The Institute for

Interconnecting

and Packaging

Electronic Circuits

IPC-L-109B

Specification for Resin Impregnated Fabric (Prepreg) for Multilayer Printed Boards

IPC-L-109B

Original Publication - March 1976

A standard developed by the Institute for Interconnecting and Packaging Electronic Circuits

Revision A - October 1980
Revision B - June 1992

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- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feed back system on use and problems for future improvement

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The material in this standard was developed by the Prepreg Task Group of the Multilayer Board Materials Subcommittee of the Base Materials Committee of the Institute for Interconnecting and Packaging Electronic Circuits.

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

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ACKNOWLEDGMENT

Any Standard involving a complex technology draws material from a vast number of sources. While the principle members of the Prepreg Task Group of the Multilayer Board Materials Subcommittee of the IPC Base Materials Committee are shown below, it is not possible to include all of those who assisted in the evolution of this Standard. To each of them, the members of the IPC extend their gratitude.

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Specification for Resin Impregnated Fabric (Prepreg) for Multilayer Printed Boards

1.0 GENERAL

1.1 Scope This specification covers the requirements for semi-cured, resin impregnated fabric (i.e. prepreg, B-stage) to be used primarily as bonding plies for multilayer printed boards.

1.2 Pregreg Callout The following system identifies the prepreg qualified to this specification by material type and performance attributes.

IPC-L-109/	01	7628
Specification Number	Specification Sheet # (See 1.2.1)	Reinforcement Style (see 1.2.2)

43	25F	16	3
Nominal Resin Content (see 1.2.3)	Nominal Resin Flow (see 1.2.4)	Nominal Gel Time (see 1.2.5)	Quality Class (see 1.2.6)

1.2.1 Specification Sheet Description At the end of this document is a series of specification sheets. Each sheet outlines requirements for a prepreg indicating reinforcement type and resin system. The sheets are provided with a number for ordering purposes. For example, if a user wished to order from specification sheet number 06, the number ''06'' would be substituted for the ''01'' in the above designation example (IPC-L-109/06).

1.2.2 Reinforcement Style The reinforcement style is identified by three or four digits. For example, ''7628'' represents glass reinforcement style 7628 per IPC-EG-140. Reinforcement properties such as thickness, construction, and weight are established in accordance with the reinforcement style designations of the appropriate material specification.

1.2.3 Nominal Resin Content Resin content is identified by a two-digit number which indicates either of two approaches: Resin Content Percent or Treated Weight, and the nominal value specified. For Resin Content Percent, the value is percent of resin by weight, while for Treated Weight the value is decigrams of total weight of resin plus reinforcement. XX may be used to represent that resin content is not a procurement requirement (see 3.8.3).

1.2.4 Nominal Resin Flow Resin flow is identified by three digits which indicate the nominal value specified and either of two techniques; military resin flow or scaled flow thickness.

1.2.4.1 Resin Flow Percentage When specified by the special considerations designator ''F'' the nominal resin flow is identified by a two digit number representing percent by weight. For example, ''28F'' represents 28 percent nominal resin flow. The designation ''XX'' **shall** be used for the nominal resin flow of no-flow type prepreg (see 3.8.4).

1.2.4.2 Nominal Scaled Flow Thickness When specified by the special considerations designator ''S,'' the nominal scaled flow thickness is identified by a two digit number that indicates the per ply pressed thickness of the test specimen in ten thousandths of an inch. For example, 70S represents 0.0070 inch per ply pressed thickness. When using metric designation the special consideration designator ''M'' will be used proceeded by a two digit number that represents the per ply pressed thickness of the test specimen in hundredths of a millimeter. Therefore, 18M would be used to identify the metric equivalent of the example above.

1.2.5 Nominal Gel Time The nominal gel time is identified by a two-digit number representing tens of seconds. For example, ''09'' represents 90 nominal seconds of gel time. The designation **shall** be XX to indicate that gel time is not applicable.

1.2.6 Quality Classifications This specification recognizes that prepreg will be subjected to classifications by intended end item use. Toward this end, four general classes have been established to reflect progressive increases in sophistication, functional performance requirements and testing inspection frequency. It should also be recognized that there may be an overlap of equipment between classes. The user has the responsibility to determine the class into which his product belongs. The four classes are:

Class 1—Consumer Products Material in this class is suitable for applications where cosmetic defects are not important and the only requirement is functionality of the complete circuit. This material has a very low level required inspection and testing.

Class 2—General Industrial Material in this class is suitable for sophisticated industrial circuit design where moderate levels of assurance are demonstrated via the use of testing and/or SPC/SQC techniques.

Class 3—High Performance Industrial Material in this class is suitable for high reliability electronic applications

where high levels of assurance are demonstrated via the use of testing and/or SPC/SQC techniques.

Class 4—High Reliability Material in this class is suitable for equipment where continuous performance is critical and/or a life support item. The material in this class requires high levels of assurance, testing and certification.

1.2.6.1 Requirements in this specification have been separated so that the performance of the prepreg may be tested to any one of the four classes as defined on the applicable specification sheet. Where no class differentiation is made, the requirements for all four classes are identical. The use of one class for a specific attribute does not mean that all other attributes must meet that same class. Selection should be based on need, however, crossover between classes requires complete definition of test requirements in the procurement document.

1.3 Dimensions and Tolerances All dimensions and tolerances specified herein are applicable only to the end product. Dimensions are expressed in millimeters. Inches, shown in brackets [ ], are not direct conversions in order to provide usable numbers. Users are cautioned to employ a single system and not intermix metric and inch-based equivalents. Reference information is shown in parentheses ( ).

2.0 APPLICABLE DOCUMENTS

The following documents of the issue in effect at the time of the order form a part of this specification to the extent specified herein.

2.1 IPC[1]

IPC-T-50 Terms and Definitions for Interconnections and Packaging Electronic Circuits

IPC-EG-140 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-TM-650 Test Methods[2]

2.1.5 Surface Examination

2.1.10 Visual Inspection for Dicyandiamide Crystals

2.3.4.2 Chemical Resistance of Prepreg Materials to Methylene Chloride

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2.5.6.2 Electric Strength of Printed Wiring Material

2.6.1 Fungus Resistance, Printed Wiring Materials

2.2 Department of Defense[3]

MIL-STD-105 Sampling Procedure And Tables For Inspection by Attributes

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts

MIL-STD-45662 Calibration System Requirements

3.0 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 Testing Qualification testing is performed to demonstrate the vendor's ability to meet all of the requirements of the specification involved by the user.

3.1.2 Quality Conformance Testing Quality conformance testing is performed on a regular basis following qualification testing to demonstrate that the vendor is continually meeting the quality requirements of the specification.

3.2 Specification Sheets The individual item requirements **shall** be as specified herein and in accordance with the applicable specification sheets. Where no specification

1. Publications are available from: IPC, 2215 Sanders Road, Northbrook, IL 60062-6135
2. For convenience, applicable test methods from IPC-TM-650 are reprinted in the back of this standard. These methods represent the latest in effect at the time of standard publication. Methods may be updated independent of standard revision. Users should check IPC-TM-650 for the most up-to-date methods.
3. Publications are available from: Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111–5094.

sheet is applicable or available, the individual requirements **shall** be as specified in complementary documents such as master drawings or ordering data sheets (see 6.1).

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

1. Purchase order
2. Master drawing or ordering data sheets (see paragraph 6.1D)
3. This specification
4. Applicable documents (see paragraph 2.0)

3.4 Qualifications All material furnished under this standard **shall** be products which are qualified. The vendor **shall** supply on request certified data that the prepreg meets the requirements of this standard using the test methods described herein. Additional data pertaining to design and engineering considerations **shall** also be provided as applicable.

3.5 Material

3.5.1 Reinforcement Construction of reinforcement fabrics **shall** be in accordance with the pertinent IPC documents (see 2.0). Other reinforcements types and their properties **shall** be agreed upon between the user and vendor.

3.5.2 Resin Systems Resin systems used to produce prepreg under this specification **shall** be as specified in the individual specification sheets (see 1.2.1).

3.5.3 Color and Visual Characteristics Unless otherwise specified, all prepreg is supplied in the natural (undyed/unpigmented) color. If another color is required by the user, it **shall** be specified on the purchase order.

Agents which may be added to a natural color resin system to enhance processing, such as tinting agents for contrast in automatic optical inspection, **shall** not decrease the visual clarity or adversely affect the performance, properties, or functionality of the prepreg.

3.6 General Requirements/Acceptability Prepreg **shall** be considered acceptable if it meets the requirements listed below, or as agreed upon between user and vendor. Unless otherwise specified (see 6.1 J.), Grade A **shall** be in effect for those properties having multiple requirement levels, e.g. Grade A or B. Requirements apply to the working area defined in 3.6.1 and 3.6.2 unless otherwise specified.

Note: When tests are performed by the procuring activity, prepreg should be properly stored and should be tested as soon as possible after receipt (not to exceed 10 days).

3.6.1 Configuration and Working Area Prepreg **shall** be supplied in a configuration of fabricated panels or rolls. The working area of the prepreg is that portion of the prepreg's configuration in which all requirements of this specification **shall** apply.

3.6.1.1 Fabricated Prepreg Panels Fabricated panels are cut-to-size pieces of prepreg that are nominally (length times width, excluding consideration of tooling holes or other cut-outs) less than 0.56 sq. meters (6.0 sq. feet). For Grade A, the working area **shall** be the area excluding a 25±5 mm [1.0±0.2 in] border. For Grade B, it is the area excluding a 15±3 [0.6±0.12 in] border.

3.6.1.2 Prepreg Rolls Prepreg rolls are continuous lengths of prepreg that are rolled for the purposes of inventory and custom panel fabrication by the user. Grade A only is applicable, in which the working area **shall** be the prepreg excluding the outer 25±5 mm [1.0±0.2 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-spliced breaks in the continuous length of the prepreg. The length of the roll **shall** be compensated to replace that prepreg unsuitable for panel fabrication (see 3.7.2).

3.6.2 Visual When tested in accordance with paragraph 4.6.1, the material **shall** meet the visual requirements of paragraphs 3.6.2.1–3.6.2.3.

3.6.2.1 Inclusions Conductive inclusions are not acceptable. Inclusions or foreign material that are non conductive **shall** be acceptable providing they are no greater than the longest dimension specified in Table 1, and occurs no more frequently than that specified in Table 1 per 300 x 300 mm [12 x 12 in] of surface for the panel size inspected or a 610 mm [2 foot] x width sample.

3.6.2.2 Impregnation Imperfections Imperfections in impregnation **shall** be acceptable providing the criteria are met as specified in Table 1.

3.6.2.3 Presence of Dicyandiamide When applicable, the presence of dicyandiamide (dicy) **shall** be in accordance with the requirements in the applicable specification sheet, when tested in accordance with 4.6.1.1.

3.7 Dimensional Requirements Length and width **shall** be determined in accordance with 4.6.2.

3.7.1 Roll Width The width of prepreg rolls **shall** be as specified in the procurements document (see 6.1). The width of the material **shall** be within +6.4 –0 mm [+1/4 –0 in] of the value specified.

3.7.2 Roll Length The length of the prepreg rolls **shall** be as specified in the procurement document (see 6.1). The length **shall** be within ±1% of the value specified.

Table 1

	Class 1	Class 2	Class 3	Class 4
Nonconductive Foreign Material Size:	NR	1.0 mm [0.040 in] max.	0.50 mm [0.020 in] max.	0.50 mm [0.020 in] max.
Frequency:	NR	6 max	2 max	2 max
Impregnation imperfections Overall prepreg thickness increase from reinforcement imperfections	NR	100% max	50% max	50% max
Dewetted areas (measured in at least 2 dimensions)	NR	6.4mm [0.25 in] max	2.3 mm [0.093 in] max	2.3 mm [0.093 in] max
Pin-holed areas	NR	1.3 mm [0.050 in] max	0.65 mm [0.025 in]	0.65 mm [0.025 in] max
Reinforcement distortion (variation in pick line) per 300 mm [12 in] distance	NR	25mm [1 in] max	25 mm [1 in] max	25 mm [1 in]
Glass exposure to creases	NR	25 mm [1 in] max	15 mm [0.6 in] max	15 mm [0.6 in] max
Silver Streaks (nonwetted fibers)	NR	3 per yarn max	1 per yarn max	None
Brown Sreaks (Binder marks) per 300 sq mm [144 sq in]	NR	10, max	2, max	None

3.7.3 Sheet or Panel Width and Length The width and length of prepreg sheets **shall** be as specified in the procurement document (see 6.1). The permissible variations from the specified length or width **shall** be as specified in Table 2. Adjacent edges **shall** be perpendicular within 0.13 mm per 25 mm [0.005 inch per inch].

Table 2 Permissible Variation in Length and Width

Prepregs	Panel Size, Inch		
	<300 mm [12 in]	300–600 mm [12–24 in]	>600 mm [24 in]
Grade A	1.6 mm [0.063 in]	3.2 mm [0.125 in]	6.4 mm [0.250 in]
Grade B	0.8 mm [0.031 in]	1.6 mm [0.063 in]	3.2 mm [0.125 in]

3.8 Physical Requirements

3.8.1 Gel Time When applicable and when tested in accordance with 4.6.3, the gel time shall conform to the nominal time as specified (see 1.2.5).

3.8.2 Volatile Content When tested in accordance with 4.6.4, the volatile content **shall** not be greater than the property values shown in the applicable specification sheet (see 3.2).

3.8.3 Resin Content The resin content **shall** be specified by resin content percent or treated weight total.

3.8.3.1 Resin Content Percent The resin content percent **shall** be specified by 3.8.3.1.1 or 3.8.3.1.2.

3.8.3.1.1 Resin Content Percent (by treated weight) When tested in accordance with 4.6.5.1 the percentage of resin content **shall** be as indicated in the applicable specification sheet.

3.8.3.1.2 Resin Content Percent (by burn-out) When tested in accordance with 4.6.5.2 the percentage of resin content **shall** be as indicated in the applicable specification sheet.

3.8.3.2 Treated Weight Total The treated weight total when applicable **shall** be as specified in the applicable specification sheet or agreed between user and vendor.

3.8.3.3 Variation Within a Panel Resin content variation is no greater than that specified in the specification sheet and class within cut-to-size panels or 0.28 sq. meters [3 sq.ft.], whichever is greater.

3.8.4 Resin Flow Resin flow **shall** be specified by resin flow percent, scaled flow thickness, or no flow inches, as applicable.

3.8.4.1 Resin Flow Percent When tested in accordance with 4.6.7.1, the percentage of resin flow **shall** not vary from the nominal percentage more than that specified by the applicable specification sheet.

3.8.4.2 Scaled Flow Thickness When tested in accordance with 4.6.7.2, the nominal prepreg thickness per ply **shall**, unless otherwise specified, not vary from the nominal thickness more than that specified by the applicable specification sheet.

3.8.4.3 Resin Flow for No Flow Type Prepreg. Resin flow shall be specified by resin flow percent when tested in accordance with 4.6.7.1 or no flow inches when testing in accordance with 4.6.7.3 and **shall** not vary more than that specified by the applicable specification sheet .

3.8.5 Density When applicable, information on the density of the reinforcement and the resin **shall** be supplied by the vendor to the user.

3.8.6 Chemical Resistance (optional) When specimens are tested in accordance with paragraph 4.6.8, the weight gain following chemical exposure **shall** be as agreed upon between the user and vendor.

3.8.7 Permittivity When specimens are tested in accordance with paragraph 4.6.9.1 the average maximum permittivity **shall** be as indicated in the applicable specification sheet.

3.8.8 Loss Tangent When specimens are tested in accordance with paragraph 4.6.9.2 the average maximum loss tangent **shall** be as indicated in the applicable specification sheet.

3.8.9 Electric Strength When specimens are tested in accordance with paragraph 4.6.9.3 the minimum average electric strength **shall** be as indicated in the applicable specification sheet.

3.8.10 Flammability Where applicable and when tested in accordance with 4.6.10, the maximum average burn length and burn time **shall** be as indicated in the applicable specification sheet.

3.8.11 Fungus Resistance When tested in accordance with paragraph 4.6.11, the specimen **shall** resist fungus growth.

3.9 Workmanship The prepreg **shall** be manufactured and processed in such a manner as to be uniform in quality and **shall** be free from defects other than those specified elsewhere in this document that will affect life and serviceability.

3.10 Shelf Life The prepreg shall be capable of meeting the requirements for resin content, resin flow, gel time (if applicable), and volatile content for a period of time as defined by the applicable specification sheet when stored under specified conditions.

3.11 Material Safety Prepregs supplied to this specification **shall** have available a Material Safety Data Sheet (M.S.D.S.) or other information as appropriate upon request.

3.12 Marking Prepreg sheets or panels **shall** have a label attached to the unit package. Prepreg rolls **shall** have a label securely attached to the compatible protective bag enveloping the roll and a label attached to the inside of the core mandrel at both ends. In addition each exterior container **shall** be marked. The following information is to be included:

a. Specification number and type of material

b. Manufacturers material designation and lot number

c. Quantity unit of issue and dimensions

d. Gross weight

e. Date packed[4]

f. Contact number, manufacturers source code number, when applicable

g. Manufacturers name and address

h. Date of manufacture[5]

i. Prepreg parameters[6]

4.0 QUALITY ASSURANCE PROVISIONS

4.1 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, unless disapproved by the procuring authority. The procuring authority reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and service is performed to the prescribed requirements.

4.1.1 Test Equipment and Inspection Facilities Test 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. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment **shall** be in accordance with MIL-STD-45662.

4.1.2 Inspection Lot

4.1.2.1 For Class 1 and 2 Prepregs An inspection lot **shall** consist of all the prepreg produced from the same batch or equivalent batches of constituent materials and under essentially the same manufacturing conditions.

4.1.2.2 Inspection Lot for Class 3 and 4 Prepreg An inspection lot **shall** be 230 meters [250 yards] or one roll, whichever is greater, and in accordance with 4.5.1.1. An inspection lot for Class 3 prepreg may be considered as per

4. Date of packing for shipment to customer or warehouse.
5. Date when material was impregnated.
6. To include as a minimum resin content or treated weight, MIL flow or scaled flow, and gel time (where applicable).

4.1.2.1 if the manufacturer can demonstrate effective SPC/SQC utilization.

4.1.3 Preparation of Samples Unless otherwise specified herein samples **shall** be prepared in accordance with standard in-house procedures.

4.1.4 Standard Laboratory Conditions Unless otherwise specified herein, all inspections **shall** be performed in accordance with the test conditions specified in the General Requirements of MIL-STD-202.

4.2 Classification of Inspections The inspections specified herein are classified as follows:

1. Materials inspection (see 4.3)
2. Qualification inspection (see 4.4)
3. Quality conformance inspection (see 4.5)

4.3 Materials Inspection Materials inspection **shall** consist of test data verifying that the material is in accordance with the referenced specification or requirements prior to such fabrication.

4.4 Qualification Testing (Class 4 only) Class 4 Qualification testing **shall** be performed at a laboratory acceptable to the customer on sample units produced with equipment and procedures normally used in production.

4.4.1 Samples Sample sheets **shall** be selected from normal production for each manufacturers brand type for which qualification is sought. The number of samples required per sheet **shall** be as specified in Table 4. The number of specimens required for the individual test methods **shall** be cut from the sheets and inspected as specified.

4.4.2 Frequency Each material (as outlined in the specification sheets) **shall** undergo qualification once. The vendor upon demand **shall** provide data that the supplied material is qualified to this standard.

4.4.3 Inspection Routine The sample specimen **shall** be subjected to the inspection specified in paragraphs 4.6 through 4.6.11. See Table 3.

4.4.4 Extension of Qualification For a given specification sheet, qualification of any prepreg **shall** be extended to all reinforcement styles, Resin Contents, Resin Flow and Gel Time (see 1.2) produced at the same facility utilizing the same resin system and essentially the same processes and sold under the same manufacturer's grade name. Qualification to a quality class **shall** be extended to all lower quality classes.

4.4.5 Requalification Requalification **shall** be required when additions, removals, or changes are made to the constituents or the manufacturing process which affect the performance, properties, or functionality of the prepreg. Other criteria for cause for requalification **shall** be agreed upon by vendor and user.

4.5 Quality Conformance Inspection

4.5.1 Quality Conformance Inspection Quality conformance group consist of the examinations specified in Table 4.

4.5.1.1 Frequencies The frequencies of inspection **shall** be by Quality Class in accordance with Table 4. Where ''lot'' is indicated in Table 4, the number of rolls to be randomly selected from each lot is as follows:

a) ***Class 1 through 3.*** One yard at the beginning and end of each master roll.

b) ***Class 4:*** One meter [yard] at the beginning of a roll and every 230 meters [250 yards] thereafter. Examples: A 460 meter [500 yard] roll would have 3 samples taken for lot testing and a 690 meter [750 yard] roll would have 4 samples taken. For runs less than 230 meters [250 yards] a sample **shall** be taken at the beginning and at the end of the roll. If a roll is not divisible by 230 meters [250 yards], then samples **shall** be taken at the beginning, at 230 meter [250 yard] increments and at the end. A 550 meter [600 yard] roll would have 4 samples taken, at the beginning, at 230 [250], 460 [500] and 550 meter [600 yard] points. If the prepreg is cut into sheets the same rules apply regardless of sheet size.

4.5.1.2 Sample Size When a period of 1 month or more is specified in Table 4, the sample size and required acceptance number shall be:

Total linear dimensions produced during each sampling period	Number of Samples	Acceptance number
730 meters [800 yards] or less	2	0
731 to 20,100 meters [801 to 22,000 yards]	3	1
20,100 meters [22,000 yards] or more	5	2

4.5.1.3 Rejected Lots If an inspection lot is rejected, the supplier may or screen out the defective units and resubmit for inspection. Resubmitted lots **shall** be inspected using tightened inspection level III from MIL-STD-105 for high reliability and double the normal sampling plan for commercial. Such lots **shall** be separate from new lots, and **shall** be clearly identified as reinspected lots.

Table 3 Qualification and Paragraph Reference Table

Test Paragraph	Requirement Paragraph	Method Paragraph	Test Method[1]
General			
Visual	3.6.2	4.6.1	2.1.5
Dimensional	3.7	4.6.2	—
Physical			
Gel Time	3.8.1	4.6.3	2.3.18
Volatile Content	3.8.2	4.6.4	2.3.19
Resin Content[2]	—	—	—
Resin Content Percent	—	—	—
By Treated Weight	3.8.3.1.1	4.6.5.1	2.3.16.1
By Burn-Off	3.8.3.1.2	4.6.5.2	2.3.16
Treated Weight Total	3.8.3.2	4.6.6	2.3.16.2
Resin Flow[3]	—	—	—
Resin Flow Percent	3.8.4.1	4.6.7.1	2.3.17
Scaled Flow Thickness	3.8.4.2	4.6.7.2	2.4.38
No Flow Inches	3.8.4.3	4.6.7.3	2.3.17.2
Density	3.8.5	—	—
Chemical Resistance	3.8.6	4.6.8	2.3.4.2
Permittivity	3.8.7	4.6.9.1	2.5.5.3
Loss Tangent	3.8.8	4.6.9.2	2.5.5.3
Electric Strength	3.8.9	4.6.9.3	2.5.6.2
Flammability	3.8.10	4.6.10	2.3.9
Fungus Resistance	3.8.11	4.6.11	2.6.1

[1]All methods are from IPC-TM-650 unless otherwise noted.
[2]For qualification purposes, Resin Content shall be in accordance with Resin Content Percent, by Burn-Off. For conformance testing (see 1.2), Resin Content may be either of 3.8.3.1.1, 3.8.3.1.2, or 3.8.3.2 as per 1.2.
[3]For prepreg types other than No Flow Prepreg, either Resin Flow percent or Scaled Flow Thickness may be specified for qualification and conformance testing.

Table 4 Frequency of Test

Tests	Class 1	Class 2	Class 3	Class 4	Specimens per Sample
Visuals	N/A	Lot	Lot	Lot	1
Dimensionals	N/A	Audit[3]	Audit[3]	Audit[3]	—
Gel Time	Lot	Lot	Lot	Lot	1
Volatile Content	N/A	N/A	Lot	Lot	1
Resin Content	Lot	Lot	Lot	Lot	1
Resin Flow	Lot	Lot	Lot	Lot	1
Density	A/R	A/R	A/R	A/R	—
Chemical Resistance[1]	N/A	3 mos.	1 mo.	Lot	3
Permittivity[2]	N/A	6 mos.	3 mos.	1 mo.	3
Loss Tangent[2]	N/A	6 mos.	1 mo.	1 mo.	3
Electric Strength	N/A	12 mos.	6 mos.	3 mos.	3
Flammability	N/A	12 mos.	6 mos.	3 mos.	3
Fungus	N/A	N/A	N/A	36 mos.	1

[1]Optional tests as agreed upon between user and vendor.
[2]Note applicable to specific material only.
[3]Vendor **shall** use a statistical sampling plan to assure conformance to dimensional specifications.
AR = As Required

If the defect cannot be screened out, the rejected lot **shall** be dispositioned in such a manner that separates it from lots which meet the Prepreg Callout (see 1.2). The vendor **shall** sample additional lots, and make processing corrections as necessary. If the additional lots inspected show the same defect it **shall** be the vendor's responsibility to contact the users regarding the problem.

4.6 Test Methods

4.6.1 Visual The specimen **shall** be tested in accordance with test method 2.1.5 of IPC-TM-650. The entire test specimen **shall** be examined with normal 20/20 vision.

4.6.1.1 Presence of Dicyandiamide The presence of dicyandiamide **shall** be determined as specified in IPC-TM-650, method 2.1.10.

4.6.2 Dimensions Length and width **shall** be measured with equipment capable of accuracy to verify the requirements of this specification.

4.6.3 Gel Time Gel time **shall** be measured as specified in IPC-TM-650, method 2.3.18.

4.6.4 Volatile Content Volatile content **shall** be measured in accordance with IPC-TM-650, method 2.3.19.

4.6.5 Resin Content Percent

4.6.5.1 Resin Content Percent (Treated Weight Method) Resin content (treated weight) **shall** be measured as specified in IPC-TM-650, method 2.3.16.1.

4.6.5.2 Resin Content Percent (by Burn-out) The final weight obtained in 4.6.4 **shall** be used as the initial weight for this test. Resin content **shall** be measured in accordance with IPC-TM- 650, method 2.3.16. The referee test method will be the burn out method in accordance with IPC-TM-650, method 2.3.16.

4.6.6 Treated Weight Total Treated weight total **shall** be measured as specified in IPC-TM-650, method 2.3.16.2.

4.6.7 Resin Flow

4.6.7.1 Resin Flow Percent Resin flow **shall** be measured in accordance with IPC-TM-650, method 2.3.17.

4.6.7.2 Scaled Flow Scaled flow thickness **shall** be tested in accordance with IPC-TM-650, method 2.4.38.

4.6.7.3 No Flow Percent **shall** be tested in accordance with 4.6.6. Inches of flow **shall** be measured in accordance with TM-650 2.3.17.2

4.6.8 Chemical Resistance Chemical resistance **shall** be measured in accordance with IPC-TM-650, method 2.3.4.2.

4.6.9 Electrical Properties Electrical properties **shall** be tested on specimens cut from fully cured 2-ply samples of a minimum size of 300 sq mm [144 sq in] that have been prepared in accordance with the manufacturers recommendations.

4.6.9.1 Permittivity The specimens **shall** be tested at 1 MHz in accordance with IPC-TM-650 method 2.5.5.3 .

4.6.9.2 Loss Tangent The specimens **shall** be tested at 1 MHz in accordance with IPC-TM-650 method 2.5.5.3 at 1 MHz.

4.6.9.3 Electric Strength The specimens **shall** be tested in accordance with IPC-TM-650 method 2.5.6.2.

4.6.10 Flammability The specimens **shall** be tested in accordance with IPC-TM-650 method 2.3.9.

4.6.11 Fungus Resistance The specimens **shall** be tested in accordance with IPC-TM-650 method 2.6.1.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging Prepreg **shall** be packed in a manner which will afford adequate protection against corrosion, deterioration, and physical damage during shipment and storage.

6.0 NOTES

6.1 Ordering Data Purchase orders should specify the following:

A. Title, number, and Date 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 or data sheet.
E. Information For Preparation of Delivery, if applicable. (See paragraph 5.0).
F. Part Identification and Marking Instructions.
H. Specify Preproduction Inspection if Applicable. (See paragraph 4.1).
I. Quality Classification (See paragraph 1.2.6).
J. Grade of property requirements other than A, if applicable (see 3.6).
K. Style, Width and Length of Material. (See paragraph 3.7).
L. Other Exceptions As Agreed Upon Between User and Vendor.

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 prepreg not listed, **shall** list a zero (0) for the specification sheet number (IPC-L-109/0).

Specification Sheet

Specification Sheet # : IPC-L-109/12
Reinforcement : Woven fabric, E-Glass
Resin System : Epoxy, majority difunctional, flame resistant
Military Designation : GFN, GFK
UL/ANSI/NEMA Designation: : FR-4
Glass Transition Range (Cured) : 110–150°C, by TM 2.4.25, IPC-TM-650

Properties	Class 1	Class 2	Class 3 & Class 4
1. Volatile Content, maximum % @ E 163°C	**NA**	**0.75**	**0.75**
2. Resin Content Tolerances	——	——	——
2a Resin Content Percent, ±% from Nominal	5.0	3.0	2.0
2b Treated Weight Total, ± mg from Nominal	TBD	TBD	TBD
2c Deviation within a Cut-to-Size Panel, ±%	3.0	2.0	1.0
3. Resin Flow Tolerance ±% from Nominal	7.0	5.0	3.0
4. Scaled Flow Tolerance ±mm [Mils] from Nominal	12.5 [0.5]	7.5 [0.3]	5.0 [0.2]
5. Gel Time Tolerance ±Seconds from Nominal	35	25	15
6. Electric Strength, minimum volts/mm [volts/mil]	NA	2.95E4 [750]	2.95E4 [750]
7. Permittivity @ 1 MHz maximum	NA	5.4	5.4
8. Loss Tangent @ 1 MHz maximum	NA	0.035	0.035
9. Flammability, maximum seconds individual	15	15	15
10. Shelf Life, as defined by Properties 1, 2, 3, 5	Minimum 6 months when stored at a maximum of 50% RH and 21°C		
11. Density of constituents: resin and reinforcement	As agreed upon between vendor and user		
12. Reinforcement	As specified in IPC-EG-140		
13. Dicyandiamide: permissable presence of crystals, clusters, flakes, or other forms	Light pattern of any form	Light pattern of crystals, only	Individual, scattered crystals, only

NA = Not Applicable

Specification Sheet

Specification Sheet # : IPC-L-109/12.1
Reinforcement : Woven fabric, E-Glass
Resin System : Epoxy, majority multifunctional, flame resistant
Military Designation : GFN, GFG
UL/ANSI/IPC Designation : FR-4
Glass Transition Range (Cured) : 150–200°C by TM 2.4.25, IPC-TM-650

Properties	Class 1	Class 2	Class 3 & Class 4
1. Volatile Content, maximum %	**NA**	**0.50**	**0.50**
2. Resin Content Tolerances	——	——	——
2a Resin Content Percent, ±% from Nominal	5.0	3.0	2.0
2b Treated Weight Total, ± mg from Nominal	TBD	TBD	TBD
2c Deviation within a Cut-to-Size Panel, %	3.0	2.0	1.0
3. Resin Flow Tolerance ±% from Nominal	7.0	5.0	3.0
4. Scaled Flow Tolerance ±mm [Mils] from Nominal	12.5 [0.5]	7.5 [0.3]	5.0 [0.2]
5. Gel Time Tolerance ±Seconds from Nominal	35	25	15
6. Electric Strength, minimum volts/mm [volts/mil]	NA	2.95E4 [750]	2.95E4[750]
7. Permittivity @ 1 MHz maximum	NA	5.4	5.4
8. Loss Tangent @ 1 MHz maximum	NA	0.025	0.025
9. Flammability, maximum seconds individual	15	15	15
10. Shelf Life, as defined by Properties 1, 2, 3, 5	Minimum 4 months when stored at a maximum of 50% RH and 21°C		
11. Density of constituents: resin and reinforcement	As agreed upon between vendor and user		
12. Reinforcement	As specified in IPC-EG-140		

NA = Not Applicable

Specification Sheet

Specification Sheet # : IPC-L-109/13
Reinforcement : Woven fabric, E-Glass
Resin System : Polyimide
Military Designation : GIN, GIL
UL/ANSI/IPC Designation : GPY
Glass Transition Range (Cured) : >250°C by TM 2.4.24, IPC-TM-650

Properties	Class 1	Class 2	Class 3 & Class 4
1. Volatile Content, maximum %	**NA**	**4.0**	**4.0**
2. Resin Content Tolerances	——	——	——
2a Resin Content Percent, ±% from Nominal	5.0	3.0	2.0
2b Treated Weight Total, ± mg from Nominal	TBD	TBD	TBD
2c Deviation within a Cut-to-Size Panel, %	3.0	2.0	1.0
3. Resin Flow Tolerance ±% from Nominal	7.0	5.0	3.0
4. Scaled Flow Tolerance ±mm [Mils] from Nominal	12.5 [0.5]	7.5 [0.3]	5.0 [0.2]
5. Gel Time Tolerance ±Seconds from Nominal	NA	NA	NA
6. Electric Strength, minimum volts/mm [volts/mil]	NA	2.95E4 [750]	2.95E4[750]
7. Permittivity @ 1 MHz maximum	NA	5.4	5.4
8. Loss Tangent @ 1 MHz maximum	NA	0.035	0.025
9. Flammability, maximum seconds individual	NA	NA	NA
10. Shelf Life, as defined by Properties 1, 2, 3	Minimum 3 months when stored at a maximum of 50% RH and 21°C		
11. Density of constituents: resin and reinforcement	As agreed upon between vendor and user		
12. Reinforcement	As specified in IPC-EG-140		

NA = Not Applicable

Specification Sheet

Specification Sheet # : IPC-L-109/13.1
Reinforcement : Woven fabric, E-Glass
Resin System : Polyimide
Military Designation : GIN, GIL
UL/ANSI/IPC Designation : GPY
Glass Transition Range (Cured) : >200°C by TM 2.4.24, IPC-TM-650

Properties	Class 1	Class 2	Class 3 & Class 4
1. Volatile Content, maximum %	**NA**	**2.0**	**2.0**
2. Resin Content Tolerances	——	——	——
2a Resin Content Percent, ±% from Nominal	5.0	3.0	2.0
2b Treated Weight Total, ± mg from Nominal	TBD	TBD	TBD
2c Deviation within a Cut-to-Size Panel, %	3.0	2.0	1.0
3. Resin Flow Tolerance ±% from Nominal	7.0	5.0	3.0
4. Scaled Flow Tolerance ±mm [Mils] from Nominal	12.5 [0.5]	7.5 [0.3]	5.0 [0.2]
5. Gel Time Tolerance ±Seconds from Nominal	NA	NA	NA
6. Electric Strength, minimum volts/mm [volts/mil]	NA	2.95E4 [750]	2.95E4[750]
7. Permittivity @ 1 MHz maximum	NA	5.4	5.4
8. Loss Tangent @ 1 MHz maximum	NA	0.035	0.025
9. Flammability, maximum seconds individual	NA	NA	NA
10. Shelf Life, as defined by Properties 1, 2, 3	Minimum 3 months when stored at a maximum of 50% RH and 21°C		
11. Density of constituents: resin and reinforcement	As agreed upon between vendor and user		
12. Reinforcement	As specified in IPC-EG-140		

NA = Not Applicable

Specification Sheet

Specification Sheet # : IPC-L-109/16
Reinforcement : Woven fabric, Aramid
Resin System : Epoxy, majority difunctional
Military Designation : AEN
UL/ANSI/IPC Designation : None
Glass Transition Range (Cured) : 110–150°C by TM 2.4.25, IPC-TM-650

Properties	Class 1	Class 2	Class 3 & Class 4
1. Volatile Content, maximum %	**NA**	**1.5**	**1.5**
2. Resin Content Tolerances	——	——	——
2a Resin Content Percent, ±% from Nominal	5.0	3.0	2.0
2b Treated Weight Total, ± mg from Nominal	TBD	TBD	TBD
2c Deviation within a Cut-to-Size Panel, %	3.0	2.0	1.0
3. Resin Flow Tolerance ±% from Nominal	7.0	5.0	3.0
4. Scaled Flow Tolerance ±mm [Mils] from Nominal	12.5 [0.5]	7.5 [0.3]	5.0 [0.2]
5. Gel Time Tolerance ±Seconds from Nominal	35	25	15
6. Electric Strength, minimum volts/mm [volts/mil]	NA	2.95E4 [750]	2.95E4[750]
7. Permittivity @ 1 MHz maximum	NA	4.0	4.0
8. Loss Tangent @ 1 MHz maximum	NA	0.025	0.025
9. Flammability, maximum seconds individual	15	15	15
10. Shelf Life, as defined by Properties 1, 2, 3	Minimum 6 months when stored at a maximum of 50% RH and 21°C		
11. Density of constituents: resin and reinforcement	As agreed upon between vendor and user		
12. Reinforcement	As specified in IPC-A-142		
13. Dicyandiamide: permissable presence of crystals, clusters, flakes, or other forms	Light pattern of any form	Light pattern of crystals, only	Individual, scattered crystals, only

NA = Not Applicable

Specification Sheet

Specification Sheet # : IPC-L-109/20
Reinforcement : Woven fabric, Quartz
Resin System : Polyimide
Military Designation : QIN
UL/ANSI/IPC Designation : None
Glass Transition Range (Cured) : >250°C by TM 2.4.24, IPC-TM-650

Properties	Class 1	Class 2	Class 3 & Class 4
1. Volatile Content, maximum %	**NA**	**5.0**	**4.0**
2. Resin Content Tolerances	——	——	——
2a Resin Content Percent, ±% from Nominal	5.0	3.0	2.0
2b Treated Weight Total, ± mg from Nominal	TBD	TBD	TBD
2c Deviation within a Cut-to-Size Panel, %	3.0	2.0	1.0
3. Resin Flow Tolerance ±% from Nominal	7.0	5.0	3.0
4. Scaled Flow Tolerance ±mm [Mils] from Nominal	12.5 [0.5]	7.5 [0.3]	5.0 [0.2]
5. Gel Time Tolerance ±Seconds from Nominal	NA	NA	NA
6. Electric Strength, minimum volts/mm [volts/mil]	NA	2.95E4 [750]	2.95E4[750]
7. Permittivity @ 1 MHz maximum	NA	3.6	3.6
8. Loss Tangent @ 1 MHz maximum	NA	0.010	0.010
9. Flammability, maximum seconds individual	NA	NA	NA
10. Shelf Life, as defined by Properties 1, 2, 3, 5	Minimum 6 months when stored at a maximum of 50% RH and 21°C		
11. Density of constituents: resin and reinforcement	As agreed upon between vendor and user		
12. Reinforcement	As specified in IPC-QF-143		

NA = Not Applicable

Specification Sheet

Specification Sheet # : IPC-L-109/21
Reinforcement : Woven fabric, Aramid
Resin System : Polyimide
Military Designation : AIN
UL/ANSI/IPC Designation : None
Glass Transition Range (Cured) : >250°C by TM 2.4.24, IPC-TM-650

Properties	Class 1	Class 2	Class 3 & Class 4
1. Volatile Content, maximum %	**NA**	**1.5**	**1.5**
2. Resin Content Tolerances	——	——	——
2a Resin Content Percent, ±% from Nominal	5.0	3.0	2.0
2b Treated Weight Total, ± mg from Nominal	TBD	TBD	TBD
2c Deviation within a Cut-to-Size Panel, %	3.0	2.0	1.0
3. Resin Flow Tolerance ±% from Nominal	7.0	5.0	3.0
4. Scaled Flow Tolerance ±mm [Mils] from Nominal	12.5 [0.5]	7.5 [0.3]	5.0 [0.2]
5. Gel Time Tolerance ±Seconds from Nominal	NA	NA	NA
6. Electric Strength, minimum volts/mm [volts/mil]	NA	2.95E4 [750]	2.95E4 [750]
7. Permittivity @ 1 MHz maximum	NA	4.2	4.2
8. Loss Tangent @ 1 MHz maximum	NA	0.035	0.035
9. Flammability, maximum seconds individual	15	15	15
10. Shelf Life, as defined by Properties 1, 2, 3, 5	Minimum 6 months when stored at a maximum of 50% RH and 21°C		
11. Density of constituents: resin and reinforcement	As agreed upon between vendor and user		
12. Reinforcement	As specified in IPC-A-142		

NA = Not Applicable

Specification Sheet

Specification Sheet # : IPC-L-109/26
Reinforcement : Woven fabric, E-Glass
Resin System : Epoxy, modified Triazine and/or Bismaleimide blend, flame resistant
Military Designation : GFN, GMN
UL/ANSI/NEMA Designation : None
Glass Transition Range (Cured) : 110–150°C, by TM 2.4.25, IPC-TM-650

	Class 1	Class 2	Class 3 & Class 4
1. Volatile Content, maximum % @ E 163°C	**NA**	**2.0**	**2.0**
2. Resin Content Tolerance	—	—	—
2a Resin Content Percent, ±% from Nominal	5.0	3.0	2.0
2b Treated Weight Total, ±mg from Nominal	TBD	TBD	TBD
2c Deviation within a Cut-to-Size Panel, ±%	3.0	2.0	1.0
3. Resin Flow Tolerance ±% from Nominal	NA	6.0	5.0
4. Scaled Flow Tolerance ±mm [Mils] from Nominal	12.5 [0.5]	7.5 [0.3]	5.0 [0.2]
5. Gel Time Tolerance ±Seconds from Nominal	25	25	15
6. Electric Strength, minimum volts/mm [volts/mil]	NA	2.95E4 [750]	2.95E4 [750]
7. Permittivity @ 1 MHz maximum	NA	4.3	4.3
8. Loss Tangent @ 1 MHz maximum	NA	0.020	0.020
9. Flammability, maximum seconds individual	15	15	15
10. Shelf Life, as defined by Properties 1, 2, 3, 5	Minimum 6 months when stored at a maximum of 50% RH and 21°C.		
11. Density of constituent: resin and reinforcement	As agreed upon between vendor and user		
12. Reinforcement	As specified in IPC-EG-140		

NA = Not Applicable

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IPC-TM-650
TEST METHODS MANUAL

Number	
2.1.5	
Subject	
Surface Examination, Unclad and Metal Clad Material	
Date	Revision
12/82	**A**
Originating Task Group	
N/A	

1.0 Scope This test method identifies the major areas of concern during a visual examination and describes the recommended procedures.

2.0 Application Documents None.

3.0 Test Specimen Any representative clad or unclad sample of printed wiring material.

4.0 Equipment/Apparatus Magnifier or microscope capable of up to 30X magnification, having a reticle capable of measuring to the nearest 0.001 in.

5.0 Procedures

5.1 Pinholes Pinholes are predetermined by visual examination using not less than 10X magnification on the specimen. Copper surfaces should be prepared by cleaning or light etching.

5.2 Pits and Dents The maximum total point count for pits and dents, per square foot of panel inspected is determined as follows:

Longest Dimension (inch)	*Point Value*
0.000 to 0.010 inclusive	1
0. 011 to 0.020 inclusive	2
0.021 to 0.030 inclusive	4
0.031 to 0.040 inclusive	7
over 0.040	30

Pits and dents should be determined visually using not less than 10X magnification on the specimen.

5.3 Scratches Scratches can be measured with the use of a microscope (30X maximum).

5.4 Wrinkles Wrinkles should be viewed by normal or corrected 20/20 vision.

5.5 Inclusions Inclusions should be measured using 18X to 30X magnification.

6.0 *Notes*

For additional reference see:
IPC-CF-150: Copper Foil
IPC-A-600: Acceptability of Printed Boards
MIL-P-13949: Laminate Materials

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IPC-TM-650
TEST METHODS MANUAL

Number	
2.1.10	
Subject	
Visual Inspection for Undissolved Dicyandiamide	
Date	Revision
12/94	**A**
Originating Task Group	
MIL-P-13949 Test Methods Task Group (7-11b)	

1.0 Scope This inspection method is designed to visually inspect for dicyandiamide, commonly called ''dicy,'' that is not dissolved in the resin of prepreg materials in which it is used as a curing agent, by means of polarized lighting.

2.0 Applicable Documents None.

3.0 Test Specimens Unless otherwise specified, one ply of prepreg cut to 101.6 x 101.6 mm [4.0 x 4.0 in].

4.0 Apparatus or Material

4.1 An incidental light source such as a photographic light box, light table or illuminated microscope base. Light intensity shall be sufficient to detect small features of the specimen under fully polarized conditions, such as a 60 watt light bulb used in a light box.

4.2 A matched pair of polarizing filter lens.

4.3 A microscope capable of magnification at least 30X to 100X.

5.0 Procedure

5.1 Preparation

5.1.1 Place one polarizing filter directly over the light source. Place the specimen over the filter.

5.1.2 Place second polarizing filter over the specimen directly in line with the first filter.

5.1.3 Set microscope to desired magnification between 30X and 100X and position over the approximate center of the filters. For referee purposes, magnification shall be at 100X.

5.1.4 Focus microscope on the specimen through the top filter.

5.1.5 Rotate top filter 90° from bottom filter (see Figure 1).

5.2 Evaluation

5.2.1 Examine for the presence of dicy over the entire specimen, excluding the edges. The dicy (if present) will cause scattering of the polarized light which can then pass through the second filter in sufficient intensity to be visible.

5.2.2 Careful scrutiny must be used to eliminate consideration of dust or cracks in the resin as dicy, because they will also diffuse polarized light. Severe incidence of undissolved dicy may be observed using partially or non-polarized light.

5.3 Report Presence of dicy shall be noted as per the degrees shown in Appendix A. Appearance as to the form, i.e., crystal, flake, or cluster, shall be reported.

6.0 Notes

6.1 Dicy is a curing agent used with epoxy resin; it is introduced at the resin mixing stage. If the mix is not homogeneous or is improperly done, particles of dicy may not dissolve or may be recrystallized. Dicy may also recrystallize during the treating operation. During lamination of the prepreg, dicy may contribute to the formation of voids or other defects.

6.2 Dicy Flake A loose mass of crystals, usually in the form of crystals radiating from a center point.

6.3 Dicy Cluster A concentration of crystals or flakes.

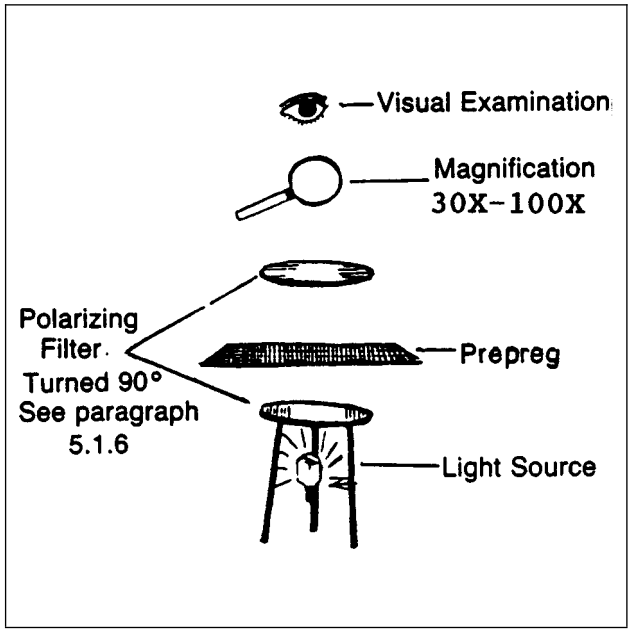
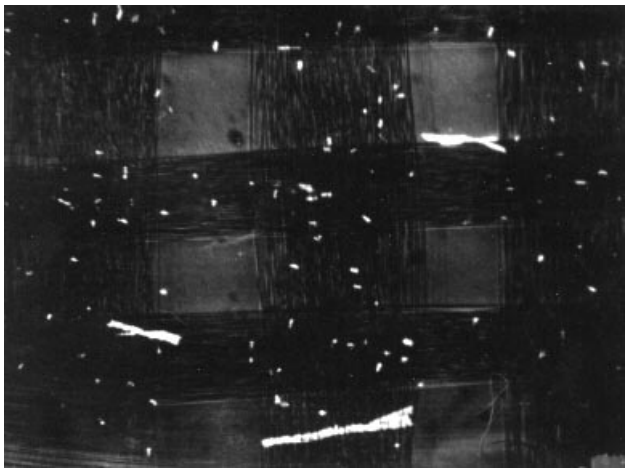


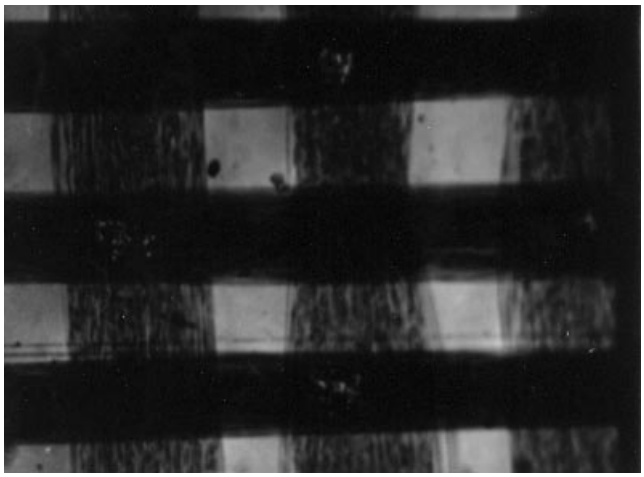
Figure 1 Dicy inspection set-up (expanded view)

Appendix A: [Photos of dicy in lowest, medium, high, and extreme levels.]

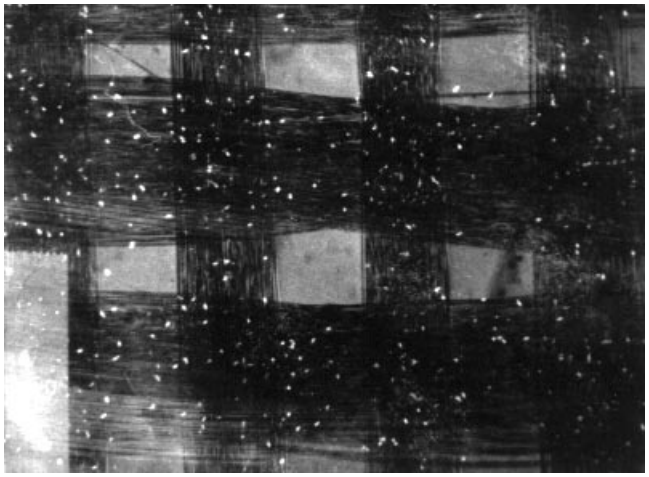
Degree 1



Degree 1



Degree 2



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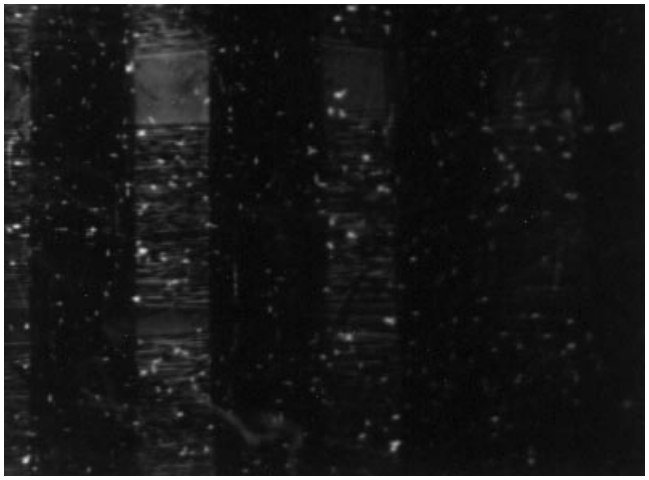
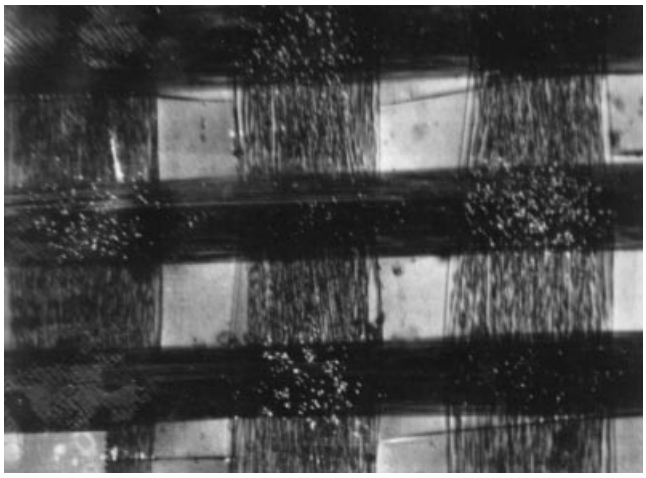
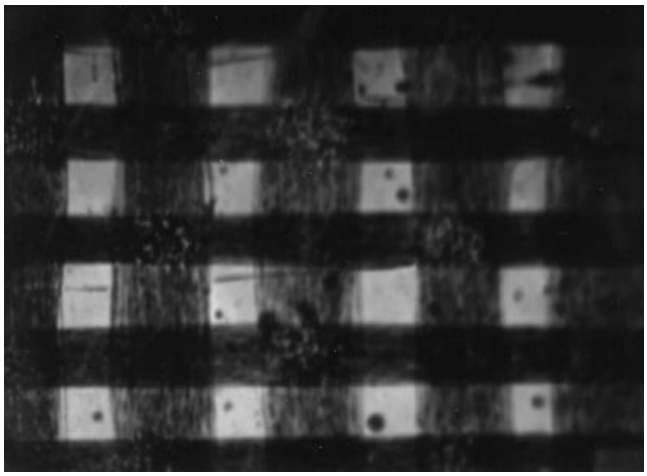


DEGREES OF DICYANDIAMIDE (DICY) CRYSTALS

Degree 3



Degree 2



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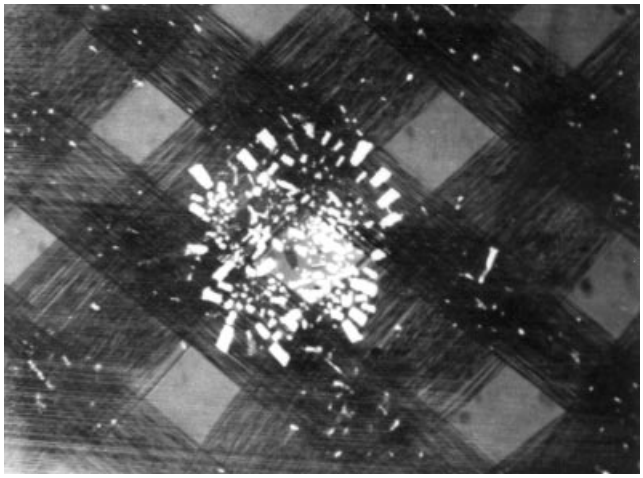

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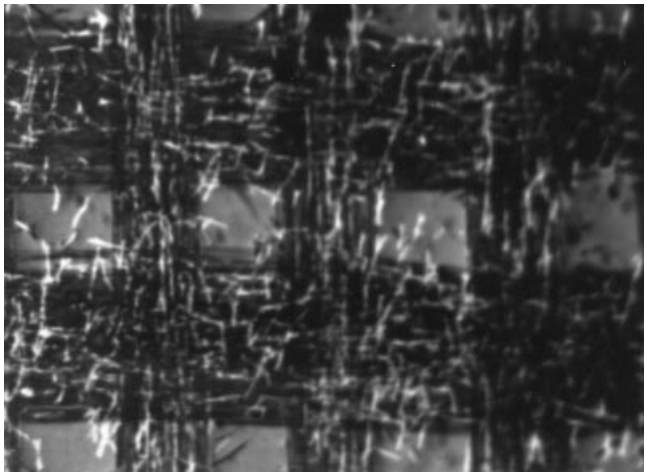

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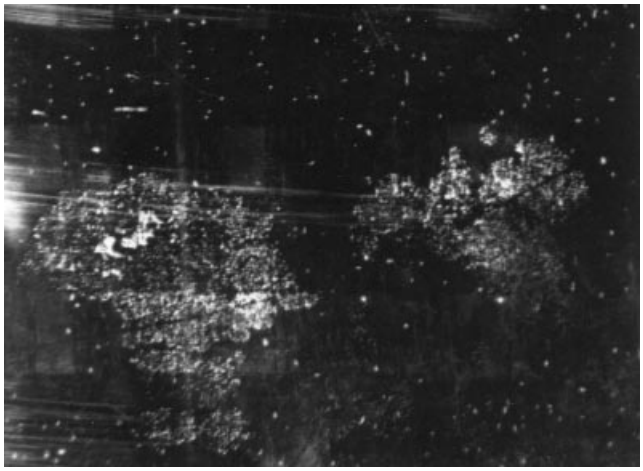

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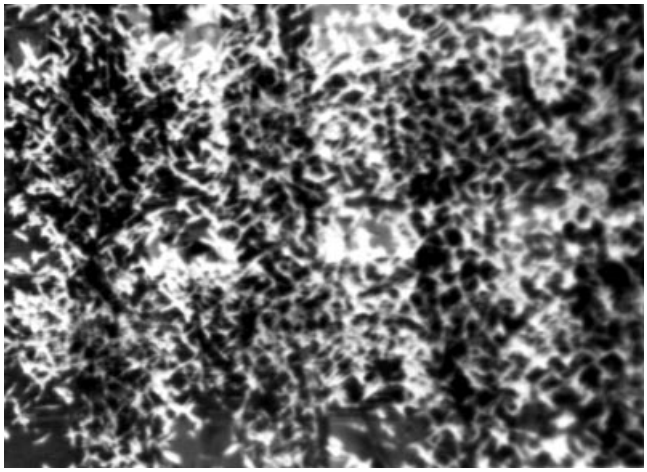

The Institute for Interconnecting and Packaging Electronic Circuits
2215 Sanders Road • Northbrook, IL 60062-6135

IPC-TM-650
TEST METHODS MANUAL

Number	
2.3.4.2	
Subject	
Chemical Resistance of Laminates, Prepreg, and Coated Foil Products, by Solvent Exposure	
Date	Revision
12/94	**A**
Originating Task Group	
MIL-P-13949 Test Methods Task Group (7-11b)	

1.0 Scope This method is designed to evaluate the resistance of dielectric materials to organic chemicals representative of those used in printed board fabrication and assembly. It is intended to provide a distinction between materials of varying chemical resistance and, when applicable, an indication of the degree of cure.

2.0 Applicable Documents

IPC-TM-650

Method 2.2.18, Determination of Thickness of Laminates by Mechanical Measurement

Weast, R.C., CRC Handbook of Chemistry and Physics, 65th Edition, E-37, 1984

3.0 Test Specimens

3.1 Number Unless otherwise specified, three specimens shall be used.

3.2 Size Unless otherwise specified, specimen shall be 50.8 x 50.8 mm ±0.5 mm [2.0 x 2.0 ±0.02 in] by the thickness of the material (see 5.1, Preparation). Edges shall be smooth, whether by the cutting procedure, or by sanding, or other means.

3.3 Location Specimen may be cut from anywhere in the sheet of material, except no specimens shall be taken closer than 25.4 mm [1.0 in] from any edge as laminated.

4.0 Apparatus or Material

4.1 Analytical balance with a draft shield and .001 gram or better resolution.

4.2 Air circulating oven, capable of 105 ±2°C [221 ±3.6°F].

4.3 Desiccator capable of maintaining an atmosphere of less than 30% relative humidity at 23°C [73°F]. See 6.2.5

4.4 Cutting apparatus such as diamond saw, shear paper cutter or router.

4.5 Edge smoothing apparatus such as 400 grit or finer sandpaper.

4.6 One liter battery jar, with cover.

4.7 Metal tongs or forceps.

4.8 Metal rack (to support specimens vertically).

4.9 Metal support (e.g. mounting clip used for microsectioning).

4.10 Laminating press capable of the specified temperature and pressure.

4.11 Timer: 1 hour with 1 second resolution.

4.12 Timer: 60 seconds, 1 second resolution.

4.13 Solvent: Methylene Chloride, Reagent Grade or HPLC Grade. MC recovered by distillation back to reagent grade may be used. HPLC Grade shall be used for referee purposes.

4.14 Prepreg (for single sided laminate and coated foil test only).

4.15 Copper foil, 1 oz./ft^2 treated (for prepreg tests only).

4.16 Ventilation hood

4.17 Micrometer, capable of measuring to within 0.025 mm [0.001 in]

4.18 Water bath at 23 ±0.5°C [73 ±0.9°F].

4.19 Thermometer capable of measuring to within 0.1°C resolution.

4.20 Etching system capable of metallic cladding removal.

5.0 Procedure

5.1 Sample Preparation

5.1.1 Single-sided Laminate Single-sided laminate less than 0.5 mm [0.020 in] shall be laminated together with the clad surfaces facing out. Two plies minimum of prepreg shall be used. The prepreg shall be of the same basic resin type and of a thickness when cured not greater than 0.13 mm [0.005 in] total, using the prepreg manufacturer's recommended press cycle. Laminate over 0.5 mm [0.020 in] shall be treated like double clad laminate without lamination.

5.1.2 Resin-coated Foil Resin-coated foil samples shall be laminated together using at least two plies of prepreg between the coated sides of the foil. The prepreg shall be of the same basic resin type and of a thickness when cured not greater than 0.127 mm [0.005 in] total, using a press cycle and any subsequent post cure which meets the manufacturer's recommendations for both the coated foil and prepreg. (See 6.2.1.1)

For qualification and referee tests, a 0.50 ±0.10 mm [0.02 in] composite core is to be built.

5.1.3 Laminate with Coated Foil Surfaces Single-sided laminate shall be tested after lamination as in 5.1.1. Double-sided laminate with coated foil on one side shall have the foil etched from the uncoated side and shall subsequently be laminated as 5.1.1. Double-sided laminate with coated foil on both sides shall be tested as is.

5.1.4 Prepreg Prepreg shall be laminated to a thickness of 0.50 ±0.10 mm [0.020 in] using treated copper foil on both sides and following the prepreg manufacturer's recommended press and post cure cycle. (See 6.2.1.1) For prepreg less than 0.13 mm [0.005 in] thick when cured, at least two plies shall be bonded to either side of an etched laminate of a thickness such that the pressed sample satisfies the required thickness.

5.1.5 Double-sided Laminate Double-sided laminate shall be submitted for testing as is.

5.2 Specimen Preparation

5.2.1 Etching Samples, as specified in 3.0, shall be etched in accordance with standard industry practices. For referee purposes, 2.3.6, 2.3.7, 2.3.7.1, or 2.3.7.2 shall be used.

5.2.2 Cut the specimens to size per 3.2. Cutting shall be performed using apparatus and in such a manner that prevents edge damage. Edge smoothing is recommended to prevent excessive absorption.

5.2.3 Markings Each specimen shall be identified by marking with a lead pencil or equivalent technique which is not removed by the solvent and which doesn't affect the results.

5.3 Preconditioning

5.3.1 Measure and record nominal thickness of the test specimen using IPC-TM-650, Method 2.2.18.

5.3.2 Place the etched specimens vertically in the metal rack and dry the specimens in the oven for 60 ±5 minutes at 105°C [221°F]. Air flow around each specimen must be assured.

5.3.3 Remove the specimens from the oven and immediately place in the desiccator to cool for 60 ±30 minutes.

5.4 Test Condition The test shall be performed at standard laboratory conditions: 23 ±2°C [73 ±0.9°F] and 50 ±5% R.H.

5.5 Measurement

5.5.1 Fill the battery jar with 750 ml of solvent and maintain the solvent temperature at 23 ±0.5°C [73 ±0.9°] using the water bath.

5.5.2 Remove the specimens individually from the desiccator and weigh to the nearest milligram on the analytical balance. Samples must be weighed within 60 seconds of removal from the desiccator. Record these weights as W_1.

5.5.3 Place the rack into the beaker of solvent, start the 60 minute timer and using tongs place the specimens in the rack at suitable intervals (recommend approximately 2 minutes). Insure that the specimens are completely immersed.

5.5.4 Place the metal clip on the balance and tare it out.

5.5.5 After 10 minutes +15, –0 seconds, using the tongs remove the first specimen from the solvent and start the 60 second timer.

5.5.6 Slowly wag the specimen in the air. As soon as the specimen is free of surface wetness, but no longer than 30 seconds, place the specimen on the balance supporting it on the metal clip such that both surfaces of the specimen are exposed (placing the specimen flat on the balance pan is not permitted since evaporation from the side next to the pan will be reduced.)

5.5.7 After 60 +5, –0 seconds from the time of removal from the solution, note the weight of the specimen and record it as W_2.

5.5.8 Repeat 5.5.5 – 5.5.7 for the remaining specimens insuring the immersion time of each specimen is kept within the tolerance.

5.5.9 A fresh batch of solvent shall be used for no more than 18 specimens or for a period of time no longer than 8 hours.

5.6 Evaluation

5.6.1 Weight Gain

5.6.1.1 Subtract the dry weight of each specimen, W_1, from the final weight, W_2 of each specimen after immersion. Record the weight gain in mg.

5.6.1.2 Calculate the average weight gain in mg.

5.6.2 Appearance Examine the specimens using 20/20 vision for any changes to the appearance of the material, such as hazing, whitening or swelling.

5.7 Report

5.7.1 Report the average weight gain in milligrams for the material tested.

5.7.2 Report the measured specimen thickness.

5.7.3 Report actual test conditions for temperature and humidity and the solvent temperature.

5.7.4 Report any anomalies in the test or any variations from the specified procedures or tolerances.

5.7.5 Report any changes in the visual quality of the specimens as determined in 5.6.2.

6.0 Notes

6.1 Safety Considerations See the MSDS sheet for the solvent used before running this test.

6.1.1 During test, the beaker with the test solvent should be covered or under a ventilation hood.

6.1.2 Dispose of the spent solvent in accordance with local regulations.

6.2 Factors Affecting Tests

6.2.1 Sample

6.2.1.1 Same Sample The results obtained on the same sheet of material may be significantly affected by the degree of cure of the material and the thermal history of the sample.

6.2.1.2 Variation Due to Thickness of Sample There is a very small difference due to sample thickness. This is under 10% on typical epoxy materials for 0.2 mm [0.008 in] to 1.5 mm [0.060 in] and under 5% on more chemical resistant material from 0.13 mm [0.005 in] to 1.5 mm [0.060 in].

6.2.2 Accuracy Since there are no standards for this type of test, the accuracy of the method cannot be established.

6.2.3 Precision the reproducibility of this test depends on the degree of control over the controlled variables and some other variables such as atmospheric pressure, which are generally not controlled in industrial laboratories. Precision between laboratories with 20% to 50% RH was 10% at the 90 mg level and 16% at the 25 mg level.

6.2.4 Desiccants Desiccants capable of 0.002 mg moisture levels include P_{205}, Mg $(C10_4)_2$, anhydrous BaO and fused KOH.

Some other desiccants such as $CaCl_2$ result in considerably higher moisture levels and may not be used in this test. (See Weast R.C., CRC Handbook of Chemistry and Physics, 65th edition, E–37, 1984.)

6.2.5 Humidity Considerations

6.2.5.1 Effect of Humidity Higher humidity will produce higher solvent pickup due to retarded solvent evaporation.

6.2.5.2 Control of Humidity Control of the critical environment can be obtained in uncontrolled laboratories using an enclosed balance with a saturated salt solution of $Mg(No_3)_2$, $6H_20$ (for 50% RH).

All significant openings in the enclosure are sealed with tape and an inner door is fabricated with a small opening for sample entry and exit. A shallow pan is fabricated to occupy most of the balance floor without contacting the weighing pan. If the balance door is closed immediately after sample entry and exit, 50 ±5% RH can be maintained.

Verification of conditions in the enclosure during a simulated test can be made using a rapid response humidity probe; however, this should be done with unconditioned specimens since solvents will affect the response of many humidity probes.

6.2.6 Temperature Considerations The effect of the solvent temperature on results is severe. A variation of 5°C [9°F] can result in an error as high as 50% relative to values determined at 23°C [73°F].

6.3 Consideration of Other Test Parameters

6.3.1 Using Same Solvent Shorter dwell times, e.g., 3 minutes, generally result in better discrimination between material of varying chemical resistance. However, test variability is generally increased. Shorter tests are excellent for side by side comparisons of materials.

Longer tests, e.g., 30 minutes, often do not differentiate adequately between materials, and while useful on homogeneous material, variability on material with surface coatings may be excessive.

6.3.2 Other Solvent Blends Other solvents and various methylene chloride based combinations have been commonly used in the industry. However, results and precision of the test may vary significantly and the added problem of variability in solution make-up is introduced.

6.4 Supercession This test method supersedes 2.3.4.2, dated 5/86, and 2.3.4.3, dated 5/86.

6.5 Desiccator Conditions The Test Methods Task Group determined that a great majority of test laboratories are unable to consistently hold the Relative Humidity in a desiccator to less than 20%. Based on data from participating company lab management, the lowest practically feasible RH for use with the affected IPC Test Methods is 30% maximum.

The Institute for Interconnecting and Packaging Electronic Circuits
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IPC-TM-650
TEST METHODS MANUAL

Number	
2.3.9	
Subject	
Flammability of Prepreg and Thin Laminate	
Date	Revision
12/94	**C**
Originating Task Group	
MIL-P-13949 Test Methods Task Group (7-11b)	

1.0 Scope This test method is designed to determine the degree of flame resistance of laminates less than 0.5 mm [0.020 in] in thickness, and prepreg.

2.0 Applicable Documents

IPC-TM-650
Method 2.3.6, Etching, Ammonium Persulfate
Method 2.3.7, Etching Ferric Chloride
Method 2.3.7.1, Cupric Chloride Etching
Method 2.3.7.2, Alkaline Etching

3.0 Test Specimens

3.1 Size The test specimen shall be 25.4 mm [1.0 in] wide by 457 mm [18 in] long by the thickness of the material cut from the sheet such that the 457 mm [18 in] dimension is parallel to the warp yarn. The specimen shall be marked 152.4 mm [6 in] from one end. This mark may be made by cutting a small nick into the edge of the strip.

3.2 Quantity and Sampling A minimum of three specimens shall be used for each material tested and each test condition, unless otherwise specified. The specimens shall be cut from various locations across the width of the sheet no closer than 25.4 mm [1 in] from the edge of the sheet.

4.0 Apparatus or Material

4.1 Test Chamber A laboratory hood, totally enclosed, with a heat-resistant glass window for observing the test, shall be used. The exhaust fan shall be turned off during the test, but may be turned on to clear out the fumes between tests.

4.2 Speciman Holder Clamping device shall be provided within the test chamber so that the specimen will hang with its length in a vertical position approximately coincident with the central vertical axis of the test chamber.

4.3 Laboratory Burner A Bunsen or Tirrill Burner shall be used having a tube length of 101.6 mm [4.0 in] and an inside diameter of 9.4 mm [0.370 in]. The burner shall not be equipped with end attachments.

4.4 Gas Supply The gas supply shall be regulated and metered for uniform flow. The standard gas shall be Technical Grade methane. Natural gas having a nominal heat content of 1000 BTU per cubic foot [37 MJ/m^3] or [37 megajoule per cubic meter] may be substituted. Other fuel gases such as butane, propane and acetylene may be used provided they are equivalent in flame temperature. Technical grade methane shall be used for referee testing.

4.5 Timer Stopwatch or other suitable timing device with a precision of 0.5 seconds, minimum.

4.6 Desiccator Desiccation chamber capable of maintaining an atmosphere of less than 30% RH at 23°C [73°F].

4.7 Conditioning oven of circulating draft type capable of maintaining 125 ±2°C [257 ±3.6°F].

4.8 Thin steel scale or template for gauging flame height.

4.9 Etching system capable of complete removal of the metal cladding.

4.10 Cutting apparatus such as shears or equivalent equipment.

5.0 Procedure

5.1 Specimen Preparation Metal-clad laminates shall be completely etched using standard industry practices (see IPC-TM- 650, Methods 2.3.7, 2.3.7.1, or 2.3.7.2). Unclad laminate and prepreg shall be tested in the as-is condition. Specimens shall be cut to size in accordance with 3.1.

5.2 Conditioning Unless otherwise specified, the specimens shall be conditioned in standard ambient laboratory conditions of 23 ±2°C [73 ±3.6°F] and 50 ±5% RH for a minimum of 24 hours prior to testing.

5.3 Specimen Mounting A specimen shall be clamped to the clamping device in the chamber so that the specimen hangs with its length in a vertical position approximately coincident with the central vertical axis of the test chamber. The marked end of the specimen shall be nearest the laboratory burner. The lower end of the specimen shall be at a height 25.4 mm [1.0 in] more than the height of the laboratory burner used to provide the ignition, as shown in Figure 1.

Note: A small weight may be hung from the lower end of the specimen by a wire at least 127 mm [5.0 in] in length to prevent it from curling during burning.

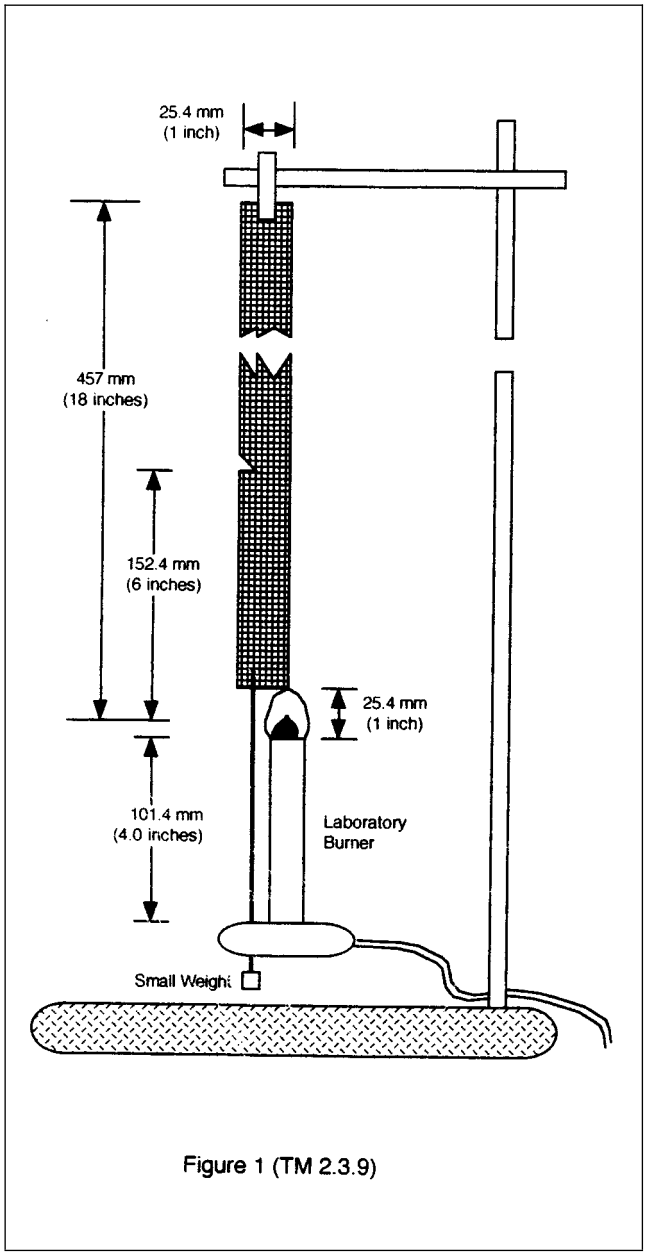

Figure 1 (TM 2.3.9)

Figure 1

5.4 Adjustment of Test Flame The burner is ignited and adjusted to produce a blue flame 25.4 mm [1.0 in] high. The correct flame is obtained by adjusting the gas supply and the air ports of the burner until a blue flame with a yellow-tipped outer cone 25.4 mm [1.0 in] high is produced. The air supply is increased slightly by opening the air ports only until the yellow tip just disappears and completely blue inner and outer flame cones are formed. The flame is remeasured for correct height. The procedure is repeated as necessary until all conditions are met. The burner tube is vertical during adjustment and testing.

5.5 Measurement Position the burner beneath the specimen and allow the flame to impinge upon the specimen for 5 ± 0.5 seconds (see 6.3 and 6.4). Remove the burner from beneath the specimen, and determine the time from removal of burner to when burning has stopped. Record the time of burning and record whether the burning has progressed beyond the 152.4 mm [6.0 in] length. If the burning has progressed beyond the 152.4 mm [6.0 in] mark, measure the total length of the burned material.

5.6 Evaluation

5.7.1 Nonburning by This Test If the specimen does not ignite on two attempts, it shall be reported as ''Nonburning by this test.''

5.7.2 Burning by This Test If a specimen burns up to 152.4 mm [6.0 in], it shall be reported as ''Burning by this test.''

5.7.3 Self-extinguishing by This Test If a specimen begins to burn after the first or second ignition but extinguishes before the flame burns up to 152.4 mm [6.0 in], it shall be reported as ''Self-extinguishing'' by this test.

5.8 Report the total time of burn and the total length of burn.

6.0 Notes

6.1 Since laminates and prepregs do not drip molten or flaming material, provisions for this evaluation have been deleted from the method.

6.2 The inside of the burner barrel should be cleaned frequently. Specimen combustion by-products can collect around and inside the barrel tip. These deposits can be flushed out during burner ignition and flame adjustment resulting in a false yellow flame tip. Proper flame adjustment becomes very difficult.

6.3 Desiccator Conditions The Test Methods Task Group determined that a great majority of test laboratories are unable to consistently hold the Relative Humidity in a desiccator to less than 20%. Based on data from participating company lab management, the lowest practically feasible RH for use with the affected IPC Test Methods is 30% maximum.

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IPC-TM-650
TEST METHODS MANUAL

Number	
2.3.16	
Subject	
Resin Content of Prepreg, by Burn-off	
Date	Revision
12/94	**B**
Originating Task Group	
MIL-P-13949 Test Methods Task Group (7-11b)	

1.0 Scope This method is designed to determine the resin content percent of prepreg which is reinforced with inorganic fabric, by removal of the resin from the reinforcement using a burn-off step.

2.0 Applicable Documents None.

3.0 Test Specimens

3.1 Size Specimens shall be approximately 102 mm x 102 mm [4.0 in. x 4.0 in]. If the reinforcement is a continuous fiber woven fabric, the sides shall be cut on a bias to the orientation of the fabric.

3.2 Quantity and Sampling Unless otherwise specified, three specimens shall be taken equally spaced across the width (web) of a roll or from different locations in a predetermined quantity of paneled prepreg, such as an inspection lot.

4.0 Apparatus or Material

4.1 Analytical Balance Analytical balance capable of weighing to the nearest milligram [0.001 gram].

4.2 Muffle Furnace Muffle furnace capable of maintaining 550 ±50°C [1022 ±90°F].

4.3 Crucible Crucible of sufficient size and type to hold the specimen when placed in a muffle furnace.

4.4 Cutting Apparatus Shears or other equipment capable of cutting specimens to the specified size.

4.5 Desiccator Desiccation chamber capable of maintaining an atmosphere less than 30% R.H., at 23°C [73°F].

5.0 Procedure

5.1 Specimen Preparation

5.1.1 Cut the specimens to the specified size.

5.1.2 Unless the prepreg is tested within 10 minutes of its manufacture, the specimens shall be desiccated for a minimum of 4 hours. For referee testing, the specimens shall be desiccated.

5.2 Measurement

5.2.1 Each specimen shall be weighed in a previously weighed crucible to the nearest milligram.

5.2.2 Place the crucible containing the specimen in the muffle furnace maintained at 550 ±50°C [1022 ±90°F] for 5 minutes, minimum.

5.2.3 Remove the crucible with contents from the furnace and place in the desiccator until cooled to room temperature.

Note: If the contents of the crucible shows evidence of glass fusion, discard the specimen and repeat the test with a new specimen, except lower the temperature of the muffle furnace by 50°C [122°F]. If the contents show evidence of incomplete combustion of the resin, increase the temperature of the furnace or extend the time of combustion. In any case, the residual glass cloth, after combustion, must be completely free of resin residue, and show no evidence of glass fusion.

5.2.4 Weigh the crucible with contents to the nearest milligram.

5.2 Calculation The resin content of the prepreg is calculated as follows:

$$\text{Resin content (\%)} = \frac{\text{Loss of Weight of Specimen} \times 100}{\text{Original Weight of Specimen}}$$

5.3 Report The results shall be recorded in a report indicating resin content percent for each specimen and the average of all specimens of the same materials.

6.0 Notes

6.1 Reinforcements used for prepreg covered by this test method may be woven or nonwoven, and continuous or noncontinuous fibers, any of which are referred to as fabrics.

6.2 Desiccator Conditions The Test Methods Task Group determined that a great majority of test laboratories are unable to consistently hold the Relative Humidity in a desiccator to less than 20%. Based on data from participating company lab management, the lowest practically feasible RH for use with the affected IPC Test Methods is 30% maximum.

The Institute for Interconnecting and Packaging Electronic Circuits
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IPC-TM-650
TEST METHODS MANUAL

Number	
2.3.16.1	
Subject	
Resin Content of Prepreg, by Treated Weight	
Date	Revision
12/94	**C**
Originating Task Group	
MIL-P-13949 Test Methods Task Group (7-11b)	

1.0 Scope This method is designed to determine the resin content of a prepreg without removing the resin from the reinforcement. The basis weight of the fabric must be known. This method is applicable to both organic and inorganic reinforcements.
Note: For referee testing of prepregs with inorganic reinforcement, Method 2.3.16 shall be used.

2.0 Applicable Documents

IPC-EG-140 Specification for Finished Fabric Woven from ''E'' Glass for Printed Boards

IPC-SG-141 Specification for Finished Fabric Woven from ''S'' Glass

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-TM-650

Method 2.1.6.1, Weight of Fabric Reinforcements

Method 2.3.17, Resin Flow Percent of Prepreg

Method 2.3.19, Volatile Content of Prepreg Materials

3.0 Test Specimens

3.1 Size Specimens shall be 101.6 mm x 101.6 mm [4.0 in x 4.0 in]. If the reinforcement is a continuous fiber woven fabric, the sides shall be cut on a bias to the orientation of the fabric.

3.2 Quality and Sampling Unless otherwise specified, three specimens shall be taken equally spaced across the width (web) of a roll or from different locations in a predetermined quantity of paneled prepreg, such as an inspection lot. If specimens are to be used for Resin Flow Percent (TM 2.3.17), then four specimens shall be used, cut from adjacent points in a roll or cut panels (see 6.4).

4.0 Apparatus or Material

4.1 Analytical balance, capable of weighing to the nearest milligram (0.001 gram).

4.2 Static shield (a thin piece of metal, e.g., 7 oz./sq. ft. copper foil 5 in x 5 in (127 mm x 127 mm) or larger). This is not needed if the balance pan is larger than the specimen.

4.3 Sample cutting apparatus—die cut press, or equivalent, capable of cutting specimens to the specified size.

4.4 Desiccator capable of maintaining an atmosphere less than 30% R.H. at 23°C [73°F].
Note: Do not use vacuum or other means which would be capable of removing solvent or resin fractions.

5.0 Procedure

5.1 Preconditioning Unless the prepreg is tested within 10 minutes of production the specimen shall be desiccated for a minimum of 4 hours. For referee testing, the specimens shall be desiccated.

5.2 Test Conditions The test shall be performed at standard laboratory conditions. For materials which absorb moisture rapidly, care should be taken to insure that moisture content is not significant by measurement immediately after removal from desiccation.

5.3 Measurement

5.3.1 Place the static shield on the balance pan.

5.3.2 Zero the balance.

5.3.3 If applicable, remove the specimens from the desiccator. Place the specimens together on the balance, insuring that they sit entirely on the balance pan, or the static shield if needed (see 6.4).

5.3.4 Determine and record the weight of the specimens to the nearest 0.1g. For prepregs of nominal 0.15 mm [0.006 in] thickness and less, weigh to the nearest 0.001g.

5.4 Calculations

5.4.1 Determine the basis weight of the fabric using one of the methods of Appendix A.

5.4.2 Calculate the Resin Content (RC) of the material from

the treated weight (TW) and the basis weight (BW) of the fabric for 41,290 mm^2 [64 in^2]. The basis weight may be determined by any suitable method in Appendix A.

$$RC = \left(1 - \frac{BW}{TW}\right) \times 100$$

where:

RC = Resin Content in %
BW = weight of the fabric as determined in accordance with Appendix A
TW = treated weight from 5.3.4.

5.5 Report

5.5.1 Report the Resin Content to the nearest .1%.

5.5.2 Report the method used to determine the basis weight of the reinforcement.

5.5.3 Report any anomalies in the test or any variations from the specified procedures or tolerances

6.0 Notes

6.1 The solvent or volatile content of the prepreg (excluding moisture) is considered part of the treated weight using this method. If it is desired to exclude solvent content, the specimen should be vacuumed for an appropriate time and temperature.

6.2 The accuracy of this method for determination of resin content is dependent primarily upon the accuracy of the basis weight and the consistency of the reinforcement.

6.3. The effect of static charges may present a serious problem in weighing material which has been stored if the sample is larger than the sample pan.

6.4 If it is desired to check variation across the web the individual specimens may be weighed separately or 4 specimens may be cut down the web at each location to be tested.

6.5 Desiccator Conditions The Test Methods Task Group determined that a great majority of test laboratories are unable to consistently hold the Relative Humidity in a desiccator to less than 20%. Based on data from participating company lab management, the lowest practically feasible RH for use with the affected IPC Test Methods is 30% maximum.

Appendix A

Determination of Basis Weight of Reinforcement All the following methods consider any finishes applied to the fabric as part of the fabric. In most cases, the level of organic material is negligible; however, special considerations have to be made for material such as greige goods, which have substantial amount of organic (5% or more), and for organic fabrics which may have significant moisture content.

Methods shown are based on four specimens, with a total area of 41,290 mm^2 [64.0 in^2].

Method 1 Determine the Basis Weight from the actual length, width and weight of the roll.

$$BW = 806.4 \frac{WR}{L \times W}$$

BW = Basis Wt in g
WR = Roll weight in lb.
L = Roll length in yds.
W = Roll width in in.

Method 2 Determine the Basis Weight from median statistical or typical fabric weight in oz/yd^2

BW = 1.40 W
BW = Basis wt in g
W = Weight of 1 yd^2 in oz.

Method 3 Determine the Basis Weight from the actual fabric weight at the beginning of the roll, using Method 2.1.6.1.

Method 4 Determine the Basis Weight from the reported weight supplied by the manufacturer.

BW = 1.40W
BW = Basis Wt in g
W = Weight of 1 yd^2 in oz

Method 5 Determine the Basis Weight by consulting the unit weight tables in the applicable documents; see 2.0.

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IPC-TM-650
TEST METHODS MANUAL

Number	
2.3.16.2	
Subject	
Treated Weight of Prepreg	
Date	Revision
12/94	
Originating Task Group	
MIL-P-13949 Test Methods Task Group (7-11b)	

1.0 Scope This method is designed for determining the treated weight of a specific area of prepreg. Treated weight is an alternative to Resin Content Percent as a means of determining the usability and functionality of prepreg. This method is applicable to both organic and inorganic reinforcements but effective use of this technique requires knowledge of resin and reinforcement specific gravity, as well as basis weight of the reinforcement.

2.0 Applicable Documents

IPC-EG-140 Specification for Finished Fabric Woven From ''E'' Glass for Printed Board

IPC-SG-141 Specification for Finished Fabric Woven From ''S'' Glass

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-TM-650

Method 2.4.38, Prepreg Scaled Flow Testing
Method 2.3.16, Resin Content of Prepreg by Burn-off

3.0 Test Specimens

3.1 Size The prepreg specimen shall be two or more die cut plies. Each ply shall be 140 ±0.25 mm [5.5 ±0.01 in] by 178 ±0.25 mm [7.0 ± 0.01 in].Use of the specimen for scaled flow test (IPC-TM-650, Method 2.4.38) is recommended. See 2.4.38 for additional criteria.

Alternate specimen sizes such as 102 mm x 102 mm [4 in x 4 in] or 457 mm x 610 mm [18 in x 24 in] are acceptable by agreement between supplier and user.

3.2 Quantity and Sampling Unless otherwise specified, three specimens shall be taken from the lot at randomly selected locations, whether taken from a roll or from precut panels. Specimens shall be taken from the fabric roll (as supplied by the manufacturer) no closer to the selvage (or cut edge) than a distance equal to one-tenth of the width of the roll.

4.0 Apparatus or Material

4.1 Analytical balance capable of weighing to the nearest 0.001g.

4.2 Static shield (a thin piece of metal, e.g., 7 oz copper foil at least 25.4 mm [1.0 in] larger in length and width than the prepreg specimen). This is not required if the balance pan is larger than the specimen.

4.3 Sample cutting press with die 140 ±0.25 mm x 178 ±0.25 mm [5.50 ± 0.01 in x 7.00 ± 0.01 in].

4.4 Kraft paper or equivalent back up material for cutting press.

4.5 Desiccator capable of maintaining an atmosphere less than 30% R.H. at 23°C [73°F].

5.0 Procedure

5.1 Specimen Preparation

5.1.1 Cut the specimens to the specified size and configuration, see 3.1.

5.1.2 Preconditioning Unless the prepreg is tested within 10 minutes of production, the specimen shall be desiccated for a minimum of 4 hours. For referee testing, the specimens shall be desiccated.

5.2 Test Conditions The test shall be performed at standard laboratory conditions. For materials which absorb moisture rapidly, care should be taken to insure that moisture content is not significant by measurement immediately after removal from desiccation.

5.3 Equipment Setup Place the static shield on the balance pan and zero the balance.

5.4 Measurement

5.4.1 Place each specimen on the balance, ensuring that it sits entirely on the static shield.

5.4.2 Determine and record the treated weight of each specimen to the nearest 0.001g.

5.5 Report

5.5.1 Average the individual specimen weight and report the average per ply treated weight to the nearest 0.001g per 25.4 sq mm [1.0 sq in] .

6.0 Notes

6.1 The volatile content of the prepreg (excluding moisture) is considered part of the treated weight using this method. If it is desired to exclude volatile content, the specimen should be baked for an appropriate time and temperature.

6.2 The effect of static charges may present a serious problem in weighing material if the specimen size is greater than the sample pan.

6.3 If it is desired to check variation across or along the web, individual specimens should be taken from the location in question.

6.4 If it is desirable to check the weight uniformity of the reinforcement, this can be done by burn-off similar to IPC-TM-650, Method 2.3.16, if inorganic.

6.5 Calculations Treated weight can be used to specify and/or predict prepreg thickness and resin content. Equations to calculate thickness and resin content for woven fabric ''E''-glass reinforced epoxy FR-4 prepreg are given below. The calculations assume a resin specific gravity of 1.37 gr/cc and an ''E''-Glass specific gravity of 2.59 gr/cc.

Woven ''E''-glass fabric nominal dry weights and tolerances are assumed the values given in IPC-EG-140. **The nominal dry weights and tolerances for other reinforcements, such as ''S'' glass, woven aramid, and quartz fabric, can be found in IPC-SG-141, IPC-A-142, IPC-QF-143.** Appropriate values for the specific gravities of other resins and reinforcements and the basis weights of other reinforcements are the responsibility of the vendor or can be negotiated between vendor and user. Inorganic reinforcement basis weight can be measured as given in 6.4.

6.5.1 Resin Content The resin content can be calculated from the average per ply treated weight and the measured or nominal unit glass fabric weight. Conversely, the treated weight can be calculated from the resin content. Equations to calculate both are shown below:

$$RC = \left(1 - \frac{BW}{TW}\right) \times 100$$

$$TW = \frac{BW}{1 - (RC/100)}$$

Where:

RC = resin content by weight
TW = treated weight (weight per area per ply)
BW = unit basis weight (weight per area per ply)

6.5.2 Prepreg Thickness The average prepreg thickness can be calculated using the average per ply treated weight and the measured or nominal unit glass fabric weight. Equations to calculate prepreg thickness for Scaled Flow test sized specimens (38.5 square inches per ply) are given below:In general:

$$H_o = \frac{1.585TW}{d_r} - \frac{1.585W_f\,(d_f - d_r)}{d_f\,d_r}$$

For ''E''-glass reinforced FR-4 epoxy prepreg:

$$H_o = 1.157\ TW - 0.545\ W_f$$

Where:

H_o = prepreg thickness (mils per ply)
TW = treated weight (weight per 38.5 sq in per ply)
W_f = unit glass fabric weight (weight per 38.5 sq in per ply)
d_r = resin density (grams per cubic centimeter)
d_f = fabric fiber density (grams per cubic centimeter)

6.6 Desiccator Conditions The Test Methods Task Group determined that a great majority of test laboratories are unable to consistently hold the Relative Humidity in a desiccator to less than 20%. Based on data from participating company lab management, the lowest practically feasible RH for use with the affected IPC Test Methods is 30% maximum.

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IPC-TM-650
TEST METHODS MANUAL

Number	
2.3.17	
Subject	
Resin Flow Percent of Prepreg	
Date	Revision
12/94	**C**
Originating Task Group	
MIL-P-13949 Test Methods Task Group (7-11b)	

1.0 Scope This test method is designed to measure the Resin Flow Percent by weight in prepreg.

2.0 Applicable Documents None

3.0 Test Specimens

3.1 Size and Configuration A specimen shall consist of multiple plies of prepreg cut 102 ±0.25 mm [4.0 ±0.010 in] by 102 ±0.25 mm [4.0 ±0.010 in] . If the reinforcement is a continuous fiber woven fabric, the sides shall be cut on a bias to the fabric weave. Unless otherwise specified, the test specimen shall have four plies. (Note: an alternative specimen configuration commonly used is a stack that weighs approximately 20 g.)

3.2 Quantity and Sampling Unless otherwise specified, the number of specimens tested shall be as follows: for qualification testing, 3 specimens shall be tested with the pieces for each specimen taken from areas of the prepreg that represents the center and both sides of the material as impregnated. For lot testing, one specimen shall be tested, with the pieces randomly taken. Pieces shall be taken no closer to the selvage (or cut edge) than a distance equal to one-tenth of the width of the roll.

4.0 Apparatus or Material

4.1 Laminating Press Unless otherwise specified, laminating press capable of maintaining a temperature of 171 ±3°C [340 ±5°F] and capable of providing a pressure of 1380 ±70 kPa [200 ±10 psi] on the test specimen (see 6.1).

4.2 Analytical Balance Analytical balance capable of weighing to the nearest 0.001 gram.

4.3 Plates Caul plates approximately 3.2 mm [0.125 in] thick and at least 152 mm x 152 mm [6.0 in x 6.0 in], but no larger than the press platen size, and made from type 304 steel, or equivalent.

4.4 Circle Punch A punch or die set capable of cutting a circle 91.1 ±0.25 mm [3.192 ±0.010 in] in diameter.

4.5 Desiccator Desiccation chamber capable of maintaining an atmosphere of less than 30% R.H. at 23°C [73°F].

4.6 Release Material The release material shall be Tedlar, Type MR, (polyvinyl fluoride, PVF) or equivalent, cut at least as large as the caul plates.

5.0 Procedure

5.1 Specimen Preparation

5.1.1 The prepreg shall be cut to conform with the specimen size and configuration, see 3.1.

5.1.2 For referee purposes only, specimens shall be desiccated for a minimum of 4 hours.

5.2 Measurement

5.2.1 Determine the weight of each specimen to the nearest 0.005 gram. Record this as the original weight, or W_o.

5.2.2 Stack the plies of prepreg for one specimen with the grain of the cloth aligned in the same direction and place between two pieces of release film. Place this package between two caul plates that are at room temperature.

5.2.3 Place specimen and caul plates in a preheated laminating press maintained at the specified temperature and immediately apply pressure such that the specified pressure is achieved within 5 seconds after press closure. Unless otherwise specified, the temperature shall be 171 ±3°C [340 ±5°F] and the pressure shall be 200 ±10 psi [1380 ±70 kPa].

5.2.4 Maintain the specified pressure for 10 + 6, – 0 minutes.

5.2.5 Open press, remove specimen, and allow to cool to room temperature.

5.2.6 If applicable, post cure the test specimen in accordance with the manufacturer's post cure method (in order to prevent specimen damage by cutting).

5.2.7 Using the punch and die set, remove a circular disc measuring 91.1 mm [3.192 in] in diameter from the center of the specimen.

5.2.8 Weigh the circular specimen on the analytical balance to the nearest 0.005 gram. Record this as the disc weight, or W_D.

5.3 Calculation The resin flow is calculated as follows:

$$\text{Resin Flow, Percent} = \left(\frac{W_O - 2\,W_D}{W_O}\right) \times 100$$

W_o = Original weight of the specimen
W_D = Disc weight of the specimen (cut from the specimen after pressing)

5.4 Report The resin flow, percent, for each specimen tested and the average of all specimens tested shall be reported.

6.0 Notes None

6.1 Other resins may require different temperature settings to achieve flow. Pressure may also be dependent on the resin chemistry. Agreement of temperature and pressure by supplier and user other than as specified should be included in the report, see 5.4.

6.2 Desiccator Conditions The Test Methods Task Group determined that a great majority of test laboratories are unable to consistently hold the Relative Humidity in a desiccator to less than 20%. Based on data from participating company lab management, the lowest practically feasible RH for use with the affected IPC Test Methods is 30% maximum.

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Number	
2.3.17.2	
Subject	
Resin flow of ''No Flow'' Prepreg	
Date	Revision
12/94	**A**
Originating Task Group	
MIL-P-13949 Test Methods Task Group (7-11b)	

1.0 Scope This test method is designed to measure the Resin Flow of ''no flow'' prepreg used for bonding and adhesion without formation of resin bead as caused by flow of the resin.

2.0 Applicable Documents None

3.0 Test Specimens

3.1 Size and Configuration A specimen shall consist of multiple plies of prepreg cut approximately 102 mm [4.0 in] x 102 mm [4.0 in]. If the reinforcement is a continuous fiber woven fabric, the sides shall be cut on a bias to the fabric weave. Unless otherwise specified, the test specimen shall have three plies.

3.2 Quantity and Sampling Unless otherwise specified, the number of specimens tested shall be as follows: For qualification testing, 3 specimens shall be tested, with the pieces for each taken from areas of the prepreg that represents the center and both edges of the material as impregnated. For lot testing, one specimen shall be tested, with the pieces randomly taken from the prepreg. Pieces shall be taken no less than 25.4 mm [1 in] from the impregnated edge.

4.0 Apparatus or Material

4.1 Laminating Press Unless otherwise specified, a laminating press capable of maintaining at a temperature of 171 ±2.8°C [340 ±5°F] and capable of providing a pressure of 1380 ±70 kPa [200 ±10 psi] on the test sample, see 6.1

4.2 Hole Punch Hole cutting tool, such as a hole punch or die set capable of cutting a 25.4 ±1.3 mm [1.0 ±0.05 in] hole.

4.3 Materials

4.3.1 Release material shall be Tedlar type (polyvinyl fluoride, PVF), or equivalent, of 0.05 mm [0.002 in] thickness, maximum, at least as large as the size of the caul plates.

4.3.2 Any copper-clad laminate of thickness between 0.25 mm [0.010 in] and 0.38 mm [0.0151 in] shall be cut to approximately 152 mm x 152 mm [6 in x 6 in].

4.3.3 Conformal press pad material equivalent to 0.5 mm [0.020 in] cotton linter paper, and cut to approximately 152 mm x 152 mm [6 in x 6 in].

4.4 Measuring Microscope Bausch and Lomb, model SUB–73 stereozoom microscope with 31–16–08 micrometer disc, Carl Zeiss Stage Micrometer, or equivalent.

4.5 Caul Plates Caul plates shall be 3.2 mm [0.125 in] thick and 152 mm [6.0 in] square and made from type 304 steel, or equivalent.

4.6 Desiccator Desiccation chamber capable of maintaining an atmosphere of less than 30% RH, at 23°C [73°F].

5.0 Procedure

5.1 Specimen Preparation

5.1.1 The prepreg shall be cut to conform with the specimen size and configuration as per 3.1.

5.1.2 If testing is to be performed more than 10 minutes after the prepreg has been manufactured, specimens shall be desiccated for 4 ±1/4 hrs. prior to testing.

5.1.3 Cleaning of Copper Cladding When applicable for referee purposes, clean the metallic cladding on the copper clad laminate by wiping the copper cladding with isopropyl alcohol. The copper clad laminate shall be immersed in suitable container containing 22-23° BAUME 20 percent by volume solution of hydrochloric acid, technical grade, maintained at 21°C ±5.6°C [170°F ±10°F] for a period of 15 seconds. After removal of the copper clad laminate from the hydrochloric acid, the copper cladding then shall be rinsed with a cold water spray rinse for 5 seconds and blown dry with filtered, oil free, compressed air.

5.2 Measurement

5.2.1 A specimen shall be formed by stacking three plies of prepreg with the grain of the reinforcement aligned in the same direction. Only if necessary to prevent ply slippage, tack the three plies together using a standard soldering iron within one quarter inch from one or more corners so that the plies lay flat to one another. Using a 25.4 mm [1.0 in] diameter hole punch, cut 2 holes at least 25.4 mm [1 in] apart (See Figure 1) in approximately the middle of the specimen. Caution should be taken during cutting in order to prevent any loose fibers

from protruding into the clearance hole. Measure the diameter of each hole in 3 places, each approximately 60° radial angle from the others and determine the average diameter of the holes.

5.2.2 Place the stack onto and in the middle of a 152 mm x 152 mm [6 in x 6 in] copper clad laminate of thickness between 0.25 mm [0.010 in] and 0.38 mm [.015 in] thick and cover the stack with a sheet of release film. Over the release film place 2 pieces press pad material. For referee purposes, the surface of the copper cladding shall be cleaned immediately prior to lay-up using the procedure in paragraph 5.1.3. (The cleaning is to standardize the surface against which the resin will flow.)

5.2.3 Place the stack (specimen plus laminate, release, and padding) between the two caul plates. Load the stack into the laminating press maintained at 171° ±2.8°C [340° ±5°F] and close immediately to 1380 ±70 kPa [200 ±10 psi]. After holding at full pressure for 20 minutes, minimum, release the pressure and remove the package.

5.3 Evaluation After the package has cooled to room temp, measure the diameter of the punched holes at the point of maximum and minimum diameter as formed by the resin flow. Subtract the average diameter of holes obtained in 5.2.1 from the maximum and minimum diameters.

5.4 Report The results shall be reported including the following:

1. Identification of specimens tested.
2. Resin flow, for each specimen tested in terms of the maximum flow and minimum flow in millimeters (thousands of an inch) for both die-cut holes.

6.0 Notes

6.1 Agreement between supplier and user other than that specified in 4.1 may be necessary for specific resin chemistries.

6.2 Desiccator Conditions The Test Methods Task Group determined that a great majority of test laboratories are unable to consistently hold the Relative Humidity in a desiccator to less than 20%. Based on data from participating company lab management, the lowest practically feasible RH for use with the affected IPC Test Methods is 30% maximum.

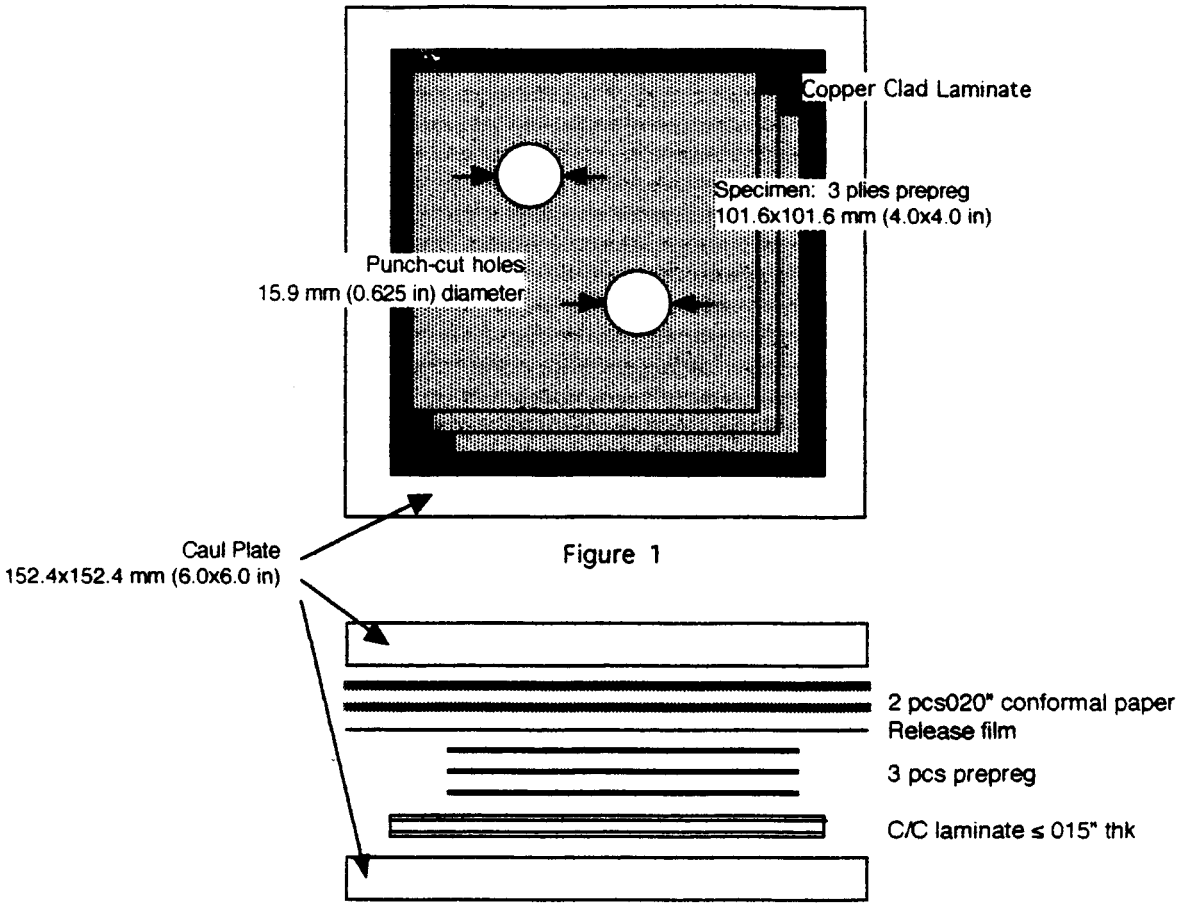
Copper Clad Laminate
Specimen: 3 plies prepreg
101.6x101.6 mm (4.0x4.0 in)
Punch-cut holes
15.9 mm (0.625 in) diameter
Caul Plate
152.4x152.4 mm (6.0x6.0 in)
Figure 1
2 pcs020" conformal paper
Release film
3 pcs prepreg
C/C laminate ≤ 015" thk

Figure 1

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Number	
2.3.18	
Subject	
Gel Time For Prepreg Materials	
Date	Revision
4/86	**A**
Originating Task Group	
N/A	

1.0 Scope

1.1 The purpose of this test method is to provide a procedure for determining the gel time of resin preimpregnated ''B'' Stage glass fabric.

2.0 Applicable Documents None.

3.0 Test Specimen

3.1 Sufficient quantity of prepreg to yield approximately 1000 milligrams of dry resin powder.

4.0 Equipment/Apparatus

4.1 Platen, hot plate or melting point apparatus capable of maintaining a temperature of 171° ±0.5°C (340°F ±0.9°F).

4.2 Timer, capable of determining time within ±1 second.

4.3 Toothpicks.

4.4 Plastic/polyethylene bags or suitable container.

4.5 Analytical balance capable of weighing within ±20 milligrams.

4.6 Wire Mesh—60 mesh.

4.7 Montan Wax.

5.0 Procedure

5.1 Place the prepreg (B-Stage) in a plastic bag or other suitable container, and extract the dry resin from the B-Stage by folding or crushing.

5.2 Allow the B-Stage resin to collect in the bottom of the plastic bag.

5.3 Pour the collected resin into a container through 60 wire mesh, to remove any fiber glass particles.

5.4 Set the melting point apparatus at 171° ±0.5°C (340° ±0.9°F) and allow to stabilize at that temperature.

5.5 Using the analytical balance weigh out 200 ±20 milligrams of resin on to 3 in. x 3 in. sheet of wax paper or a suitable container.

5.6 Make sure that the melting point apparatus is clean; mold released with montan wax or equivalent; and wiped free of any visible mold release.

5.7 Pour 200 milligram sample of resin on the center of the melting point apparatus and start the timing device immediately.

5.8 Place the tapered end of a round toothpick against the surface of the cure plate (end of the toothpick not in contact with surface of the cure plate will have to be elevated slightly).

5.9 Roll toothpick back and forth, maintaining contact with the surface of the cure plate until 20 seconds have elapsed.

5.10 At this time start stroking the resin immediately, using a circular motion 3/8 in. to 1/2 in. in diameter. Stroke in such a manner that every circle moves part of the resin from the center of the pool to the outside, and part of the resin from the outside of the pool toward the center. Care should be taken to limit the pool size to an area 3/4 in. to 7/8 in. in diameter.

5.11 Keep the toothpick in contact with resin and surface of the cure plate at all times. As the resin becomes stiff, it will not be possible to continue exchanging outside resin with inside resin, but continue stroking with as much exchange as possible without breaking the toothpick.

5.12 If the resin breaks up, continue stroking the largest piece. If this piece breaks up, continue stroking the largest remaining piece of this portion even though now a larger piece of the original pool may be present at some other place on the hot plate.

5.13 When the stroked piece separates from the hot plate, stop the watch. This is the end point, and the total elapsed time in the gel time.

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IPC-TM-650
TEST METHODS MANUAL

Number	
2.3.19	
Subject	
Volatile Content of Prepreg	
Date	Revision
12/94	**C**
Originating Task Group	
MIL-P-13949 Test Methods Task Group (7-11b)	

1.0 Scope This test method is designed to measure the volatile content of prepreg used as bonding plies in the manufacture of laminate and printed boards.

2.0 Applicable Documents None

3.0 Test Specimens

3.1 Specimen Size The test specimen shall be a ply of prepreg cut with its diagonal parallel to the X or Y axis of the prepreg. The specimen shall be approximately 101.6 x 101.6 mm [4 in x 4 in]. A hole approximately 3.18 mm [0.125 in] in diameter shall be punched in one corner of the specimen.

3.2 Quantity and Sampling Unless otherwise specified, for each material tested, three specimens shall be prepared; one specimen shall be cut from the center of the width and one each from each edge of the sheet of prepreg. Specimens shall be cut no closer than 25.4 mm [1 in] from the edge of the prepreg sheet.

4.0 Apparatus or Material

4.1 Analytical Balance Analytical balance capable of weighing to the nearest milligram [0.001 gram].

4.2 Oven Air circulating oven capable of maintaining ±2.8°C [±5°F] at the specified test temperature (see Table 1).

4.3 Desiccator Desiccation chamber capable of maintaining an atmosphere less than 30% R.H. at 23°C [73.4°F]. Vacuum drying systems, or equivalent, that could absorb or remove organic components shall not be used.

4.4 Hanging Device to Support Prepreg

Table 1

Prepreg(1) Material Type	Oven(1) Temperature	Test(1) Time
Difunctional Epoxy, Tetrafunctional Epoxy, Multifunctional Epoxy, Polyimide Blend	163°C (325°F)	15 ± 1 minute
Polyimide	225°C (437°F)	30 ± 1 minute
Cyanate Ester	145°C (293°F)	15 ± 1 minute

(1) For material types that do not conform to the types listed, follow the manufacturer's instructions for temperature and time.

4.4.1 Paper clip, alligator clip, or equivalent (Method A)

4.4.2 Clip jig, as shown in Figure 1. (Method B)

5.0 Procedure

5.1 Specimen Preparation

5.1.1 The prepreg shall be cut to conform with the specimen size and configuration as per 3.1.

5.1.2 Preconditioning Unless the prepreg is tested within 10 minutes of manufacture, specimens shall be desiccated for 24 ±2 hours before testing. Specimens tested as part of manufacturing control procedures are exempt from desiccation. For referee testing, desiccation shall be performed. (See 6.1.)

5.2 Method A

5.2.1 Apply mold release to the hanging device and allow to air dry.

5.2.2 Weigh the hanging device to the nearest milligram [0.001 gram]. Record as W_1.

5.2.3 Weigh each specimen with a hanging device to the nearest milligram [0.001 gram]. Record as W_2.

5.2.4 Place each specimen and hanging device in the air circulating oven at the temperature and for the time specified in Table 1 or by the governing document.

5.2.5 Remove each specimen with the hanging device and weigh within two minutes to the nearest milligram [0.001 gram]. Record as W_3.

5.2.6 Calculate and record the volatile content as follows:

$$\text{Volatile content}(\%) = \left(\frac{W_2 - W_3}{W_2 - W_1}\right) \times 100$$

W_1 = (see 5.2.2)
W_2 = (see 5.2.3)
W_3 = (see 5.2.5)

5.3 Method B

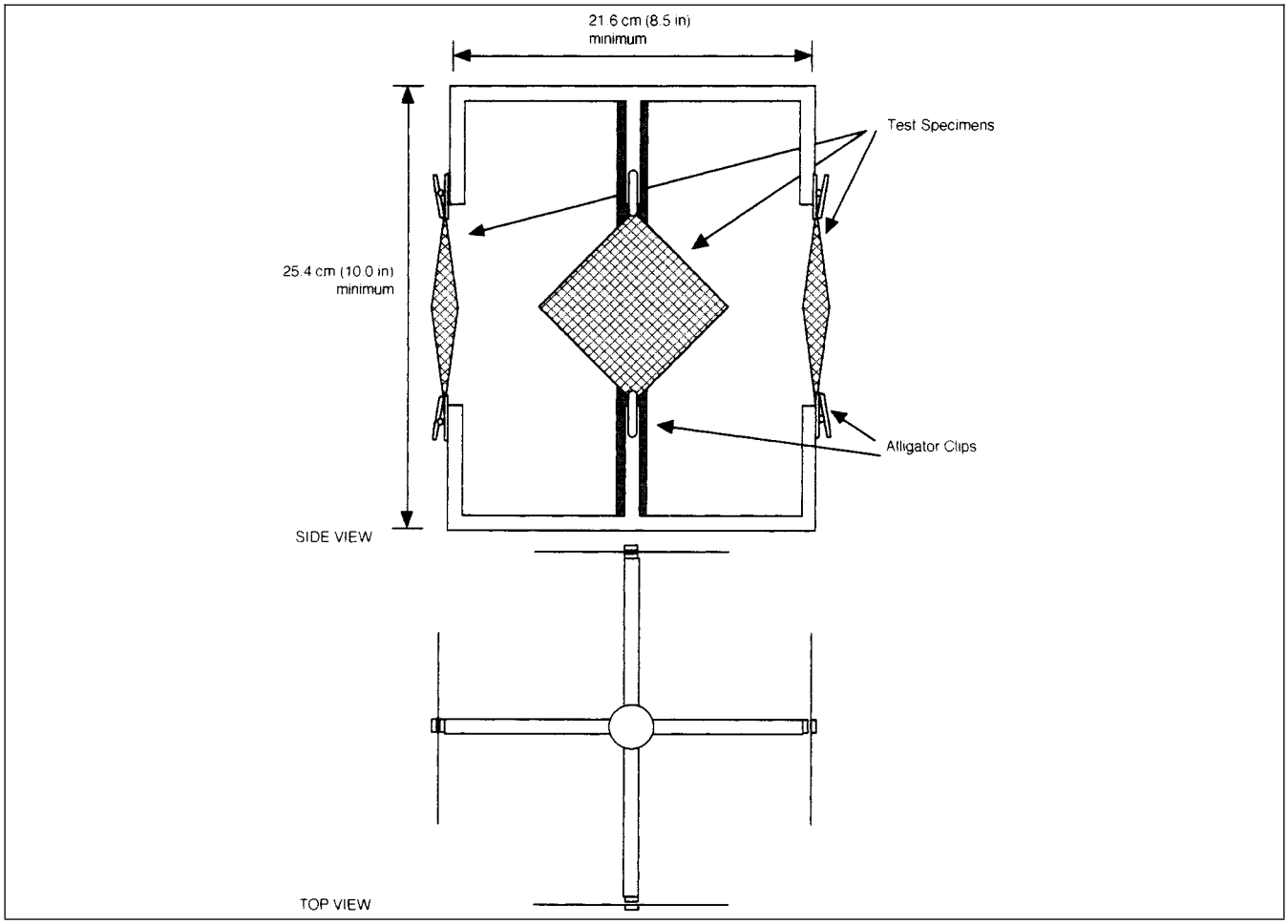

Figure 1 Method of holding device

5.3.1 Apply mold release to the alligator clips on the apparatus shown in Figure 1 and allow to air dry.

5.3.2 Weigh each specimen to the nearest milligram [.001 gram]. Record as W1.

5.3.3 Secure each specimen at diagonally opposite corners from the metal hanging apparatus as shown in Figure 1.

5.3.4 Place the apparatus with specimens in the air circulating oven at the temperature and for the time specified in Table 1 or by the governing document.

5.3.5 Remove the specimens from the oven and from the holding apparatus and weigh each specimen within two minutes to the nearest milligram [0.001 gram]. Record as W2.

5.4 Calculation Calculate and record the volatile content as follows:

$$\text{VolatileContent (\%)} = \left(\frac{W_1 - W_2}{W_1}\right) \times 100$$

5.5 Report The results should be reported and shall contain the following:

(1) Identification of prepreg material type tested.

(2) Percent volatile content for each specimen tested and the average.

(3) Test temperature and time in oven.

6.0 Notes

6.1 Moisture Content

6.1.1 Exclusion of Moisture Content Desiccation of the specimens is performed for the following reasons.

6.1.1.1 This test method is based on the understanding that ''Volatile Content'' refers to organic solvents and other ingredients of the prepreg that may remain in the material after curing. Water or moisture content is not considered as a ''Volatile'' for purposes of this test, and therefore desiccation is a fundamental step to exclude H_20 from the data. It is not possible to remove all H_20 from material that is hygroscopic, but the most significant content is removed.

6.1.1.2 This method has a high intrinsic variability potential, and since moisture content is extremely variable and dependent on the storage environment, meaningful data is best achieved by removing the moisture.

6.1.2 Moisture Content Determination This method can be performed in an alternative manner, in which the specimen is weighed before it is desiccated. The difference between the ''As Is Weight'' and the ''Weight After Desiccation'' (but before oven drying) is the moisture content.

6.2 Alternate Specimen Holder Method B has been designed to minimize the problem of specimens flopping around in the air circulating oven.

6.3 Desiccator Conditions The Test Methods Task Group determined that a great majority of test laboratories are unable to consistently hold the Relative Humidity in a desiccator to less than 20%. Based on data from participating company lab management, the lowest practically feasible RH for use with the affected IPC Test Methods is 30% maximum.

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IPC-TM-650
TEST METHODS MANUAL

Number	
2.4.38	
Subject	
Prepreg Scaled Flow Testing	
Date	Revision
6/91	**A**
Originating Task Group	
N/A	

1.0 Scope This procedure defines a test method used to determine the scaled flow parameters of an epoxy resin, pre-impregnated glass fabric (prepreg). The test is appropriate for checking material consistency, but is not solely intended for defining the suitability of prepreg to be used in a specific printed wiring board product or process.

2.0 Terms and Definitions

2.1 Scaled Flow Parameter Test A test procedure intended to measure multilayer lamination prepreg flow characteristics.

3.0 Apparatus

3.1 Test Specimen The prepreg specimen size shall be 5.50 ± 0.05 inches by 7.00 ± 0.05 inches. Specimens shall be cut with the 7 inch dimension parallel to the machine (warp) direction.

3.2 Release Material The release material shall be polyvinyl fluoride (PVF) or equivalent at least 7 x 9 inches in size.

3.3 Tape Tape shall be suitable for holding the sample during processing.

3.4 Press Plate The press plate used shall be metal between 0.125 to 0.250 inches thick, and 4.50 ± 0.01 x 6.00 ± 0.01 inches in size. The plate shall be flat and parallel within 0.001 inches.

3.5 Lamination Press A lamination press with a minimum platen size of 8 x 8 inches, capable of applying a uniform pressure of 840 lb force (31.0 PSI) ± 5% and capable of maintaining a temperature range of 120-180°C with a tolerance of ± 2° of required temperature.

3.6 Prepreg Cutting Equipment Cutter capable of maintaining tolerances defined in 3.1.

3.7 Balance A balance capable of weighing to ± 0.01 gram.

3.8 Micrometer A measuring instrument for measuring thickness to ± 0.0001 inch.

3.9 Desiccator A stabilization chamber (drying cabinet) with significant desiccant (calcium sulfate or equivalent) capable of maintaining less than 10% relative humidity at 21 ± 2°C (70 ± 5°F).

4.0 Test Procedure

4.1 Specimen Conditioning The specimens shall be cut to size and then placed in a stabilization chamber (see 3.9) for a period of 24 hours. Testing shall be performed within 15 minutes of removal from chamber. *Note:* Specimens tested within 15 minutes of their manufacture need not be desiccated.

4.2 Specimens shall be gathered into a stack for test purposes. Number of plies shall be determined from Table 1.

Table 1

Glass Thickness	Number of Plies (stack-up)
Up to 0.0025 in. (i.e., style104, 106, 108, etc.)	18-20
*Greater than 0.0025 in (i.e., style 112, 113, 116, etc.)	10

Note: Glass styles thicker than style 116 have shown some difficulty in consistency of test results.

4.3 Weigh stack of prepreg to the nearest 0.01 gram, record weight as Wo.

4.4 Center press plate (see 3.4) on the laminating press platen. Close press and preheat lamination press (see 3.5) and press plate to 150 ± 2°C. (Other temperature can be used as agreed upon by user and vendor.)

4.5 Place the stack of prepreg on one of the release sheets (see 3.2) which has been previously cut to a 7 x 9 inch size. Use tape to hold the sample in place. Position tape on opposite corners, such that it does not interfere with the 4.5 x 6.0 inch specimen center to be tested. The second release sheet is placed on top of the stack to form a sandwich. See Figure 1.

4.6 Open press and immediately place the stack sandwich on the press plate, being careful to center the stack on the press plate. *Note:* Make sure that the release material is in place.

4.7 Unless otherwise specified, press the specimen with a force of 840 lb (31.0 psi) ± 5% for 10 minutes minimum. Full

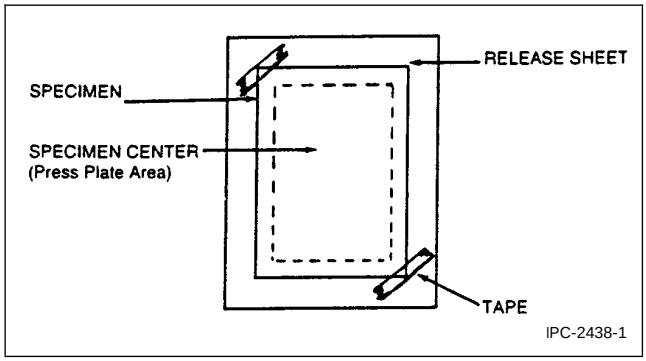

Figure 1

force is to be applied within 15 seconds after sample is placed on the press plate.

4.8 Carefully remove the hot specimen from the press, flip over onto a smooth flat surface and cool for 5 minutes or to a rigid state before making measurements.

4.9 Remove release material from stack. Using the template shown in Figure 2, mark the points to be measured. Cut the stack when required to facilitate measuring the specific points along the cut line shown in Figure 2.

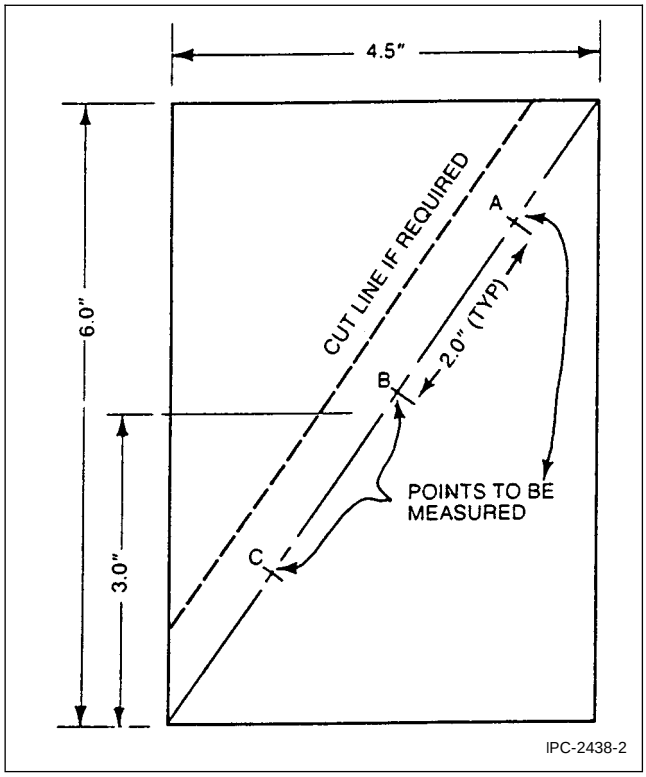

Figure 2

5.0 Test Results

5.1 Measure the thickness to the nearest 0.0001 inch with a micrometer at the three intervals defined by the template. Record all three measurements for each test specimen. If there is a thickness variation between the three measurements of 0.003 inches or more, the test must be repeated. Average the three measurements to determine final measured thickness.

5.2 Use the initial weight, WO, to determine the initial thickness (Ho) either from the formula in Appendix or from Table 2.

5.3 Final thickness per ply can be calculated by dividing the final measured thickness by the number of plies. Initial thickness and final thickness can be used to calculate thickness change.

Appendix

Determination of Initial Thickness: (See Table 2)

$$ho = \left[\frac{Wo}{n}(5.54 \times 10^{-2}) - \right] 2.12 \times 10^{-2}$$

Where:

ho = Initial thickness per ply (mils)

Wo = Initial stack weight (g)

Wg = Unit glass weight (g/in2)

n = Number of plies

Unit Glass Weights: (Approximated from test results)

Style	Weight (g/in2)
104	0.0128
106	0.0164
108/1080	0.0311
112/2112	0.0464
113/2113	0.0538
116/2116	0.0691
7628	0.1312

Table 2 Initial Stackweight (Wo, grams) vs. Calculated Initial Thickness (ho, mils)

104		106		108		112		113		116		7628	
Wo	ho	Wo	ho	Wo	ho	Wo	ho	Wo	ho	Wo	ho	Wo	ho
20	1.03	25	1.28	40	1.95	35	3.13	35	2.97	45	3.82	80	6.71
21	1.10	26	1.35	41	2.02	36	3.24	36	3.09	46	3.94	81	6.73
22	1.16	27	1.41	42	2.08	37	3.36	37	3.21	47	4.06	82	6.85
23	1.23	28	1.48	43	2.15	38	3.48	38	3.32	48	4.17	83	6.97
24	1.29	29	1.54	44	2.21	39	3.60	39	3.44	59	4.29	84	7.08
25	1.36	30	1.61	45	2.28	40	3.71	40	3.56	50	4.41	85	7.20
26	1.43	31	1.68	46	2.34	41	3.83	41	3.67	51	4.52	86	7.32
27	1.49	32	1.74	47	2.41	42	3.95	42	3.79	52	4.64	87	7.44
28	1.56	33	1.81	48	2.47	43	4.07	43	3.91	53	4.76	88	7.55
29	1.62	34	1.87	49	2.54	44	4.18	44	4.03	54	4.88	89	7.67
30	1.69	35	1.94	50	2.60	45	4.30	45	4.14	55	4.99	90	7.79
31	1.75	36	2.00	51	2.67	46	4.42	46	4.26	56	5.11	91	7.91
32	1.82	37	2.07	52	2.73	47	4.54	47	4.38	57	5.23	92	8.02
33	1.88	38	2.13	53	2.80	48	4.65	48	4.50	58	5.35	93	8.14
34	1.95	39	2.20	54	2.86	49	4.77	49	4.61	59	5.46	94	8.26
35	2.01	40	2.26	55	2.93	50	4.89	50	4.73	60	5.58	95	8.38
36	2.08	41	2.33	56	2.99	51	5.01	51	4.85	61	5.70	96	8.49
37	2.14	42	2.39	57	3.06	52	5.12	52	4.97	62	5.82	97	8.61
38	2.21	43	2.46	58	3.13	53	5.24	53	5.08	63	5.95	98	8.73
39	2.27	44	2.52	59	3.19	54	5.36	54	5.20	64	6.05	99	8.85
40	2.34	45	2.59	60	3.26	55	5.48	55	5.32	65	6.17	100	8.96
41	2.40	46	2.65	61	3.32	56	5.59	56	5.44	66	6.29	101	9.08
42	2.47	47	2.72	62	3.39	57	5.71	57	5.55	67	6.40	102	9.20
43	2.53	58	2.78	63	3.45	58	5.83	58	5.67	68	6.52	103	9.32
44	2.60	59	2.85	64	3.52	59	5.95	59	5.79	69	6.64	104	9.43
45	2.66	50	2.91	65	3.58	60	6.06	60	5.91	70	6.76	105	9.55

Wo = grams, ho = mils; (n) for 104, 106, 108 = 18; (n) for 112, 113, 116 7628 = 10

Reference Documents

1. Journal of Elastomers and Plastics, 10,367 (1978), C.J. Bartlett
2. Journal of Elastomers and Plastics, 10,365 (1978) D.P. Bloechle
3. IPC-TP-281, The Use of Scaled Flow Testing for B-Stage Prepreg, C.J. Bartlett, D.P. Bloechle, W.A. Mazeika
4. IPC-TP-418, Application of Scaled Flow Testing as an Incoming Inspection Criteria, H.J. Brown
5. IPC-TP-420, Scaled Flow for Testing CRC Prepreg, J. Del, P. Marx, J. Sallo
6. D.P. Bloechle, ‘‘Epoxy Prepreg Characterization using Scaled Flow Testing Techniques,’’ Circuit World, 9,1 (1982), p.8

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IPC-TM-650
TEST METHODS MANUAL

Number	
2.5.5.3	
Subject	
Permittivity (Dielectric Constant) and Loss Tangent (Dissipation Factor) of Materials (Two Fluid Cell Method)	
Date	Revision
12/87	**C**
Originating Task Group	
N/A	

1.0 Scope

1.1 Purpose This method is suitable for determining the volume permittivity, (dielectric constant) and loss tangent (dissipation factor) of insulating materials at 1 MHz. It is not dependent on either direct or indirect measurement of specimen thickness and therefore is very useful for thin films and laminates but may also be used on specimens up to approximately 6.35 mm [0.25 in] thick.

It is useful for all ranges of permittivity and for loss tangent as low as 0.0005 providing the range and accuracy of the bridge used are adequate.

1.2 Description of Method The two fluid method utilizes air as one fluid and a suitable liquid, normally Dow 200 1.0CS silicone fluid, as the second. Using an established value for the permittivity of air, the values for the permittivity of the fluid and the sample may easily be calculated. The cell spacing is fixed during all readings but does not need to be known accurately for the series of readings required. Since specimens do not require any electrodes to be applied and since many specimens can be measured at one time without changing any spacings or machine settings, the method is not only very accurate but very rapid.

The method has been used for measurement of PTFE and epoxy glass laminates and flexible films, e.g. polyimide.

Reproducibility lab to lab is excellent for permittivity provided minimal precautions are observed and bridge accuracy is appropriate. On most materials, the effects of small changes in moisture or temperature are larger than any error due to the method. Lab to lab correlation on stable material such as PTFE have shown results to be consistently within 0.005 or (0.20%).

2.0 Applicable Document

3.0 Test Specimens

3.1 Number Unless otherwise specified in the material specification, one specimen is adequate for materials which are uniform, e.g. unreinforced plastics. For woven reinforced materials where resin content may vary, at least 2 specimens, representing the thinnest and thickest part of the sample, should be tested. For material with random reinforcement, a minimum of three specimens from the edge and center of the sheet are recommended to characterize variation within the sheet.

3.2 Form Individual specimens shall be 81.3 mm ± 1.3 mm x 81.3 to 101.6 mm [3.2 in ± 0.05 in x 3.2 in to 4.0 in] x thickness.

For materials under 0.254 mm [0.010 in], individual specimens should be stacked to a minimum of 0.381 mm [0.015 in] to maximize accuracy. Thinner specimen buildups may be used if the correlation with the 0.381 mm [0.015 in] specimen is within the required accuracy for the particular equipment, cell spacing and material being tested.

3.3 Foil Clad Materials All foil clad materials shall have the metal cladding completely removed by etching and shall be rinsed and dried prior to conditioning.

3.4 Marking Mark each specimen in the upper left corner with an engraving pencil or an ink which is not soluble in the Dow Corning 200 fluid.

4.0 Apparatus/Materials

4.1 1 MHz Capacitance Bridge with 0-200 (or 0-100) pf range.[1]

4.2 Cell Balsbaugh LD-3[2] or equivalent (see Figure 1) three terminal cell. *Note:* For accuracy of 1% or better, room temperature must not vary more than 1°C during measurements. Temperature control is necessary if laboratory variation exceeds these limits.

1. Capacitance Bridge—Suggested is Boonton 76A automatic capacitance bridge. This model has adequate capacitance range and adequate conductance resolution (0.001 microsiemen) to permit measurement of dissipation factors down to approximately 0.0005. Other bridges, e.g. Boonton 75D, are also adequate for low loss materials and some other bridges may be suitable for higher loss materials, such as epoxy where dissipation factors exceed 0.01 and resolution of 0.01 microsiemen or even 0.1 microsiemen may be adequate.
2. Balsbaugh LD-3 Gillian and Co,, Watertown, MA, (617) 624-5688 or Zincast Corporation, 44 Homestead Ave., Stanford, CT 06902, (203) 359-0109

4.3 Test Leads 2 RG 58/U coax cables approximately 304.8 mm [12 in] long with suitable connectors for the bridge. One lead shall have a banana plug (high lead) and the low lead should have a GR874[3] at the cell end. (Note: The use of a G874-QBJA[4] instead of the standard GR874 will permit a BNC[5] connector to be used for the cell connection of the low lead, reducing the chances of damaging the 874 connector.)

4.4 Flask with stopper (for silicone fluid storage).

4.5 Beaker for cell overflow.

4.6 Funnel.

4.7 Filter paper (coarse).

4.8 1 Centistoke Dow Corning 200 Fluid (500 ml minimum).

Note: Fluid must be at the same ambient temperature as the test cell and should be stored in close proximity to the test cell.

4.9 Forceps or large tweezers.

5.0 Procedure

5.1 Conditioning All materials which are affected by moisture, including all reinforced laminates and most films, should be conditioned at 23°C ± 2°C 50 ± 5% RH for a minimum of 24 hours prior to testing. If required by the specification, specimens may be tested after humidity or water immersion or tested after desiccation.

5.2 Test Conditions For ambient temperature tests the temperature should be 23°C ± 2°C.

Note: Variation should not exceed 1°C during the test. Ambient humidity is not critical for most materials. The exception is very thin, very hydroscopic material such as polyimide film, where moisture content may be well over 1%. Such material must be tested at the desired humidity since the dielectric constant will increase measurably with moisture content and changes may occur very rapidly after removal from a controlled environment. For materials which experience glass transitions in the room temperature region, e.g. PTFE, some acrylics, the temperature should be 23°C ± 1°C.

5.3 Set Up

5.3.1 Open the electrode on the cell. Blow out the cell using clean compressed air to remove any dust or silicone fluid.

5.3.2 Warm up the bridge for at least the minimum amount of time recommended by the manufacturer.

5.3.3 Attach the low lead to the guarded electrode of the cell and the bridge.

5.3.4 Attach the high lead to the bridge and place the banana plug in the vicinity of, but not touching, the banana plug jack of the test cell.

Note: Be certain the shielding on the high lead does not contact the banana plug.

5.3.5 Set the bridge up on appropriate ranges:

Capacitance: 200 pf (or 100 pf)
Conductance: microsiemens

0-2 PTFE and very low loss material.
0-20 Epoxy and other moderate loss materials.
0-200 Some phenolic and very high loss materials.

Note: For very thick specimens >3.18 mm [>0.125 in] the 0 to 20 pf range can often be used, increasing the precision of the measurement. All values must be obtained on the same range for both capacitance and conductance.

5.3.6 Set the cell spacing on the LD-3 to approximately 125% of the material thickness 0.51 mm minimum to 7.62 [0.020 in minimum to 0.3 in] *Note:* The spacing may be as little as 10% or as much as 50% greater than specimen thickness without a significant effect on results.

5.3.7 Zero the bridge for both capacitance and conductance.

5.4 Measurement

5.4.1 Connect the banana plug of the high lead to the cell.

5.4.2 Record the capacitance of the air filled cell as C_1 to

3. GR874—Catalogue #874-9414 Gilbert Engineering, Glendale, AZ, (602) 245-1050
4. G874-QBJA—Catalogue #874 QBJA Gilbert Engineering, Glendale, AZ
5. BNC—Catalogue #999-225 Amphenol

the nearest .01 pf (or nearest .001 pf if the 0-20 pf scale is used).

5.4.3 Remove the specimen from the humidity controlled environment.

5.4.4 Insert the first specimen to be tested with the marked corner remaining in the upper left and the right side of the test specimen against one side of the test cell. *Note:* This will ensure that subsequent measurements are taken using the same area of the specimen.

5.4.5 Read and record the value of capacitance with the specimen in the cell as C_3.

5.4.6 Remove the first specimen and obtain C_3 for any other specimens to be measured with same cell spacing.

5.4.7 After removing the last specimen from the cell, fill the cell with Dow Corning 200 Fluid using the funnel and a filter to remove any small particles from the fluid and collect any excess fluid from the overflow pipe on the cell with the small beaker.

5.4.8 Allow a few seconds for the temperature of the cell and fluid to equilibrate and record the capacitance of the liquid filled cell as C_2.

Note: If the capacitance is drifting consistently in one direction, the fluid is not at equilibrium.

5.4.9 Record the conductance of the fluid filled as cell G_1.

Note: The value obtained will vary somewhat with cell spacing and humidity but should not exceed 500 microsiemen (200 microsiemen if low loss material, with a loss tangent under .001 is being tested). Values beyond this are generally indicative of problems with the leads, contamination of the fluid or bridge error and must be corrected if correct dissipation factor is to be determined.

5.4.10 Insert the first specimen in the fluid filled cell exactly as in the dry reading and record the value of the capacitance as C_4 and the value of the conductance as G_2.

Note: Values should stabilize within a few seconds after specimen insertion. If they do not there is very likely air trapped in the cell. This is quite common if multiple thin specimens are used to form one test specimen. If this occurs presoaking the specimen with fluid before immersion and inserting one ply at a time should eliminate the problem.

5.4.11 Remove the first specimen and insert each subsequent specimen in the same order as the dry values were obtained and record the C_4 and G_2 values for each.

5.4.12 After the last specimen is measured and removed from fluid, check and record the values of the capacitance and conductance.

Note: If the level of the fluid with the specimen removed does not cover the electrodes, fill the cell before checking the final values. This check on C_2 will be used to verify the amount of influence that changes in ambient temperature have had on the values obtained.

6.0 Calculation

6.1 Calculate the value of the permittivity (dielectric constant) of each specimen tested using the equation:

$$DK = \frac{1.00058}{C1}\left(C1 + \frac{(C3–C1)\,(C2–C1)\,C4}{(C3–C1)\,C4 – (C4–C2)\,C3}\right)$$

Round the value obtained to the nearest .01.

6.2 Calculate the value of the loss tangent (dissipation factor) of each specimen tested using the equation:

$$DF = \frac{G2}{6.2832\,C4} + \left(\frac{DK * .99942\,C1–C4}{C\,4–C2}\right)\left(\frac{G2}{6.2832\,C4} – \frac{G1}{6.2832\,C2}\right)$$

Round the value to the nearest .0001.

Note: Values should be calculated using a computer and must not be rounded prematurely.

6.3 If the value of C_2 changed during the course of the measurements, use the final values of C_2 and G_2, the value of C_1, and the values on the last specimen for C_3 and C_4 to recalculate the DK and Df of the final specimen. If the difference in DK values is significant, the temperature of the cell must be controlled more precisely during the measurement period.

6.4 Calculate the average permittivity (dielectric constant) (if more than one specimen was tested).

6.5 Calculate the average loss tangent (dissipation factor) (if more than one specimen was tested).

7.0 Report

7.1 Report the minimum, maximum and average values of the permittivity (dielectric constant).

7.2 Report the average value of the loss tangent (dissipation factor).

7.3 Report the specimen preconditioning, e.g. C-24/23/50.

7.4 Report the actual test conditions for temperature and humidity.

7.5 Report if the specimen was built up.

7.6 Report the approximate cell spacing.

7.7 Report any anomalies in the test or variations from the prescribed procedures or tolerances.

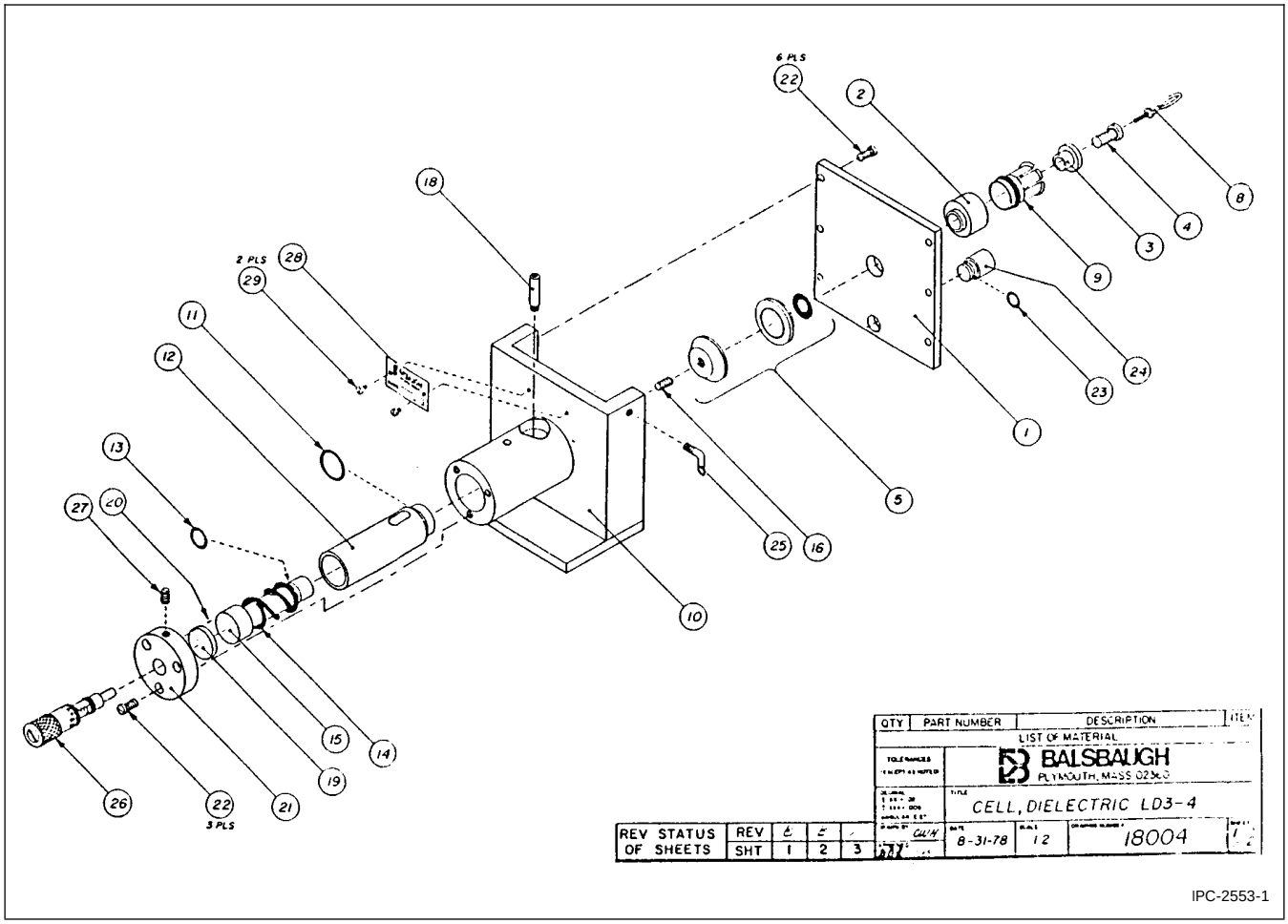

Figure 1

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IPC-TM-650
TEST METHODS MANUAL

Number	
2.5.6.2	
Subject	
Electric Strength of Printed Wiring Material	
Date	Revision
5/86	
Originating Task Group	
N/A	

1.0 Scope This method describes a technique for evaluating the ability of an insulating material to resist electrical breakdown perpendicular to the plane of the material when subjected to short term, high voltages at standard AC power frequencies of 50-60 Hz.

1.1 Applicability and Use of Data This method may be used on material of any thickness up to approximately 0.125 inch, however, for material over 0.020 inch, other methods such as dielectric breakdown are normally used to characterize a material's electrical integrity. Results of this test may be drastically affected by moisture content, and results obtained using different preconditioning may not be comparable.

This method uses an oil medium to prevent flashover on a small specimen and results may not be comparable to tests run in air. Values obtained using this method should not be used for predicting the insulating ability of ultra thin metal clad laminates.

The values determined by this method generally decrease with increasing specimen thickness for otherwise identical material. This method is based on the techniques described in ASTM D149.

2.0 Applicable Document

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

3.0 Test Specimens

3.1 Number Three specimens shall be prepared unless otherwise specified.

3.2 Form Specimens should be 4.0 inch ± 1.0 inch X 4.0 ± 1.0 inch; however, size is not critical as long as no flashover occurs around the edges.

3.3 Location Specimens shall be cut by any convenient means from both edges[1] and the center of the laminate (except no specimen shall be taken closer than 1 inch from the edge of full size sheets).

3.4 Foil Clad Material Foil clad materials shall have all metal cladding removed by etching and should be thoroughly cleaned prior to conditioning or testing.

3.5 Uncured Material Uncured material must be fully cured. Under normal conditions, two ply lamination is recomrnended for comparison of prepreg material. Single ply laminates are recommended for cover lays and similar products designed for single ply usage.

4.0 Apparatus/Materials

4.1 High voltage breakdown tester, 25 KV, minimum with an adequate current rating[2], a motorized control capable of 500 volts per second rate of rise and a meter capable of indicating breakdown voltage within 5% over the entire range of actual breakdown voltages (generally 1 KV to 20 KV).

4.2 Oil tank filled with insulating oil[3].

4.3 Electrode test set 2 inch diameter electrodes with 1/4 inch radius on the edge of the electrodes and 50 g. ±2 g. load applied by the weight of upper electrode (in air).

4.4 Two high voltage test leads (leads rated in excess of the tester voltage capability are recommended).

4.5 Micrometer capable of resolving at least 0.0001 inch. *Note:* For accurate measurement of material under 0.005 inch test accuracy may be severely limited by the ability to measure the specimen accurately.

4.6 Constant temperature water bath, capable of maintaining 50°C ± 2°C, filled with distilled water.

1. Edges: For a reinforced laminate the specimens shall be from opposite edges of the reinforcement.
2. Current capacity: 40 milliamps is normally satisfactory.
3. Insulating oil: Shell Dial AX Insulating Oil has been found suitable for breakdowns up to 100 KV.

4.7 Large beaker or pan filled with ambient temperature distilled water.

4.8 Rack for supporting and separating specimens in the 50°C water bath.

4.9 Lint free paper towels.

5.0 Procedure

5.1 Preconditioning Unless otherwise specified, the specimen shall be conditioned for 48 hours (±2 hours -0 hours) in distilled water maintained at 50°C ± 2°C.

Following this the specimen shall be immersed in the ambient temperature distilled water for 30 minutes minimum, 4 hours maximum, to achieve temperature equilibrium without significant changes in moisture content.

5.2 Test Conditions The test should be performed at ambient temperature, 23°C ± 5°C. Relative humidity is not significant as the tests are performed under oil.

5.3 Equipment Set Up

5.3.1 Set the high voltage tester in accordance with the manufacturer's instructions so that the voltage range will be adequate for the material being tested.

5.3.2 Set up the control for testing using a 500 volt per second rate of rise.

5.3.3 Attach the leads (if not permanently wired) such that the high lead is connected to one electrode and the ground lead is connected to the other electrode.

5.4 Test

5.4.1 Remove a preconditioned specimen from the ambient temperature water and wipe dry with a lint free paper towel.

5.4.2 Determine and record the thickness of the specimen at four locations 1 inch from the edge at the midpoint of each side.

5.4.3 Insert the specimen into the test fixture centering it to reduce chances of flashover.

5.4.4 Operate the tester such that the voltage is applied with a 500 volts per second increase and observe the point at which the tester indicates a breakdown.

5.4.5 Record the breakdown voltage to the nearest .1 KV for values over 10 KV and to at least the nearest 5% for all lower values.

5.4.6 Remove the specimen from the oil medium and verify that a breakdown has occurred. If none is apparent reinsert the specimen, carefully centering it, and retest as in 5.4.4 and 5.4.5. *Note:* If flashover occurs, either a larger specimen or new oil must be used.

4.7 Test the remaining two specimens as in 5.4.1 through 5.4.6.

6.0 Calculations

6.1 Calculate the average thickness for each specimen from the four individual values measured.

6.2 Determine the electric strength in volts per mil for each specimen by dividing the breakdown voltage expressed in kilovolts by the thickness express in inches.

$$ES = \frac{6.8\ KV}{.005\ inch} \times \frac{1000\ V}{KV} \times \frac{1\ inch}{1000\ mils} = 1360\ v/mil$$

6.3 Determine the average electric strength by averaging the individual values for each specimen. Round the average to the nearest 10 volts/mil.

6.4 If any specimen falls below the specification minimum, calculate the percentage of the requirement:

$$^{ES}min = \frac{Lowest\ Value}{Spec\ Value} \times 100\%$$

e.g. Value = 670 volts per mil

Specification = 750 volts per mil

$$^{ES}min = \frac{670}{750} \times 100\% = .893 \times 100\% = .89 \times 100\% = 89\%$$

7.0 Report

7.1 Report the average value for electric strength in volts per mil to the nearest 10 volts per mil.

7.2 Report the minimum value in percent of requirement if it is below the requirement for average electric strength.

7.3 Report the actual thickness range of the material tested including the minimum and maximum individual thickness measurements.

7.4 Report any anomalies in the test or any variations from the prescribed procedures or tolerances.

8.0 ***Notes***

8.1 This test method may be modified to an air medium to predict performance in normal environments more accurately, however, unless the electrode is effectively guarded, the breakdown will generally occur in air.

8.2 For testing the effect of copper foil on clad laminate under 0.005 inch it is suggested that two inch circular electrodes be left on the 4 inch X 4 inch specimen by etching. The ground electrode may be slightly larger to assure registration.

8.3 For materials which are compressible, a standard pressure of 25 PSI is to be used for determining specimen thickness.

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IPC-TM-650
TEST METHODS MANUAL

Number	
2.6.1	
Subject	
Fungus Resistance Printed Wiring Materials	
Date	Revision
1/95	**D**
Originating Task Group	
Flux Specifications Task Group (5-24a)	

1.0 Scope The fungus resistance test is used to determine the resistance of materials to fungi and to determine if such material is adversely affected by fungi under conditions favorable for their development, namely high humidity, warm atmosphere, and presence of inorganic salts.

2.0 Applicable Documents None

3.0 Test Specimen Specimens must be a minimum size of 50 mm x 50 mm with copper foil (if applicable) removed by etching using standard commercial practices.

4.0 Apparatus and Reagents

4.1 Test Chamber The autoclave shall be capable of maintaining 30°C and 95% relative humidity and an ultra violet (360 nm) source for subsequent decontamination. Provisions shall be made to prevent condensation from dripping on the test item. There shall be free circulation of air around the test item and the contact area of fixtures supporting the test item shall be kept to a minimum.

4.2 Sterilizer

4.3 Centrifuge

4.4 pH Meter

4.5 Colony Counter

4.6 Incubator

4.7 Dishwasher

4.8 Petri Dishes

4.9 Filter Paper

4.10 Media Solutions

4.11 Microorganism

4.12 Atomizer, 15,000 ± 3000 spores

5.0 Procedures

5.1 Preparation of Test Media

5.1.1 Mineral-Salts Solution Prepare the solution to contain the following:

Potassium dihydrogen orthophosphate (KH_2PO_4).....0.7g

Potassium monohydrogen orthophosphate (K_2HPO_4).....0.7g

Magnesium sulfate heptahydrate ($MgSo_4\ 7H_2O$.....0.7g

Ammonium nitrate (NH_4NO_3).....1.0g

Sodium chloride (NaCl).....0.005g

Ferrous sulfate heptahydrate ($FeSo_4\ 7H_2O$) 0.002g

Zinc sulfate heptahydrate ($ZnSO_47H_2O$).....0.002g

Manganous sulfate monohydrate ($MnSO_4\ H_2O$).....0.001g

Distilled water.....1000 ml

Sterilize the mineral salts solution by autoclaving at 121°C for 20 minutes. Adjust the pH of the solution by the addition of 0.01 normal solution of NaOH so that after sterilization the pH is between 6.0 and 6.5. Prepare sufficient salts solution for the required tests.

5.1.2 Purity of Reagents Reagent grade chemicals shall be used in all tests. Unless otherwise specified, it is intended that all reagents shall conform to the specification of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.

5.1.3 Purity of Water Unless otherwise specified, references to water shall be understood to mean distilled water or water of equal purity.

5.1.4 Preparation of Mixed Spore Suspension The following test fungi shall be used:

Description	ATCC
Aspergillus niger	9642
Chaetomium globosum	6205
Gliocladium virans	9645
Aureobasidium pullulans	9348
Penicillium funiculosum	9644

5.1.5 Maintain cultures of these fungi separately on an appropriate medium such as potato dextrose agar. However, the culture of chaetomium globosum shall be cultured on

strips of filter paper on the surface of mineral salts agar. (Mineral salts agar is identical to mineral salts solution, but contains in addition 15.0 g of agar per liter).

5.1.6 The stock cultures may be kept for not more than 4 months at 6°± 4°C, at which time subcultures shall be made and new stocks shall be selected from the subcultures.

5.1.7 If genetic or physiological changes occur, obtain new cultures as specified above. Subcultures used for preparing new stock cultures or the spore suspension shall be incubated at 30°C for 9 to 12 days or longer.

5.1.8 Prepare a spore suspension of each of the five fungi by pouring into one subculture of each fungus, a 10-ml portion of a sterile solution containing 0.05 g per liter of a nontoxic wetting agent such as sodium dioctyl sulfosuccinate or sodium lauryl sulfate.

5.1.9 Use a sterile platinum or nichrome inoculating wire to scrape gently the surface growth from the culture of the test organism.

5.1.10 Pour the spore charge into a sterile 125-ml glass-stoppered Erlenmeyer flask containing 45 ml of sterile water and 50 to 75 solid glass beads, 5 mm in diameter.

5.1.11 Shake the flash vigorously to liberate the spores from the fruiting bodies and to break the spore clumps.

5.1.12 Filter the dispersed fungal spore suspension, through a 6 mm layer of glass wool contained in a glass funnel, into a sterile flask.

5.1.13 This process should remove large mycelial fragments and clumps of agar which could interfere with the spraying process.

5.1.14 Centrifuge the filtered spore suspension aseptically and discard the supernatant liquid.

5.1.15 Resuspend the residue in 50 ml of sterile water and centrifuge. Wash the spores obtained from each of the fungi in this manner three times.

5.1.16 Dilute the final washed residue with sterile mineral-salts solution in such a manner that the resultant spore suspension shall contain 1,000,000 ± 200,000 spores per ml as determined with a counting chamber.

5.1.17 Repeat this operation for each organism used in the test and blend equal volumes of the resultant spore suspension to obtain the final mixed spore suspension. The spore suspension may be prepared fresh each day or may be held at 6° ± 4°C for not more than 7 days.

5.2 Viability of Inoculum Control With each daily group of tests, place each of 3 pieces of sterilized filter paper, 25 mm x 25 mm square, on hardened mineral-salts agar in separate Petri dishes. Inoculate these with the spore suspension by spraying the suspension from a sterilized atomizer until initiation of droplet coalescence. Incubate these at 30°C at a relative humidity not less than 85% and examine them after 7 days of incubation. There shall be copious growth on all three of the filter paper control specimens. Absence of such growth requires repetition of the test.

5.3 Control Items

5.3.1 In addition to the viability of inoculum control, known susceptible substrates shall be inoculated along with the test item to insure that proper conditions are present in the incubation chamber to promote fungus growth.

5.3.2 The control items shall consist of cotton duck 8.25-ounce strips that are 5 cm, that have been dipped into a solution containing 10% glycerol, 0.1% potassium dihydrogen orthophosphate (KH_2PO_4), 0.1% ammonium nitrate (NH_4NO_3), 0.025% magnesium sulfate ($MgSO_4$ $7H_2O$), and 0.05% yeast extract (pH 5.3), and from which the excess liquid has been removed.

5.3.3 The strips should be hung to air dry before being inoculated and placed into the chamber.

5.4 Inoculation of Test and Control Item

5.4.1 Mount the test and control items on suitable fixtures or suspend from hangers. No cleaning of the test item shall be permitted for 72 hours prior to the beginning of the fungus test.

Equipment handling prior to and during the fungus test shall be accomplished without contamination of the equipment.

5.4.2 Precondition the chamber and its contents at: 30°C and 97 ± 2% relative humidity for at least 4 hours.

5.4.3 Inoculate the test and control items with the mixed fungus spore suspension (3.1.2) by spraying it on and into the test and control items (if not hermetically sealed) in the form of a fine mist from a previously sterilized atomizer or nebulizer. In spraying the test and control items, care should be taken to spray all surfaces which are exposed during use or maintenance. If the surfaces are nonwetting, spray until initiation of droplet coalescence. Incubation is to be started immediately following the inoculation.

5.5 Test Incubation of Test Items

5.5.1 Incubate test items under cyclic temperature and humidity conditions to include 20 hours of relative humidity at 95 ± 5% at an air temperature of 30° ± 1°C followed by 4 hours of 100% relative humidity at 25° ± 1°C.

5.5.2 After 7 days, inspect the growth on the control items to be assured that the environmental conditions are suitable for growth. If inspection reveals that the environmental conditions are unsuitable for growth, the entire test shall be repeated.

5.5.3 If the control items show satisfactory fungus growth, continue the test for a period of 28 days from the time of inoculation, or as specified.

5.6 Evaluation

5.6.1 Report those specimens which were found to be nutrient to fungus growth.

5.6.2 Corrosion should be noted separately from the fungus test results.

6.0 *Notes*

6.1 Source for Microorganisms

6.1.1

American Type Culture Collection
12301 Parklawn Drive
Rockville, MD 20852 USA
(301) 881-2600 TELEX: 908768 ATCC ROVE

6.2 Secondary Sources for Microorganisms

6.2.1

Pioneering Research Division
U.S. Army Natick Laboratories
Natick, Massachusetts 01760

6.2.2.

USDA Northern Regional Research Center
1815 North University St.
Peoria, IL 61604
Contact: Dr. Stephen Peterson
309-685-4011

6.3 After evaluation, the materials and the test chamber must be decontaminated by exposure on all sides to ultraviolet rays (360 nm) for a minimum of two hours, or sprayed with a solution of 1:750 zephiran chloride solution. (One part zephiran chloride to 750 parts distilled water).

6.4 Safety Observe all appropriate precautions on MSDS for chemicals involved in this test method.

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IPC-L-109B

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1. I recommend changes to the following:

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___ Test Method number _____, paragraph number _____

The referenced paragraph number has proven to be:

___ Unclear ___ Too Rigid ___ In Error

___ Other _____

2. Recommendations for correction:

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Submitted by:

Name Telephone

Company

Address

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