittivity	: A – 3.05, B – 3.20, X – AABUS*
ID Reference	: CRM-5
Glass Transition Range	: N/A

**LAMINATE REQUIREMENTS**

Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150°C [221°F] 3. After Process Solutions C. All other foil – composite	AABUS  0.61 [3.48] 0.61 [3.48] 0.61 [3.48] AABUS	AABUS  0.61 [3.48] 0.61 [3.48] 0.61 [3.48] AABUS	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>6</sup> – 10 <sup>5</sup>	– 10 <sup>6</sup> 10 <sup>5</sup>	MΩ-cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>4</sup> – 10 <sup>3</sup>	– 10 <sup>4</sup> 10 <sup>3</sup>	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.50	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.006	0.006	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	151 [21,900] 137 [19,870]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288°C [550°F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

**BONDING LAYER REQUIREMENTS**

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement		N/A		
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

## Revision Date: January 2002

**SPECIFICATION SHEET**

Specification Sheet #	: IPC-4103/13
Reinforcement	: Woven E-Glass Face Sheets, Non-Woven E-Glass Core
Resin System	: Polyester
Filler	: Kaolin
Permittivity Range	: 3.00 – 3.50
Permittivity Test Frequency	: 10 <sup>6</sup> or 10 <sup>10</sup> Hz
Nominal Permittivity	: A – 3.20, B – 3.25, C – 3.40, X – AABUS*
ID Reference	: CRM-5
Glass Transition Range	: N/A

**LAMINATE REQUIREMENTS**

Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150°C [221°F] 3. After Process Solutions C. All other foil – composite	AABUS  0.61 [3.48] 0.61 [3.48] 0.61 [3.48] AABUS	AABUS  0.61 [3.48] 0.61 [3.48] 0.61 [3.48] AABUS	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>6</sup> – 10 <sup>5</sup>	– 10 <sup>6</sup> 10 <sup>5</sup>	MΩ-cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>4</sup> – 10 <sup>3</sup>	– 10 <sup>4</sup> 10 <sup>3</sup>	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.50	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.015	0.015	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	151 [21,900] 137 [19,870]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288°C [550°F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

**BONDING LAYER REQUIREMENTS**

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement		N/A		
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.

Revision Date: January 2002

<b>SPECIFICATION SHEET</b>					
Specification Sheet #	:	IPC-4103/14			
Reinforcement	:	Woven E-Glass			
Resin System	:	Polyester			
Filler	:	None			
Permittivity Range	:	3.0 – 4.0			
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz			
Nominal Permittivity	:	A – 3.05, B – 3.29, X – AABUS*			
ID Reference	:	N/A			
Glass Transition Range	:	N/A			
<b>LAMINATE REQUIREMENTS</b>					
Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum					
A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz.	AABUS*	–		2.4.8	3.9.1.1
B. Standard profile copper foil			N/mm	2.4.8.2	3.9.1.1.1
1. After Thermal Stress	0.61 [3.48]	–	[lb/inch]	2.4.8.3	3.9.1.1.2
2. At 150°C [221°F]	0.61 [3.48]	–			3.9.1.1.3
3. After Process Solutions	0.61 [3.48]	–			
C. All other foil – composite	AABUS*	–			
2. Volume Resistivity, minimum					
A. C-96/35/90	10 <sup>6</sup>	–	MΩ-cm	2.5.17.1	3.11.1.3
B. After moisture resistance	–	–			
C. At elevated temperature E-24/125	10 <sup>5</sup>	–			
3. Surface Resistivity, minimum					
A. C-96/35/90	10 <sup>5</sup>	–	MΩ	2.5.17.1	3.11.1.4
B. After moisture resistance	–	–			
C. At elevated temperature E-24/125	10 <sup>3</sup>	–			
4. Moisture Absorption, maximum	0.30	–	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	–	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	–	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.008	–	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum					
A. Length direction	–	–	N/mm <sup>2</sup>	2.4.4	3.9.1.3
B. Cross direction	–	–	[lb/inch <sup>2</sup> ]		
9. Thermal Stress 10 s at 288°C [550°F], minimum					
A. Unetched	Pass Visual	–	s	2.4.13.1	3.10.1.2
B. Etched	Pass Visual	–			
10. Electric Strength, minimum	20 [508]	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability					
A. Average burn time, maximum	5	–	s	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	–		2.3.10	3.10.1.1
12. CTE, average maximum					
X, Y Axes	–	–	ppm/°C	2.4.41	3.10.1.8
Z Axis	–	–		2.4.41.1	
<b>BONDING LAYER REQUIREMENTS</b>					
Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.	
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A	N/A
2. Reinforcement		N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.



Revision Date: January 2002

<b>SPECIFICATION SHEET</b>					
Specification Sheet #	:	IPC-4103/15			
Reinforcement	:	None			
Resin System	:	Thermoplastic			
Filler	:	None			
Permittivity Range	:	1.98 – 2.35			
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz			
Nominal Permittivity	:	A – 1.98, B – 2.28, C – 2.32, D – 2.35, X – AABUS*			
ID Reference	:	N/A			
Glass Transition Range	:	A – 121°C, B – 168°C, C – 260°C			
<b>LAMINATE REQUIREMENTS</b>					
Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum					
A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz.	–	–	N/mm [lb/inch]	2.4.8	3.9.1.1
B. Standard profile copper foil	–	–		2.4.8.2	3.9.1.1.1
1. After Thermal Stress	–	–		2.4.8.3	3.9.1.1.2
2. At 150°C [221°F]	–	–			3.9.1.1.3
3. After Process Solutions	–	–			
C. All other foil – composite	–	–			
2. Volume Resistivity, minimum					
A. C-96/35/90	10 <sup>11</sup>	–	MΩ-cm	ASTM D-257	
B. After moisture resistance	–	–			
C. At elevated temperature E-24/125	–	–			
3. Surface Resistivity, minimum					
A. C-96/35/90	10 <sup>9</sup>	–	MΩ	ASTM D-257	
B. After moisture resistance	–	–			
C. At elevated temperature E-24/125	–	–			
4. Moisture Absorption, maximum	0.05	–	%	ASTM-D-570	3.12.1.1
5. Dielectric Breakdown, minimum	–	–	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>6</sup> Hz, maximum	As Specified Above	–	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>6</sup> Hz, maximum	0.003	–	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum					
A. Length direction	–	–	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
B. Cross direction	–	–			
9. Thermal Stress 10 s at 288°C [550°F], minimum					
A. Unetched	–	–	s	2.4.13.1	3.10.1.2
B. Etched	–	–			
10. Electric Strength, minimum	100 [2450]	–	V/mm [V/mil]	ASTM D-149	3.11.1.6 3.11.2.3
11. Flammability					
A. Average burn time, maximum	–	–	s	2.3.9	3.10.2.1
B. Individual burn time, maximum	–	–		2.3.10	3.10.1.1
12. CTE, average maximum					
X,Y Axes	–	–	ppm/°C	2.4.41	3.10.1.8
Z Axis	–	–		2.4.41.1	
<b>BONDING LAYER REQUIREMENTS</b>					
Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.	
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A	N/A
2. Reinforcement		N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A	N/A
4. Minimum Bonding Temperature	As specified above	°C	AABUS*		N/A
5. Maximum Process Temperature	AABUS*	°C	AABUS*		N/A

\*AABUS = As agreed upon between user and supplier.

Revision Date: January 2002

**SPECIFICATION SHEET**

Specification Sheet #	:	IPC-4103/16
Reinforcement	:	Woven or Non-Woven E-Glass
Resin System	:	PTFE
Filler	:	Ceramic
Permittivity Range	:	3.00 – 4.90
Permittivity Test Frequency	:	10 <sup>6</sup> or 10 <sup>10</sup> Hz
Nominal Permittivity	:	A – 3.20, B – 3.50, C – 4.50, X – AABUS*
ID Reference	:	N/A
Glass Transition Range	:	N/A

**LAMINATE REQUIREMENTS**

Laminate Requirement	Specification <0.76 mm [<0.030 in]	Specification ≥0.76 mm [≥0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150°C [221°F] 3. After Process Solutions C. All other foil – composite	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	AABUS*  0.71 [3.98] 0.71 [3.98] 0.71 [3.98] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>3</sup> – 10 <sup>3</sup>	10 <sup>3</sup> – 10 <sup>3</sup>	MΩ-cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10 <sup>3</sup> – 10 <sup>3</sup>	10 <sup>3</sup> – 10 <sup>3</sup>	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.35	0.35	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10 <sup>10</sup> Hz, maximum	As Specified Above	–	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10 <sup>10</sup> Hz, maximum	0.04	0.04	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	28 [4060] 21 [3050]	N/mm <sup>2</sup> [lb/inch <sup>2</sup> ]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288°C [550°F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.7 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

**BONDING LAYER REQUIREMENTS**

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement		N/A		
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

\*AABUS = As agreed upon between user and supplier.



ASSOCIATION CONNECTING  
ELECTRONICS INDUSTRIES

# ANSI/IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits Definition Submission/Approval Sheet

The purpose of this form is to keep current with terms routinely used in the industry and their definitions. Individuals or companies are invited to comment. Please complete this form and return to:

IPC  
2215 Sanders Road  
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- This is a **NEW** term and definition being submitted.
- This is an **ADDITION** to an existing term and definition(s).
- This is a **CHANGE** to an existing definition.

Term	Definition

If space not adequate, use reverse side or attach additional sheet(s).

Artwork:  Not Applicable  Required  To be supplied

Included: Electronic File Name: \_\_\_\_\_

Document(s) to which this term applies: \_\_\_\_\_

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Date Received: _____	Date of Initial Review: _____
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Revision Inclusion: _____	<input type="checkbox"/> Accept Modify
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Terms and Definition Committee Final Approval Authorization: Committee 2-30 has approved the above term for release in the next revision.	
Name: _____ Committee: <u>IPC 2-30</u> Date: _____	

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 tel 847/790-5398  
 e-mail: [AliciaBalonek@ipc.org](mailto:AliciaBalonek@ipc.org)

### APEX<sup>®</sup> / IPC SMEMA Council Electronics Assembly Process Exhibition & Conference



APEX is the premier technical conference and exhibition dedicated entirely to the electronics assembly industry. Visit [www.GoAPEX.org](http://www.GoAPEX.org) for upcoming dates and more information.

#### Exhibitor information:

Contact: Mary MacKinnon  
 tel 847/790-5386  
 e-mail: [MaryMacKinnon@ipc.org](mailto:MaryMacKinnon@ipc.org)

#### Registration information:

tel 847/790-5360  
 fax 847/509-9798  
 e-mail: [goapex@ipc.org](mailto:goapex@ipc.org)

### How to Get Involved

The first step is to join IPC. An application for membership can be found in the back of this publication. Once you become a member, the opportunities to enhance your competitiveness are vast. Join a technical committee and learn from our industry's best while you help develop the standards for our industry. Participate in market research programs which forecast the future of our industry. Participate in Capitol Hill Day and lobby your Congressmen and Senators for better industry support. Pick from a wide variety of educational opportunities: workshops, tutorials, and conferences. More up-to-date details on IPC opportunities can be found on our web page: [www.ipc.org](http://www.ipc.org).

For information on how to get involved, contact:

Jeanette Ferdman, Membership Director  
 tel 847/790-5309 fax 847/509-9798  
 e-mail: [JeanetteFerdman@ipc.org](mailto:JeanetteFerdman@ipc.org) www.[ipc.org](http://ipc.org)

# Application for IPC Site Membership



Thank you for your decision to join IPC, Association Connecting Electronics Industries. IPC membership is site specific, which means that benefits of IPC membership are extended only to employees at the site that is designated on this application. To help IPC serve your member site in the most effective manner possible, please tell us what work is being done at your site by choosing the most appropriate member category. *(Check one box only.)*

## INDEPENDENT PRINTED CIRCUIT BOARD MANUFACTURER

This facility manufactures, and sells to other companies, printed wiring boards (PWB's) or other electronic interconnection products on the merchant market.

**What products do you make for sale?**

One- and two-sided rigid, multilayer printed boards     Flexible printed boards     Other interconnections

**Site General Manager** \_\_\_\_\_  
Name Title

## EMSI COMPANY - Independent Electronics Assembly

This facility assembles printed wiring boards, on a contract basis, and may offer other electronic interconnection products for sale.

**Site General Manager** \_\_\_\_\_  
Name Title

## OEM - Original Equipment Manufacturer

This facility purchases and/or manufactures printed wiring boards or other interconnection products for use in a final product, which we manufacture and sell.

**What is your company's primary product line?**

\_\_\_\_\_  
**Site General Manager** \_\_\_\_\_  
Name Title

## INDUSTRY SUPPLIER

This facility supplies raw materials, machinery, equipment, or services used in the manufacture or assembly of electronic interconnection products.

**What products or services does your company supply?** (50 word limit, please)

The information that you provide here will appear in the next edition of the IPC Membership Directory.

*Our company supplies:*

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## GOVERNMENT AGENCY/ACADEMIC TECHNICAL LIAISON

This government agency or accredited university, college or technical training school is directly concerned with design, research and utilization of electronic interconnection devices. (Must be a non-profit or not-for-profit organization.)

# Application for IPC Site Membership



**Site Information:** (Please print or type)

Company Name			
Street Address			
City	State	Zip/Postal Code	Country
Main Switchboard Phone No		Main Fax No.	
Company E-Mail Address		Website URL	
Name of Primary Contact for all IPC matters		Title	Mail Stop
Phone No.	Fax No	E-Mail	
Name of Senior Management Contact:		Title:	Mail Stop
Phone No	Fax No	E-Mail	

Please attach business card of primary contact here.

**Please designate your site's Technical Representatives:**

For PWB/PWA design-related information and activities:

Contact Name	Title	Phone	Fax	E-mail
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For PCB fabrication-related information and activities:

Contact Name	Title	Phone	Fax	E-mail
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For Electronics Assembly-related information and activities:

Contact Name	Title	Phone	Fax	E-mail
--------------	-------	-------	-----	--------

**Please designate your site's Management Representatives:**

For PWB/PWA design-related information and activities:

Contact Name	Title	Phone	Fax	E-mail
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For PCB fabrication-related information and activities:

Contact Name	Title	Phone	Fax	E-mail
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For Electronics Assembly-related information and activities:

Contact Name	Title	Phone	Fax	E-mail
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# Application for IPC Site Membership



## MEMBERSHIP DUES SCHEDULE

### Please check one:

- \$1,000.00** – Annual dues for Primary Site Membership  
Twelve months of IPC membership begins from the time the application and payment are received at the IPC office.
- \$800.00** – Annual dues for Additional Facility Membership  
An additional membership for a site within an organization where there already is a current Primary Site IPC membership.
- \$600.00\*\*** – Annual dues for an independent PCB/PWA fabricator or independent EMSI provider with annual sales of less than \$1,000,000.00. USD  
\*\* Please provide proof of annual sales.
- \$250.00** – Annual dues for Government Agency or Academic Technical Liaison Membership. Must be not-for-profit organization.

### TMRC MEMBERSHIP

- Please send information on participation in the Technology Market Research Council (TMRC) program. Only current IPC member sites are eligible to participate in this **calendar year** program, which is available for an additional fee.
- Yes, sign up our site now:**
  - \$950.00** - Primary TMRC member site
  - \$400.00** - Additional facility TMRC member. Another site within our organization is already a TMRC program participant.

### Name of Primary Contact for all TMRC matters:

\_\_\_\_\_

Phone \_\_\_\_\_

Fax \_\_\_\_\_

E-Mail \_\_\_\_\_

## PAYMENT INFORMATION

Enclosed is our check/money order for \$ \_\_\_\_\_

### Mail application with check or money order to:

IPC  
Dept. 77-3491  
Chicago, IL 60678-3491

### Fax or mail application with credit card payment to:

IPC  
\*2215 Sanders Road  
Northbrook, IL 60062-6135  
Tel: 847-509-9700  
Fax: 847-509-9798

*\* Overnight deliveries to this address only*

Please bill my credit card (circle one) for \$ \_\_\_\_\_

- MasterCard     American Express     Visa     Diners Club

Account No \_\_\_\_\_

Expiration Date \_\_\_\_\_

Name of Card Holder \_\_\_\_\_

Authorized Signature \_\_\_\_\_

Phone Number \_\_\_\_\_

## QUESTIONS ?

Call the IPC Member Services Department in Northbrook, Illinois,  
at: 847-509-9700 (extensions 5309/5372)  
or fax us at 847.509-9798

E-mail: [JeanetteFerdman@ipc.org](mailto:JeanetteFerdman@ipc.org) [SusanStorck@ipc.org](mailto:SusanStorck@ipc.org)

# Application for IPC Site Membership



## INFORMATION DISTRIBUTION

IPC has significant member benefits available to a wide range of individuals within your organization. To ensure that your facility takes advantage of these benefits, please provide the name of the individual responsible for each of the functional areas listed below. If one person has multiple responsibilities, please list that person's name as many times as necessary.

### **Chief Executive:**

Name	Title/Mail Stop	Phone	Fax	E-mail
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### **Sales/Marketing:**

Name	Title/Mail Stop	Phone	Fax	E-mail
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### **Finance (CFO)**

Name	Title/Mail Stop	Phone	Fax	E-mail
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### **Human Resources**

Name	Title/Mail Stop	Phone	Fax	E-mail
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### **Environmental/Safety**

Name	Title/Mail Stop	Phone	Fax	E-mail
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### **Design/Artwork**

Name	Title/Mail Stop	Phone	Fax	E-mail
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### **Product Assurance**

Name	Title/Mail Stop	Phone	Fax	E-mail
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### **Manufacturing**

Name	Title/Mail Stop	Phone	Fax	E-mail
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### **Training**

Name	Title/Mail Stop	Phone	Fax	E-mail
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### **Purchasing**

Name	Title/Mail Stop	Phone	Fax	E-mail
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## IPC REVIEW SUBSCRIPTION LIST

One of the many benefits of IPC membership is a subscription to the *IPC Review*, our monthly magazine. Please list below the names of individuals who would benefit from receiving our magazine, which provides information about the industry, IPC news, and other items of interest. A subscription for the IPC Primary Contact person is entered automatically.

Name	Title/Mail Stop
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Name	Title/Mail Stop
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Name	Title/Mail Stop
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Name	Title/Mail Stop
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Name	Title/Mail Stop
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Name	Title/Mail Stop
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ASSOCIATION CONNECTING  
ELECTRONICS INDUSTRIES®

# Standard Improvement Form

IPC-4103

The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard.

Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to:

IPC  
2215 Sanders Road  
Northbrook, IL 60062-6135  
Fax 847 509.9798  
E-mail: answers@ipc.org

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1. I recommend changes to the following:

Requirement, paragraph number \_\_\_\_\_  
 Test Method number \_\_\_\_\_, paragraph number \_\_\_\_\_

The referenced paragraph number has proven to be:

Unclear  Too Rigid  In Error  
 Other \_\_\_\_\_

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2. Recommendations for correction:

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3. Other suggestions for document improvement:

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Submitted by:

Name \_\_\_\_\_ Telephone \_\_\_\_\_

Company \_\_\_\_\_ E-mail \_\_\_\_\_

Address \_\_\_\_\_

City/State/Zip \_\_\_\_\_ Date \_\_\_\_\_

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