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IPC-6016

Qualification and Performance Specification for High Density Interconnect (HDI) Layers or Boards

IPC-6016
May 1999

A standard developed by IPC

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

QUALIFICATION AND PERFORMANCE SPECIFICATION FOR HIGH DENSITY INTERCONNECT (HDI) LAYERS OR BOARDS

FOREWORD

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IEC-PAS 62293 was submitted by the IPC (The Institute for Interconnecting and Packaging Electronic Circuits) and has been processed by IEC technical committee 91: Electronics assembly technology.

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document.
Draft PAS	**Report on voting**
91/248/PAS	91/269/RVD

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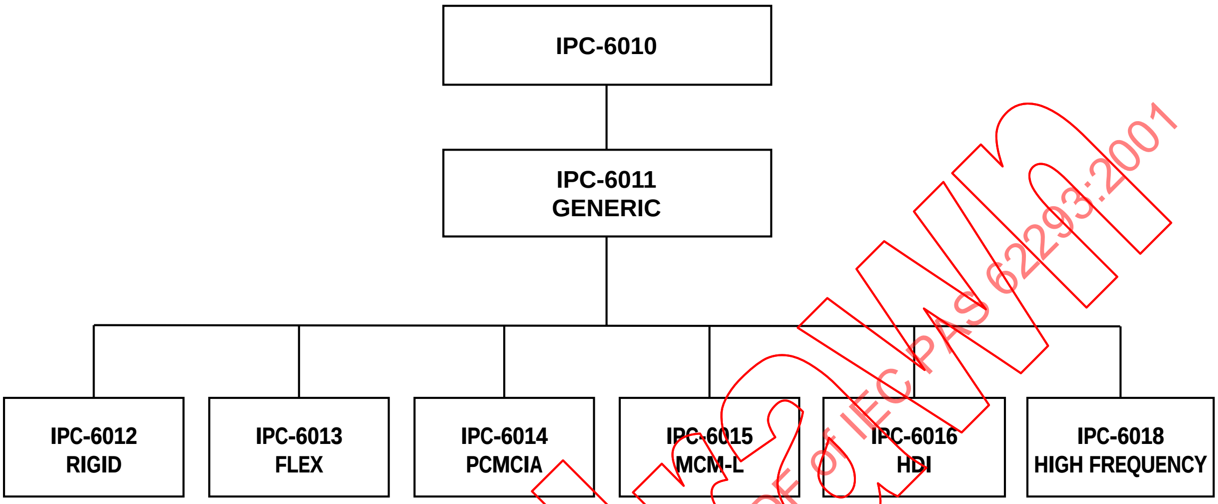

FOREWORD

This specification is intended to provide information on the detailed performance criteria of High Density Interconnect layers only. The information contained herein supplements the generic requirements, identified in IPC-6011, as well as requirements relating to the core construction, identified in the sectionals: IPC-6012 (rigid), IPC-6013 (flex), IPC-6015 (MCM-L) or IPC-6018 (microwave). This document would be specified for and apply only to the added HDI features. The HDI layer should not modify most (if any) of the criteria set forth in the specification for the core construction. When used together, these documents should lead both manufacturer and customer to consistent terms of acceptability. If the HDI board does not employ a core construction, the customer should decide and specify which sectional performance specification should be used for evaluating criteria that is not covered in this document.

Within this document there are a number of performance criteria that are application dependent. These criteria are listed ''slash sheets'' in the back of the document that detail performance requirements based upon application. A blank slash sheet is also included to define needed requirements (agreed to by manufacturer and customer) for applications not currently covered.

NOTE: IPC-6016 was developed with consideration to HDI layers that use modified ''conventional'' plated-through hole processes and chemistries. The industry does not yet have enough experience to develop performance standards for HDI layers formed by novel processes that are drastically different from ''conventional'' plated-through hole constructions (i.e., non-plated copper processes). As experiences are gathered, criteria for these processes will be added. In the meantime, the customer and manufacturer should work together to set the criteria for acceptance of product using the new technologies.

IPC's documentation strategy is to provide distinct documents that focus on specific aspects of electronic packaging issues. In this regard, document sets are used to provide the total information related to a particular electronic packaging topic. A document set is identified by a four digit number that ends in zero (0) (i.e., IPC-6010). The generic specification, the first document of the set, is supplemented by one or multiple sectional documents, each of which provide specific focus on one aspect of a topic or technology. IPC invites input on the effectiveness of the documentation and encourages user response through the ''Standard Improvement Form'' located at the back of each document.

Acknowledgment

Any Standard involving a complex technology draws material from a vast number of sources. While the principal members of the HDI Performance Subcommittee (D-43) 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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Qualification and Performance Specification for High Density Interconnect (HDI) Layers or Boards

1 SCOPE

This specification establishes the specific requirements for organic high-density interconnect (HDI) layers with microvia technology and the quality and reliability assurance requirements that must be met for their acquisition.

1.1 Purpose The requirements contained herein are intended to reflect the electrical, mechanical, and environmental properties unique to the HDI layer. It is NOT intended to specify overall requirements for the core, which are already documented in the sectional performance specifications: IPC-6012 (rigid), IPC-6013 (flex), IPC-6015 (MCM-L), or IPC-6018 (microwave).

1.2 Performance Classification This specification recognizes HDI layers or boards will be subject to variations in performance requirements based on end use. The acceptance criteria of HDI layers are organized into slash sheet categories (A, B, C, etc., see Appendix A), which reflect those typical end-use applications. Users of this document **shall** select a slash sheet category that most closely resembles their product and are encouraged to modify it as necessary.

1.3 Slash Sheet Categories

A. Chip Carrier
B. Hand Held (cell phones, pagers)
C. High Performance (avionics, military, medical)
D. Harsh Environment (automotive, space)
E. Portable (laptops, PDAs)

1.4 Documentation Hierarchy This document, combined with IPC-6011 and the applicable sectional performance specification(s) (IPC-6012, IPC-6013, IPC-6015 or IPC-6018), constitute a qualification and performance specification for HDI layers or boards.

2 APPLICABLE DOCUMENTS

The following specifications of the revision in effect at the time of order form a part of this document to the extent specified herein. If a conflict of requirements exists between IPC-6016 and the listed applicable documents, IPC-6016 **shall** take precedence.

2.1 IPC[1]

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

IPC-PC-90 General Requirements for Implementation of Statistical Process Control

IPC-FC-231 Flexible Base Dielectrics for Use in Flexible Printed Wiring

IPC-FC-232 Adhesive Coated Dielectric Films for Use as Cover Sheets for Flexible Printed Wiring and Flexible Binding Films

IPC-FC-241 Flexible Metal-Clad Dielectrics for Use in Fabrication of Flexible Printed Wiring

IPC-AI-642 User's Guidelines for Automated Inspection of Artwork, Innerlayers, and Unpopulated PWBs

IPC-TM-650 Test Methods Manual[2]

2.1.1	Microsectioning
2.1.1.2	Microsectioning—Semi or Automatic Technique Microsection Equipment (Alternate)
2.4.1	Adhesion, Tape Testing
2.4.8	Peel Strength of Metallic Clad Laminates
2.4.21.1	Bond Strength, Surface Mount Lands Perpendicular Pull Method
2.4.22	Bow and Twist
2.5.7	Dielectric Withstanding Voltage, PWB
2.6.3	Moisture and Insulation Resistance, Printed Boards
2.6.7.2	Thermal Shock, Continuity and Microsection, Printed Boards
2.6.8	Thermal Stress, Plated-Through Holes
2.6.8.1	Thermal Stress, Laminate
2.6.20	Assessment of Plastic Surface Mount Components for Susceptibility to Moisture/Reflow Induced Damage

IPC-ET-652 Guidelines and Requirements for Electrical Testing of Unpopulated Printed Boards

IPC-CC-830 Qualification and Performance of Electrical Insulating Compound for Printed Board Assemblies

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[1] IPC, 2215 Sanders Road, Northbrook, IL 60062-6135

[2] For convenience, applicable test methods are reprinted in the back of this standard. They represent the latest method in effect at the time of publication. Test methods may be updated independent of standard revision. Users should check the IPC website (www.ipc.org) for the most current test method available.

IPC-2221 Generic Standard on Printed Board Design

IPC-2226 Sectional Design Standard for Organic High Density Interconnect (HDI)

IPC-4101 Specification for Base Materials for Rigid and Multilayer Printed Boards

IPC-4104 Specification for High Density Interconnect (HDI) and Microvia Materials

IPC-6011 Generic Performance Specification for Printed Boards

IPC-6012 Qualification and Performance Specification for Rigid Printed Boards

IPC-6013 Qualification and Performance Specification for Flexible Printed Boards

IPC-6015 Qualification and Performance Specification for Organic Multichip Module (MCM-L) Mounting and Interconnecting Structures

IPC-6018 Microwave End Product Board Inspection and Test

IPC-7721 Repair and Modification of Printed Boards and Electronic Assemblies

2.2 Joint Industry Standards[1]

J-STD-003 Solderability Tests for Printed Boards

3 REQUIREMENTS

3.1 General Printed boards with HDI layers furnished under this specification **shall** meet or exceed all of the requirements of this document and applicable slash sheet or as modified by the procurement documentation.

3.1.1 Terms and Definitions The definition of terms used herein **shall** be as specified in IPC-T-50 or as listed in 3.1.1.1 through 3.1.1.4.

3.1.1.1 Target Land The land on which the microvia ends and makes connection.

3.1.1.2 Capture Land The land where the microvia starts, and varies in shape and size based on use (i.e., component mounting, via entrance conductor, etc.)

3.1.1.3 Microvia Processed/plated hole ≤ 0.15 mm diameter (this specification can also be used for layers or boards where vias are > 0.15 mm diameter).

3.1.1.4 Core A single-sided, double-sided or multilayer board or flex circuit that is used as a carrier for HDI layers and meets the requirements of one of the following performance specifications: IPC-6012, IPC-6013, IPC-6015 or IPC-6018.

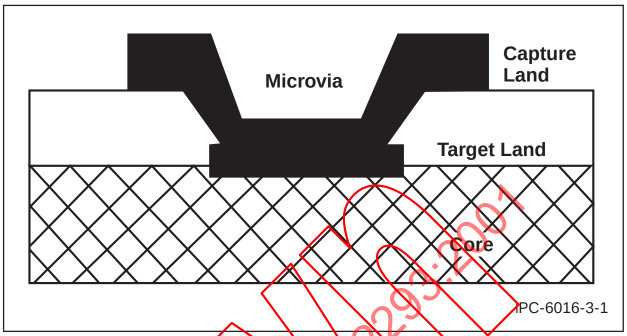

Figure 3-1 Typical Microvia Structure

3.2 Materials

3.2.1 Rigid Laminates Rigid reinforced laminates, clad and unclad, **shall** be as specified on the procurement documentation and **shall** be selected from IPC-4101 or IPC-4104. The type and metal thickness **shall** be as specified on the procurement documentation.

3.2.2 Flexible Films Flexible films, metal clad and unclad, **shall** be as specified on the procurement documentation and **shall** be selected from IPC-FC-231, IPC-FC-232 and IPC-FC-241. The type and metal thickness **shall** be as specified on the procurement documentation.

3.2.3 Bonding Materials Bonding materials **shall** be as specified on the procurement documentation and **shall** be selected from IPC-FC-232 and IPC-4101.

3.2.4 Other Dielectric and Conductive Materials Other materials **shall** be selected from IPC-4104 or as specified on the procurement documentation.

3.2.5 Metal Foils Metal foil materials **shall** be selected in accordance with the sectional performance specification for the applicable core board (i.e., IPC-6012 or IPC-6013).

3.2.6 Metallic Plating and Coatings The final circuit finish and other depositions **shall** be selected in accordance with and meet the requirements established in the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.). The minimum thickness of plated copper in the microvia **shall** be 10 µm. The minimum thickness of conductive material in microvias, which are formed and made conductive by a process that is significantly different from conventional plated-through hole constructions (i.e., non-plated copper processes), **shall** be as specified on the procurement documentation.

3.2.7 Solder Resist Solder resist material **shall** be selected in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.2.8 Marking Inks Marking inks **shall** be selected in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.2.9 Hole Fill Material When required, the material used for hole fill **shall** be selected from IPC-4104 or as specified on the procurement documentation. Hole fill material **shall** provide a planar surface and survive performance testing as the product requires without lifting or cracking the dielectric layer.

3.3 Visual Examination Finished boards using HDI layers **shall** be examined in accordance with the following procedure. They **shall** be of uniform quality and **shall** conform to 3.3.1 through 3.3.7.

Visual examination of the circuits for applicable dimensional or workmanship attributes **shall** be conducted at 30X minimum.

3.3.1 Edges Nicks or halos on finished board edges **shall** be acceptable provided the penetration does not bridge adjacent conductors or reduce the spacing requirements below the minimum specified on the procurement documentation. Nonconductive burrs along the edges of the finished board **shall** be acceptable.

3.3.2 Surface Dielectric Imperfections Pits or surface voids are acceptable provided they do not bridge conductors or reduce the spacing requirements below the minimum specified on the procurement documentation.

Scratches, dents, or tool marks are acceptable provided they do not penetrate to a depth that reduces the dielectric thickness below the minimum specified on the procurement documentation.

3.3.3 Lifted Lands The finished HDI layer or board **shall not** exhibit any lifted lands.

3.3.4 Marking Markings **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.3.5 Solderability Solderability of surfaces **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.3.6 Adhesion

3.3.6.1 Metal to Metal Adhesion The adhesion of the plating **shall** be tested in accordance with IPC-TM-650, Method 2.4.1, using a strip of pressure sensitive tape applied to the surface and removed by manual force applied perpendicular to the circuit pattern.

There **shall** be no evidence of any portion of the plating or the conductor pattern being removed, as shown by particles of the plating or pattern adhering to the tape. If overhanging metal breaks off (sliver) and adheres to the tape, this is not evidence of plating adhesion failure.

3.3.6.2 Metal to Dielectric Adhesion Peel strength testing **shall** be performed in accordance with IPC-TM-650, Method 2.4.8, if not supplied in the laminate certification. Type and frequency of test **shall** be specified on the procurement documentation. Peel strength **shall** meet the value specified on the applicable slash sheet.

3.3.6.3 Dielectric to Core Adhesion Thermal stress testing **shall** be performed in accordance with IPC-TM-650, Method 2.6.8.1. There **shall** be no evidence of delamination or blistering.

3.3.7 Workmanship HDI layers or boards **shall** be processed in such a manner as to be uniform in quality and show no visual evidence of dirt, foreign matter, oil, fingerprints, flux residue, and other contaminants that affect life, ability to assemble, and serviceability. Darkened appearance in non-plated holes, which is seen when the nonmetallic semi-conductive coating is used, is not foreign matter and does not affect life or function.

HDI layers or boards **shall** be free of defects in excess of those allowed in this specification. There **shall** be no evidence of any lifting or separation of platings from the surface of the conductive pattern, or of the conductor from the base laminate in excess of that allowed. There **shall** be no loose plating slivers on the surface of the HDI layer or board.

3.4 Dimensional Requirements All dimensional characteristics **shall** be as specified on the procurement documentation.

The accuracy, repeatability, and reproducibility of the equipment used to verify the characteristics of HDI layers or boards should be 10% or less of the tolerance range of the dimensions being verified. A measurement system evaluation **shall** be performed on each gauging system (see IPC-9191).

Automated inspection technology is allowed provided it meets requirements for repeatability (see IPC-AI-642).

3.4.1 Hole Pattern Accuracy The accuracy of the hole pattern on the HDI layer or board **shall** be as specified on the appropriate specification slash sheet.

3.4.2 Registration (Internal)

3.4.2.1 Microvia to Target Land Breakout at the target land is allowed up to 180°. Breakout, if it occurs, **shall**

neither reduce the intended contact area (at the target land) below that specified on the applicable slash sheet nor reduce the minimum electrical spacing below that specified on the procurement documentation. Registration measurements at the target land may (at the suppliers option) be determined during microsection evaluation (see 3.6) or by another method as agreed upon between supplier and user.

Note: If using an ablation-type process, tangency may be required as a minimum (due to potential reduction in dielectric separation).

3.4.2.2 Plated-Through Holes Internal registration for plated-through holes **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.4.3 Annular Ring (External)

3.4.3.1 Capture Land to Microvia Capture lands **shall** have tangency at a minimum. Breakout is not allowed, unless the design and procurement documentation specify (i.e., landless microvia). See Figure 3-2.

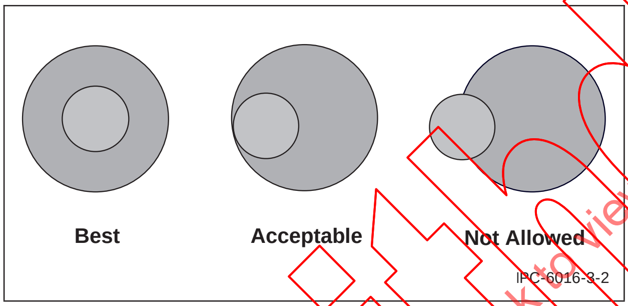

Figure 3-2 Capture Land Registration

3.4.3.2 Plated-Through Holes External annular ring for plated-through holes **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.4.4 Bow and Twist Bow, twist, or any combination thereof, **shall** be as specified in the applicable slash sheet and tested in accordance with IPC-TM-650, Method 2.4.22.

3.5 Conductor Definition All conductive surfaces on HDI layers or boards including conductors, lands and planes **shall** meet the visual and dimensional requirements of 3.5.1 through 3.5.3. Unless otherwise noted, visual examination of the circuits for applicable dimensional or workmanship attributes **shall** be conducted at 30X minimum. Other magnifications may be required by procurement documentation or specification. AOI inspection methods are permitted.

3.5.1 Conductor Width Unless otherwise specified on the procurement documentation, reductions **shall not** reduce the conductor width by more than that allowed on the respective slash sheet.

3.5.2 Conductor Spacing Unless otherwise specified on the procurement documentation, reductions **shall not** reduce the conductor spacing by more than that allowed on the applicable slash sheet.

3.5.3 Conductive Surfaces

3.5.3.1 Nicks and Pinholes in Ground or Voltage Planes For nicks and pinholes in ground or voltage planes, the maximum size allowed **shall** be 150 µm for Class 2 and 3, with no more than two per side per 25 mm x 25 mm.

3.5.3.2 Surface Mount Lands (Area for attachment such as solder, TAB, conductive adhesive) Defects such as nicks, dents, and pinholes along the edge of the land (length or width) **shall not** exceed that identified in the respective slash sheets.

3.5.3.3 Wire Bond Surface Unless otherwise defined on the procurement documentation, the bond site area **shall** be free of defects such as nicks, scratches, dents, bumps, pits, and pinholes. Other requirements (i.e., surface smoothness, hardness, etc.) **shall** be as defined between user and supplier.

3.5.3.3.1 Gold Plating Surface Wire bonding lands (gold plating surfaces) **shall** be free of any exposed nickel or copper.

3.5.3.3.2 Test Probe Dents Dents caused by test probes are acceptable when the bondable finish is not pierced and they do not violate wire bond adhesion requirements. Dents **shall** be no greater than 10 µm in diameter when examined under 10X magnification.

3.5.3.3.3 Surface Contaminants Wire bond surfaces **shall** be free of any contaminants, dirt, dust, foreign matter, and discolorations.

3.5.3.3.4 Wire Bond Adhesion Plated bonding area **shall** be evaluated in accordance with IPC-TM-650, Method 2.4.42.3, and capable of meeting the requirements of Table 3-1 without incurring any of the following situations:

a) Failure in bond (interface between wire and metallization) at substrate.

b) Separation of metallization layer on the land area.

c) Land is lifted from substrate.

3.5.3.4 Edge Board Connector Lands Edge board connector lands **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

Table 3-1 Wire Bond Adhesion Requirements

Test Condition	Wire composition and diameter	Minimum bond strength (grams force)
C or D	AL 18 AU 18	1.5 2.0
C or D	AL 25 AU 25	2.5 3.0
C or D	AL 32 AU 32	3.0 4.0
C or D	AL 33 AU 33	3.0 4.0
C or D	AL 38 AL 38	4.0 5.0
C or D	AL 76 AU 76	12.0 15.0

3.5.3.5 Conductor Edge Integrity Conductor edges **shall** have no evidence of slivers when tested in accordance IPC-TM-650, Method 2.4.1.

3.5.3.6 Nonwetting For conductive surfaces intended to be soldered, nonwetting is not permitted.

3.5.3.7 Final Finish Coverage Final finish coverage **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.5.3.8 Microvia in Land When microvias are employed as via-in-land technology, they **shall** be evaluated for acceptance as defined in the procurement documentation (i.e., coplanarity, solder wicking, entrapment).

3.6 Structural Integrity Structural integrity **shall** be evaluated on thermally-stressed test specimens or production boards using HDI.

Test specimens **shall** be representative of the part and agreed upon by user and supplier.

3.6.1 Thermal Stress Method Printed boards using HDI layers **shall** be preconditioned and tested in accordance with IPC-TM-650, Method 2.6.8, test condition B. The number of cycles **shall** be five (unless limited by the number of stress cycles acceptable for the core board) or as specified on the appropriate slash sheet.

3.6.2 Microsection Technique Following stress, HDI layers or boards **shall** be microsectioned by either of the two techniques outlined below or with another procedure agreed upon between user and supplier.

Microsectioning **shall** be accomplished per IPC-TM-650, either Method 2.1.1 or 2.1.1.2, on boards using HDI as agreed to between user and supplier. A minimum of three holes or vias **shall** be inspected in the vertical cross section. The grinding and polishing accuracy of the microsection **shall** be such that the viewing area of each of the three holes is within ± 10% of the diameter of the hole.

Microvias **shall** be examined for plating integrity and interconnection integrity at a magnification of 200X ± 5%. Referee examinations **shall** be accomplished at a magnification of 400X ± 5%. Each side of the hole **shall** be examined independently. Examination for laminate thickness, foil thickness, plating thickness, lay-up orientation, lamination, plating voids, and so forth, **shall** be accomplished at magnifications specified above.

Conventional plated-through holes **shall** be examined in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.6.3 Microvia Integrity (after Thermal Stress)

3.6.3.1 Plating Integrity Plated-through holes, blind, and/or buried vias **shall** have no separation of plating layers, no plating cracks, and internal interconnections **shall** exhibit no separation or contamination between plated hole wall and internal layers. Any additional requirements **shall** be detailed on the procurement documentation.

3.6.3.2 Dielectric Integrity There **shall** be no dielectric voids that reduce dielectric separation (layer-to-layer or within the layer) below the minimum specified in the procurement documentation.

3.6.3.3 Copper Plating Thickness Based on microsection examination or the use of suitable electronic measuring equipment, copper plating thickness in the microvia **shall** be an absolute minimum of 10 µm, as specified on the respective slash sheet, or as stated in the procurement documentation. No voids are allowed.

3.6.3.4 Fused Tin-Lead Plating and Solder Coating Fused tin-lead plating and solder coating, if used on the HDI layer, **shall** meet the solderability requirements of J-STD-003. Solder or reflowed tin-lead coverage does not apply to vertical conductor edges.

3.6.3.5 Conductor Thickness Conductor thickness **shall** be greater than or equal to the minimum specified in the procurement documentation or ≥ 80% of the nominal specified in the procurement documentation for all non-via surfaces.

3.6.3.6 Dielectric Thickness The minimum dielectric thickness over circuitry **shall** be as specified in the procurement documentation.

3.6.3.7 Microvia Contact Area Microvia contact area, as defined by the interface between the microvia and the target land, **shall not** be reduced by more than that allowed on the applicable slash sheet. Any non-conductive residues on the surface of the target land **shall** be considered part of the reduced contact area. Contact area may be determined by another method as agreed upon between supplier and user.

3.6.4 Filled Vias Buried vias and/or buried microvias **shall** be filled and inspected in accordance with the procurement documentation. Blind vias on the external layers do not have any fill requirements.

3.6.5 Lifted Lands

3.6.5.1 Microvias The finished HDI board **shall not** exhibit any lifted microvia lands after thermal stress.

3.6.5.2 Plated-Through Holes Plated-through holes on the finished HDI board can exhibit lifted lands after thermal stress provided the visual criteria of 3.3.3 are met.

3.7 Other Tests Other test and requirements specific to HDI layers and boards may be required and should be called out in the applicable slash sheets.

3.7.1 Bond Strength, Unsupported Hole or Surface Mount Land A minimum of three unsupported holes or surface mount lands **shall** be tested in accordance with the following procedure. The surface mount land or land of an unsupported hole **shall** withstand 2 kg or kg/cm^2 whichever is less.

Bond strength **shall** be performed in accordance with IPC-TM-650, Method 2.4.21.1, for surface mount lands. For the unsupported hole lands, the soldering and tensile pull method are the same as in IPC-TM-650, Method 2.4.21.1. Calculations of land area of the unsupported hole do not include the area occupied by the hole.

3.8 Solder Resist (Solder Mask) Requirements Solder resist coverage **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.) and 3.8.1.

3.8.1 Solder Resist Coverage Encroachment of solder resist **shall not** reduce the design dimension of any conductive feature by more than 10% or by 100 µm, whichever is less. Encroachment of solder resist onto flip chip attachment sites **shall** be as specified on the procurement documentation.

3.9 Electrical Properties When tested as specified below, the HDI layers and boards **shall** meet the electrical requirements detailed in the following paragraphs.

3.9.1 Circuitry HDI layers and boards **shall** be tested in accordance to IPC-ET-652.

3.9.1.1 Continuity Printed boards using HDI or qualification test boards **shall** be tested in accordance with the following procedure. There **shall** be no circuits whose resistance exceeds that specified on the applicable slash sheet. The acceptability criteria for specialized conductors **shall** be specified on the procurement documentation.

The current passed through the conductors **shall not** exceed that specified in IPC-2221 and IPC-2226 for the smallest conductor in the circuit. For qualification, the test current **shall not** exceed one ampere. HDI boards with designed resistive patterns **shall** meet the resistance requirements specified on the procurement documentation.

Alternative test methods, agreed to by supplier and user, may be utilized to verify electrical integrity of HDI boards.

3.9.1.2 Isolation HDI layers or qualification test boards **shall** be tested in accordance with the following procedure. The isolation resistance between conductors **shall** be greater than specified on the applicable slash sheet.

The voltage applied between networks must be high enough to provide sufficient current resolution for the measurement. At the same time, it must be low enough to prevent arc-over between adjacent networks, which could induce defects within the product. The minimum applied test voltage **shall** be twice the maximum rated voltage of the board. If the maximum is not specified, the test voltage **shall** be 40 volts minimum.

3.9.2 Dielectric Withstanding Voltage Applicable coupons tested as outlined in the applicable slash sheets **shall** meet the requirements of those same slash sheets without flashover, sparkover, or breakdown between conductors or conductors and lands. The dielectric withstanding voltage test **shall** be performed in accordance with IPC-TM-650, Method 2.5.7. The dielectric withstanding voltage **shall** be applied between all common portions of each conductor pattern and adjacent common portions of each conductor pattern. The voltage **shall** be applied between conductor patterns of each layer and the electrically isolated pattern of each adjacent layer. Unless otherwise defined on the procurement documentation, test voltages **shall** appear on the appropriate specification sheets.

3.9.3 Insulation Resistance Test specimens **shall** be tested in accordance with the procedure outlined below. The insulation resistance **shall** be no less than that shown on the respective slash sheets.

Specimens **shall** be conditioned at 50° ± 5°C with no added humidity for a period of 24 hours. After cooling, the insulation resistance test **shall** be performed in accordance with the ambient temperature measurements specified in IPC-TM-650, Method 2.6.3.

3.10 Environmental HDI layers and boards **shall** meet the environmental requirements detailed in this section.

3.10.1 Moisture and Insulation Resistance Test coupons **shall** be tested in accordance with the procedure outlined below. The specimen **shall not** exhibit measling, blistering, or delamination in excess of that allowed in the applicable slash sheet. Insulation resistance **shall** meet the minimum requirements established in the slash sheets for that particular application.

Testing of moisture and insulation resistance for HDI layers and boards **shall** be performed in accordance with IPC-TM-650, Method 2.6.3. Conformal coating in accordance with IPC-CC-830, if specified, **shall** be applied to the external conductors prior to chamber exposure. Final measurements **shall** be made at room temperature within two hours after removal from the test chamber. All layers **shall** have a 100 ± 10 volts DC polarizing voltage applied during chamber exposure.

3.10.2 Thermal Shock When specified, HDI boards or test specimens **shall** be tested for thermal shock in accordance with IPC-TM-650, Method 2.6.7.2, with temperature limits as specified in the applicable specification sheet. The specimen **shall** meet the circuitry requirements of 3.9.1.1. An increase of 10% or more in the resistance **shall** be considered not acceptable. After the last cycle, the specimens **shall** be microsectioned and meet the requirements of 3.6.3.1 and 3.6.3.2 and those of the applicable slash sheet.

3.10.3 Cleanliness Cleanliness **shall** be in accordance with the requirements of the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.11 Special Requirements Only when specified on the procurement documentation, some or all of the special requirements listed in 3.11.1 through 3.11.6 **shall** apply. A special notation on the procurement documentation will designate which are required.

3.11.1 Outgassing Outgassing **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.11.2 Organic Contamination Organic contamination **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.11.3 Fungus Resistance Fungus resisitaince **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.11.4 Vibration Vibration **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.11.5 Mechanical Shock Mechanical shock **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.11.6 Impedance Testing Impedance testing **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

3.12 Repair Repair of bare HDI layers and boards **shall** be as agreed upon between supplier and user (see IPC-7721).

4 QUALITY ASSURANCE

4.1 General The requirements specific to HDI layers and boards are specified herein and include the Qualification Testing, Acceptance Testing, and Quality Conformance Testing. General Quality Assurance Provisions are specified in IPC-6011. Sampling Plan, Frequency, and additional requirements not specific to the HDI layers and boards are documented in the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc.).

4.1.1 Inspection for Delivery Inspection of product for delivery **shall** be in accordance with the applicable sectional performance specification (i.e., IPC-6012, IPC-6013, etc). If the applicable sectional performance specification is not defined by the presence of a core, the inspection of product for delivery **shall** be as defined on the procurement documentation.

4.1.2 Referee Tests Two additional microsection sets from the same panel may be prepared and evaluated for microsection defects that are considered to be isolated or random in nature or caused by microsection preparation. For acceptance, both referee sets must be defect free.

Appendix A
IPC-6016 End Use Application Slash Sheets (see 1.2 & 1.3)

			Default[1] Microvia PWB	**A**	**B**	**C**	**D**	**E**	**Insert Your Application**
Inspection	**Paragraph**	**Parameter**	[1] Please read the noted paragraph when R appears as the default	**Chip Carrier**	**Hand Held** Cell Phone Pagers	**High Performance** Avionics / Military/ Medical	**Harsh Environment** Automotive Space	**Portable** PC's PDA's	**Describe:**
Materials	3.2.1 - 3.2.5	Mfr. Cert.	As specified						
Metallic Plating & Coatings	3.2.6	µm	Cu: ≥ 10; Others: as specified	Cu: $10 \le x \le 25$ Electrolytic Ni: $3 \le x \le 12$ Electroless Ni: $3 \le x \le 7$ Electrolytic Au: $0.5 \le x \le 1.5$ Electroless Au: $0.5 \le x$				Immersion Au: $0.08 \le x \le 0.20$ Electroless Ni: $1.30 \le x \le 5.00$	
Solder Resist	3.2.7		As specified						
Marking Inks	3.2.8		As specified						
Hole Fill Material	3.2.9		As specified						
Edges	3.3.1	Visual	R	Burrs do not extend 25 mm beyond					
Surface Imperfections	3.3.2	Visual	R	No evidence of delamination, measles, or conductive foreign material					
Lifted Lands	3.3.3	Visual	None allowed						
Marking	3.3.4	Visual	As specified	Completely legible from 30 cm					
Solderability	3.3.5	Visual	As specified	95% coverage of land with solder dip	J-STD-003				
Adhesion	3.3.6								
Metal to Metal	3.3.6.1	Visual	R						
Metal to Dielectric	3.3.6.2	kg/cm	0.60		0.90			0.60	
Dielectric to Core	3.3.6.3	Visual	R						
Workmanship	3.3.7	Visual	R						

Inspection	Paragraph	Parameter	Default[1] Microvia PWB	A	B	C	D	E	Insert Your Application
			[1]Please read the noted paragraph when R appears as the default	**Chip Carrier**	**Hand Held** Cell Phone Pagers	**High Performance** Avionics / Military/ Medical	**Harsh Environment** Automotive Space	**Portable** PC's PDA's	**Describe:**
Hole Pattern Acc.	3.4.1	mm	± 0.08						
Registration (Internal)	3.4.2								
Microvia Target Land	3.4.2.1	mm	R						
Annular Ring (External)	3.4.3								
Capture Land Microvia	3.4.3.1	mm	R						
Bow & Twist (Max)	3.4.4	% max	0.75%	Bds ≥ 35 mm: ≤ 0.4% Bds < 35 mm: ≤ 0.3%			0.6%		
Conductor Width	3.5.1	% reduction	20%	50% for 0.10 mm or more length			25%		
Conductor Spacing	3.5.2	% reduction	20%	50% for any length			25%		
Nicks & Pinholes	3.5.3.1	µm max.	150	< 33% of conductor width or length, < 0.010 mm deep					
Surface Lands	3.5.3.2	% max.	20%				10%		
Wire Bond Surface	3.5.3.3	Visual	R	... and even					
Gold Plating Surface	3.5.3.3.1	Visual	R						
Test Probe Dents	3.5.3.3.2	µm max.	10						
Contaminants	3.5.3.3.3	Visual	R	None					
Wire Bond Adhesion	3.5.3.3.4		R						
Edge Bond Connector Lands	3.5.3.4		As specified						
Conductor Edge Integrity	3.5.3.5	Visual	No slivers						
Nonwetting	3.5.3.6	Visual	R						
Final Finish Coverage	3.5.3.7	Visual	As specified						
Microvia in Land	3.5.3.8		As specified						
Thermal Stress	3.6.1	Cycles	5						
Microvia Integrity	3.6.3								
Plating Integrity	3.6.3.1	Microsection	R						
Dielectric Integrity	3.6.3.2	Voids/board	As specified				None		
Cu Plating Thickness	3.6.3.3	µm min.	10	10 ≤ x ≤ 25			15		

Inspection	Paragraph	Parameter	Default^1 Microvia PWB	A	B	C	D	E	Insert Your Application
			^{1}Please read the noted paragraph when R appears as the default	**Chip Carrier**	**Hand Held** Cell Phone Pagers	**High Performance** Avionics / Military/ Medical	**Harsh Environment** Automotive Space	**Portable** PC's PDA's	**Describe:**
Fused Tin-Lead	3.6.3.4	Microsection	R						
Conductor Thickness	3.6.3.5		As specified						
Dielectric Thickness	3.6.3.6	mm	As specified				≥ 0.050		
Microvia Contact Area	3.6.3.7	Microsection	50%						
Filled Vias	3.6.4	Microsection	As specified	Completely filled; Overfill ≤ 0.5 mm					
Lifted Lands	3.6.5								
Microvias	3.6.5.1	Microsection	None allowed						
Plated-Through Holes	3.6.5.2	Microsection	R						
Other Tests	3.7		R						
Bond Strength	3.7.1	kg	2						
Solder Resist Coverage	3.8.1	Visual	R						
Electrical Properties	3.9								
Continuity	3.9.1.1	ohms	50						
Isolation	3.9.1.2	megohms	10						
DWV	3.9.2	VDC	1000						
Insulation Resistance	3.9.3	megohms	> 10						
Environmental	3.10								
Moisture & Insulation Resistance	3.10.1	megohms	500					10 MΩ at 250 V	
Thermal Shock	3.10.2	ohms	< 110% of starting					< 120%	
Thermal Shock Temperature Limits	3.10.2	°C	-65 to +125	-55 to +125				-25 to +115	
Cleanliness	3.10.3	µg/cm^2	1.56						
Outgassing	3.11.1		As specified						
Organic Contamin.	3.11.2		As specified						
Fungus Resistance	3.11.3		As specified						
Vibration	3.11.4		As specified						
Mechanical Shock	3.11.5		As specified						
Impedance Testing	3.11.6		As specified						
Repair	3.12		As agreed						

Inspection	Paragraph	Parameter	Default^1 Microvia PWB	A	B	C	D	E	Insert Your Application
			^{1}Please read the noted paragraph when R appears as the default	**Chip Carrier**	**Hand Held** Cell Phone Pagers	**High Performance** Avionics / Military/ Medical	**Harsh Environment** Automotive Space	**Portable** PC's PDA's	**Describe:**
JPCA-BU01 Tests									
CTE									
Water Absorption									
Drying									
Ionic Impurity	3.10.3								
Impedance	3.11.6								
Flatness	3.4.4								
Peel Strength - Conductor	3.3.6.2								
Pull-Off Strength - Lands	3.5.3.3.4								
Thermal Resistance	? 3.6.1								
Thermal Shock - Air	3.10.2								
Bias Test (HiT/HiH)									
HiT Shelf									

METRIC CONVERSION TABLE

micrometers (microns)	mm	inch
FIVE DECIMAL PLACES		
0.05	0.00005	0.000002
0.06	0.00006	0.000002
0.07	0.00007	0.000003
0.08	0.00008	0.000003
0.09	0.00009	0.000004
0.10	0.00010	0.000004
0.11	0.00011	0.000004
0.12	0.00012	0.000005
0.13	0.00013	0.000005
0.14	0.00014	0.000006
0.15	0.00015	0.000006
0.20	0.00020	0.000008
0.25	0.00025	0.000010
FOUR DECIMAL PLACES		
0.1	0.0001	
0.2	0.0002	0.00001
0.3	0.0003	0.00001
0.4	0.0004	0.00002
0.5	0.0005	0.00002
0.6	0.0006	0.00002
0.7	0.0007	0.00003
0.8	0.0008	0.00003
0.9	0.0009	0.00004
1.0	0.0010	0.00004
1.1	0.0011	0.00004
1.2	0.0012	0.00005
1.3	0.0013	0.00005
1.4	0.0014	0.00006
1.5	0.0015	0.00006
2.0	0.0020	0.00008
2.5	0.0025	0.00010
3.0	0.0030	0.00012
3.5	0.0035	0.00014
4.0	0.0040	0.00016
4.5	0.0045	0.00018
5.0	0.0050	0.00020
5.5	0.0055	0.00022
6.0	0.0060	0.00024
6.5	0.0065	0.00026
7.0	0.0070	0.00028
7.5	0.0075	0.00030
8.0	0.0080	0.00032
8.5	0.0085	0.00034
9.0	0.0090	0.00036
FOUR DECIMAL PLACES (cont.)		
9.5	0.0095	0.00038
10.0	0.0100	0.00040
10.5	0.0105	0.00041
11.0	0.0110	0.00043
11.5	0.0115	0.00045
12.0	0.0120	0.00047
12.5	0.0125	0.00050
13.0	0.0130	0.00050
13.5	0.0135	0.00053
THREE DECIMAL PLACES		
1	0.001	0.00004
2	0.002	0.00008
3	0.003	0.00012
4	0.004	0.00016
5	0.005	0.00020
6	0.006	0.00024
7	0.007	0.00028
8	0.008	0.00032
9	0.009	0.00036
10	0.010	0.00040
11	0.011	0.00043
12	0.012	0.00047
13	0.013	0.00050
14	0.014	0.00055
15	0.015	0.00060
20	0.020	0.00080
25	0.025	0.00100
30	0.030	0.00120
35	0.035	0.00140
40	0.040	0.00160
45	0.045	0.00180
50	0.050	0.00200
55	0.055	0.00220
60	0.060	0.00240
65	0.065	0.00260
70	0.070	0.00280
75	0.075	0.00300
80	0.080	0.00320
85	0.085	0.00340
90	0.090	0.00360
95	0.095	0.00380
100	0.100	0.00400
105	0.105	0.00410
110	0.110	0.00430

micrometers (microns)	mm	inch
THREE DECIMAL PLACES (cont.)		
115	0.115	0.00450
120	0.120	0.00470
125	0.125	0.00500
130	0.130	0.00500
135	0.135	0.00530
TWO DECIMAL PLACES		
10	0.01	0.0004
20	0.02	0.0008
30	0.03	0.0012
40	0.04	0.0016
50	0.05	0.0020
60	0.06	0.0024
70	0.07	0.0028
80	0.08	0.0032
90	0.09	0.0036
100	0.10	0.0040
110	0.11	0.0043
120	0.12	0.0047
130	0.13	0.0050
140	0.14	0.0055
150	0.15	0.0060
160	0.16	0.0063
170	0.17	0.0067
180	0.18	0.0070
190	0.19	0.0075
200	0.20	0.0080
250	0.25	0.0100
300	0.30	0.0120
350	0.35	0.0140
400	0.40	0.0160
450	0.45	0.0180
500	0.50	0.0200
550	0.55	0.0220
600	0.60	0.0240
650	0.65	0.0260
700	0.70	0.0280
750	0.75	0.0300
800	0.80	0.0320
850	0.85	0.0340
900	0.90	0.0360
950	0.95	0.0380
1000	1.00	0.0400
	1.05	0.0410
	1.10	0.0430
	1.15	0.0450
	1.20	0.0470
	1.25	0.0500

micrometers (microns)	mm	inch
TWO DECIMAL PLACES (cont.)		
	1.30	0.0500
	1.40	0.0550
	1.50	0.0600
	1.60	0.0630
	1.70	0.0670
	1.80	0.0700
	1.90	0.0750
	2.00	0.0800
	2.10	0.0830
	2.20	0.0870
	2.30	0.0900
	2.40	0.0950
	2.50	0.1000
	2.60	0.1030
	2.70	0.1050
	2.80	0.1100
	2.90	0.1150
	3.00	0.1200
	3.10	0.1230
	3.20	0.1250
	3.30	0.1300
	3.40	0.1330
	3.50	0.1370
	3.60	0.1400
	3.70	0.1450
	3.80	0.1500
	3.90	0.1530
	4.00	0.1570
	4.10	0.1600
	4.20	0.1650
	4.30	0.1700
	4.40	0.1730
	4.50	0.1770
	4.60	0.1800
	4.70	0.1850
	4.80	0.1900
	4.90	0.1930
	5.00	0.1970
	5.10	0.2000
	5.20	0.2050
	5.30	0.2100
	5.40	0.2130
	5.50	0.2170
	5.60	0.2200
	5.70	0.2250
	5.80	0.2300
	5.90	0.2330

micrometers (microns)	mm	inch
TWO DECIMAL PLACES (cont.)		
	6.00	0.2350
	6.10	0.2400
	6.20	0.2450
	6.30	0.2500
	6.40	0.2500
	6.50	0.2550
	6.60	0.2600
	6.70	0.2630
	6.80	0.2670
	6.90	0.2700
	7.00	0.2750
	7.10	0.2800
	7.20	0.2830
	7.30	0.2870
	7.40	0.2900
	7.50	0.2950
	7.60	0.3000
	7.70	0.3030
	7.80	0.3070
	7.90	0.3100
	8.00	0.3150
	8.10	0.3200
	8.20	0.3230
	8.30	0.3270
	8.40	0.3300
	8.50	0.3350
	8.60	0.3400
	8.70	0.3400
	8.80	0.3450
	8.90	0.3500
	9.00	0.3550
	9.10	0.3600
	9.20	0.3630
	9.30	0.3650
	9.40	0.3700
	9.50	0.3750
	9.60	0.3770
	9.70	0.3800
	9.80	0.3850
	9.90	0.3900
	10.00	0.3930
ONE DECIMAL PLACE		
	0.1	0.004
	0.2	0.008
	0.3	0.012
	0.4	0.016
	0.5	0.020

micrometers (microns)	mm	inch
ONE DECIMAL PLACE (cont.)		
	0.6	0.024
	0.7	0.028
	0.8	0.032
	0.9	0.036
	1.0	0.040
	1.1	0.043
	1.2	0.047
	1.3	0.050
	1.4	0.055
	1.5	0.060
	2.0	0.080
	2.5	0.100
	3.0	0.120
	3.5	0.140
	4.0	0.160
	4.5	0.180
	5.0	0.200
	5.5	0.220
	6.0	0.240
	6.5	0.260
	7.0	0.280
	7.5	0.300
	8.0	0.320
	8.5	0.340
	9.0	0.360
	9.5	0.380
	10.0	0.400
	10.5	0.410
	11.0	0.430
	11.5	0.450
	12.0	0.470
	12.5	0.500
	13.0	0.500
NO DECIMAL PLACES		
	1	0.04
	2	0.08
	3	0.12
	4	0.16
	5	0.20
	6	0.24
	7	0.28
	8	0.32
	9	0.36
	10	0.40
	11	0.43
	12	0.47
	13	0.50

micrometers (microns)	mm	inch
NO DECIMAL PLACES (cont.)		
	14	0.55
	15	0.60
	20	0.80
	25	1.00
	30	1.20
	35	1.40
	40	1.60
	45	1.80
	50	2.00
	55	2.20
	60	2.40
	65	2.60
	70	2.80
	75	3.00
	80	3.20
	85	3.40
	90	3.60
	95	3.80
	100	4.00

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ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

2215 Sanders Road
Northbrook, IL 60062-6135

IPC-TM-650
TEST METHODS MANUAL

Number
2.1.1

Subject
Microsectioning, Manual Method

Date
3/98

Revision
D

Originating Task Group
Post Separation Task Group (D-33a)

1.0 Scope This procedure is to be used for preparing a metallographic specimen of printed wiring products. The finished microsection is used for evaluating the quality of the laminate system and the plated-through holes (PTHs). The PTHs can be evaluated for characteristics of the copper foils, plating, and/or coatings to determine compliance with applicable specification requirements. The same basic procedures may be used for mounting and examination of other areas. Because manual metallographic sample preparation is regarded by many as essentially an art, this method describes those techniques that have been found to be generally acceptable. It does not attempt to be so specific as to allow no acceptable variations that can differentiate metallographers. Furthermore, the success of these techniques remains highly dependent upon the skill of the individual metallographer.

2.0 Applicable Documents

IPC-MS-810 Guidelines for High Volume Microsectioning

ASTM E 3 Standard Methods of Preparation of Metallographic Specimens

3.0 Test Specimens Cut the required specimens from a printed board or test coupon. Allow sufficient clearance to prevent damage to the area to be examined. The recommended minimum clearance is 2.54 mm. Abrasive cut off wheels can cut closer to the area of examination without causing damage. Some commonly used methods include sawing using a jewelers saw, miniature band saw, or abrasive cut-off wheel; routing using a small milling machine; or punching using a sharp, hollow die (not recommended for brittle materials, i.e., polyimide and some modified epoxy resin systems). See IPC-MS-810. It is recommended that a minimum of one microsection containing at least three of the smallest diameter PTHs shall be made for each specimen tested. When microsectioning multilayer production printed boards designed without nonfunctional lands on all layers, care needs to be exercised in choosing the test location such that internal lands are connected to the selected PTHs. This is so that a complete quality evaluation can be made.

4.0 Apparatus or Material

4.1 Sample removal method (see IPC-MS-810 for the best method to meet your needs).

4.2 Mount molds

4.3 Smooth, flat mounting surface

4.4 Release agent (optional)

4.5 Sample supports (optional)

4.6 Metallographic rotary grinding/polishing system

4.7 Belt sander (optional)

4.8 Metallographic microscope capable of 100X to 200X magnification

4.9 Vacuum pump and vacuum desiccator (optional)

4.10 Room temperature curing potting material (recommended maximum cure temperature 93°C)

4.11 Abrasive paper (USA CAMI Grade grit numbers 180, 240, 320, 400, and 600. See Figure 1 for conversion from American to European grit sizes).

4.12 Cloths for polishing wheels: a hard, low, or no nap cloth for rough and intermediate polishing and a soft, woven, or medium nap cloth for final polishing.

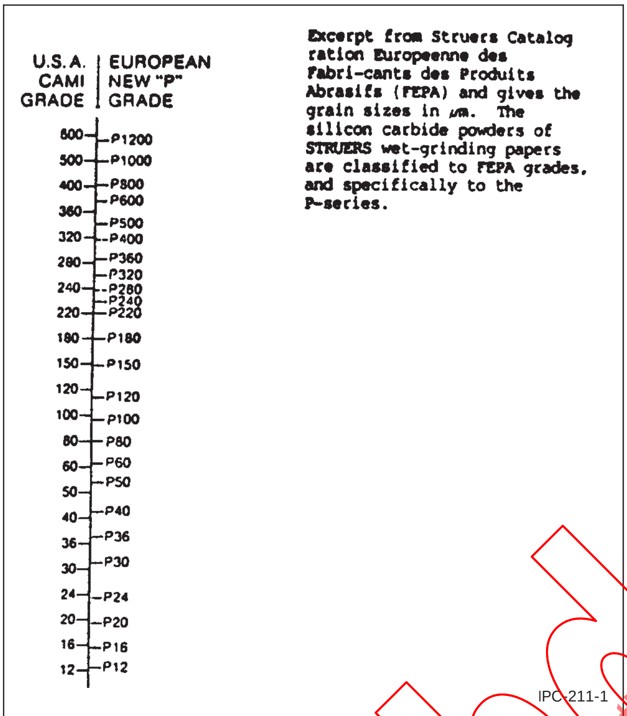
4.13 Oxide or colloidal silica polishing suspension (final polish, 0.3 to 0.04 micron)

4.14 Diamond polishing abrasive (six to 0.1 micron)

4.15 Polishing lubricant

4.16 Specimen etching solution (see 6.4)

4.17 Cotton balls and swabs for cleaning and etchant application



Excerpt from Struers Catalog ration Europeenne des Fabri-cants des Produits Abrasifs (FEPA) and gives the grain sizes in µm. The silicon carbide powders of STRUERS wet-grinding papers are classified to FEPA grades, and specifically to the P-series.

Figure 1 Abrasive paper grit size (American vs. European)

4.18 Isopropyl alcohol, 25% methanol aqueous solution, or other suitable solvent (check for reaction with the encapsulation media and marking system)

4.19 Specimen marking system

4.20 Ultrasonic cleaner (optional)

5.0 Procedure

5.1 Preparation of Specimen Grind the sample sequentially on 180, 240, 320 grit wheel to within approximately 1.27 mm of final polish depth. Deburr all edges prior to mounting.

5.2 Mounting Metallographic Sample

5.2.1 Clean mounting surface and dry thoroughly, then apply release agent to the plate and mounting rings.

5.2.2 Thoroughly clean the sample using a suitable solvent such as isopropyl or ethyl alcohol. This is especially important when microsectioning ''thermally stressed'' (solder floated) specimens. Residual flux may result in poor adhesion of the encapsulation media causing gaps between the specimen and the media. These gaps make proper metallographic sample preparation extremely difficult, if not impossible.

5.2.3 Stand specimen in mount ring, perpendicular to the base using sample supports, clips, or with the use of double-sided adhesive tape.

5.2.4 The surface to be examined should face the mounting surface.

5.2.5 Fill the mounting ring carefully with potting material, by pouring from one side to ensure complete PTH filling. Some potting materials may require dilution as recommended by the material manufacturer to reduce the viscosity in order to fill small diameter PTHs. Hand protection is recommended to prevent skin sensitization.

5.2.6 The sample must remain upright and the holes filled with encapsulating material.

5.2.7 Epoxy potting materials may require vacuum degassing in order to achieve complete hole filling.

5.2.8 Allow specimen to cure and remove hardened mount from ring. The minimum qualities the mount should exhibit are:

- No gaps between the potting material and the sample
- The PTHs filled with material
- No bubbles in the potting material

The presence of these deficiencies will result in sample preparation difficulties, as noted in 5.2.2. Identify the specimen by a permanent method. The selected marking system should remain unaffected by solvent and lubricant exposure.

5.2.9 For finite plating thickness measurements, such as gold and nickel thickness on edge board contacts, the overplated specimen may be placed at a 30° angle. This will provide viewing at twice the actual thickness. The measured thickness is then divided by two to arrive at the true thickness. For a more thorough discussion of the techniques of taper sectioning, refer to the references in 6.5.

5.3 Grinding And Polishing

5.3.1 Using the metallographic equipment, rough grind the mount on 180 grit abrasive paper no closer than to the edge of the PTH barrel walls.

Note: Copious water flow must be used to prevent overheating and damage to the specimen and removal of grinding debris.

5.3.2 Fine grind specimen, using copious water flow, to center of the PTHs utilizing 240, 320, 400, and 600 grit discs, in that order. The final paper (600 grit) should finish at the axial centerline of the PTHs. Wheel speeds of 200 to 300 rpm are generally used during fine grinding. Rotate the specimen 90° between each successive grit size and grind for twice to three times the time it takes to remove the scratches from the previous step. The scratch removal can be verified by microscopic inspection between steps. It is of great importance that the ground surface of the microsection is in a single plane. The purpose of rotating the microsection 90° between successive grit sizes is to facilitate inspection. If scratches are observed to be perpendicular to those made during the last step performed, it is a good indication that the surface is not flat and the microsection requires additional grinding. If the surface of the microsection is not flat upon completion of the grinding operations, it may not be possible to remove all of the grinding operations, and grinding scratches during rough polishing. The metallographer should recognize the fact that the coarser grit sizes (180, 240, and 320) induce a larger depth of deformed and fragmented material. Since the depth of deformation decreases sharply below a particle size of about 30 microns (400 grit), it is better practice to spend longer times on 400 grit and especially 600 grit to achieve the final plane sectioning, rather than on the coarser grit sizes.

5.3.3 Rinse sample with running tap water and blow dry with filtered air. Ultrasonically clean, if desired, between each step.

Note: Ultrasonic cleaning is highly recommended, especially between the finer grinding steps, prior to rough polishing and between all polishing steps. It is the nature of printed board specimens, especially those with epoxy base material following thermal exposures, to contain voids that can trap grinding and polishing residues that are not removed during simple rinsing. Care needs to be exercised not to damage the specimen surface with excessive ultrasonic cleaning. Ultrasonic cleaning for as little as one minute can damage a polished surface.

5.3.4 Rough polish the specimen with six micron diamond abrasive on a hard, low, or no nap cloth. Following rough polishing, microscopically examine the specimen to verify removal of all 600 grit scratches. Ultrasonically clean the specimen, if desired. Continue polishing with one to three micron diamond abrasive again using a hard, low, or no nap cloth and microscopically examine the speciment to verify the removal of all the six micron diamond scratches. Ultrasonically clean the specimen, if desired. Generally, polishing a few minutes using medium pressure during the above steps is sufficient if the microsection has been ground correctly. Wheel speeds of 200 to 300 rpm are generally used during rough and intermediate polishing. Final polishing is accomplished using a soft, woven, or medium nap cloth using a one to 0.1 micron diamond, 0.05 micron alumina or other oxide, or a colloidal silica polishing suspension. This final step is only performed for 10-20 seconds using light to medium pressure when using oxide or silica polishing compounds. When using diamond compounds on soft woven cloths, final polishing may extend several minutes (see 5.3.5). Reduced wheel speeds of 100 to 150 rpm are generally used during final polishing due to increased drag on the microsection. Typically, six micron followed by one micron diamond and a 0.04 micron colloidal silica or 0.05 micron alumina have been used successfully. However, other variations such as six micron, three micron, and 0.25 micron diamond have also been used successfully. Some have even used 1.0 and 0.3 micron alumina on napless cloths followed by 0.05 micron alumina on a soft, medium napped cloth. This procedure can be used successfully, depending upon the skill of the metallographer, but will generally result in poorer edge retention and more relief effects than the diamond compounds (see 6.5, Reference 1).

5.3.5 Warning The use of napped cloths can result in poor edge retention (rounding) and relief between constituents since it exacerbates the varying rates of material removal (i.e., tin-lead alloy and the softer encapsulation media are removed at a faster rate than the copper or glass fibers in the base material). The higher the nap, the more the effect. The user needs to minimize the polishing time and use ample lubricant and light pressure during final polishing.

5.3.6 Rinse in mild soap and warm water or solvent and blow dry.

5.3.7 Examine and repolish, beginning with six micron diamond, if necessary, until:

1. There are no scratches larger than those induced by the final polishing abrasive.

2. The specimen is not higher or lower than the mounting material.
3. There is no smearing of the copper plating into the PTH or base material.
4. The plane of microsectioning is at the centerline of the hole as defined by the governing specification. If the grinding depth is insufficient, additional grinding and repolishing may be required.
5. There is little, if any, visible preparation induced damage to the glass fibers of the base material.

See IPC-MS-810 for photomicrographs illustrating some of the above qualities. When the required microsection quality has been achieved, examine the microsection of multilayer printed boards in the ''as-polished'' condition as specified in 5.4.1 to identify suspect areas of internal layer separation that appear as dark lines or partial dark lines. These areas should be verified after metallographic etching. There may not be a one-to-one correlation of all separations noted ''as-polished'' versus those noted after etching, when examined at the specified magnifications.

5.3.8 Swab specimen with suitable etching solution (see 6.4) typically applied for two to three seconds, repeat two to three second swabbings if necessary, to reveal the plating interfaces.

Caution: Over etching may totally obscure the demarcation line between the copper foil and electroplate copper, preventing accurate inspection.

5.3.9 Rinse in running tap or deionized water to remove etchant.

5.3.10 Rinse in solvent and blow dry.

5.4 Evaluation

5.4.1 Set the magnification at 100X and measure all characteristics required by the standard or specification using a metallograph set for bright field illumination. Referee at 200X, unless otherwise specified.

5.4.2 Measure the plating thickness in at least three PTHs. Total surface copper thickness can also be determined on the same specimen cross-section. Record the plating thickness determinations and quality of the plating. Plating thickness determinations should not be made at nodules, voids, or cracks.

5.4.3 Quality observations may include the following: blisters, laminate voids, cracks, resin recession, hole wall pull-away, plating uniformity, burrs and nodules, plating voids, and wicking. In addition, plating quality for multilayer printed boards may include: innerplane bond to PTH, resin smear, glass fiber protrusion, and resin etchback. Some of the plating conditions may be observed on the polished specimen prior to etching.

6.0 *Notes*

6.1 Overplating the specimen per ASTM E 3 with a layer of copper or other plating with a hardness similar to the specimen, prior to encapsulation, provides better edge retention, thereby providing more accurate thickness measurements.

6.2 For a more accurate evaluation of possible internal layer separations, the procedures covered in 6.2.1 and 6.2.2 are recommended.

6.2.1 Regrind Procedure

6.2.1.1 After polishing and examining with a metallographic microscope, turn power off at the final grinding wheel.

6.2.1.2 Gently regrind the specimen using copious amounts of water and 600 grit paper with the wheel in a stationary position parallel to the PTH barrels. Six to eight double strokes should be sufficient. This action will remove any copper metal smear that may have occurred over the interconnection separation during rotary polishing.

6.2.1.3 Rinse and dry specimen and repolish per 5.3.3 through 5.3.7, then reexamine under the metallograph to determine if interconnection separation exists.

6.2.1.4 After examination in the ''as-polished'' condition (and taking photomicrographs, if desired), etch the specimens with the mild etchant described in 6.4, and reexamine the specimen again for interconnection separation and all other characteristics. There may not be a one-to-one correlation of all separations noted ''as polished.''

6.2.2 Mechanical/Chemical Preparation (Attack Polishing) Another useful technique is a simultaneous mechanical/chemical polish at the final polishing step. Use a mixture of 95% collodial silica and 5% by volume hydrogen peroxide (30% concentration) and polish on a chemically resistant cloth. This results in a simultaneous mechanical and chemical abrasion of the specimen. The metallographer must be careful to balance the mechanical abrasion with the chemical abrasion. Too much mechanical abrasion will result in fine scratches; too much chemical polishing will result in etching of the specimen. Neither of these conditions is desirable. Experimentation will be required to develop the optimal balance.

6.3 In order to develop more insight into detected interconnection separations, regrind and repolish the specimen in the horizontal plan (perpendicular to the original vertical plane), and examine the semicircumferential interface. This method has a low success rate when the separation affects less than 50% of the internal layer thickness (as noted on the vertical microsection).

6.4 The following is the recommended solution for specimen etching.

25 ml ammonium hydroxide (25-30%)
25 ml-35 ml of 3-5% by volume stabilized hydrogen peroxide

The addition of 25 ml of water (distilled or reverse osmosis) will dilute the solution, resulting in longer etching times, which may be desirable in certain situations.

Wait five minutes before using. Prepare fresh every few hours.

6.4.1 There are other etchant solutions that have been used or that may be developed for etching copper. Care must be exercised in their selection and use because of the sensitive nature of the electrolytic, electroless, and foil etching characteristics as well as possible galvanic effects in the presence of tin-lead. See 6.5, Reference 2 and IPC-MS-810.

6.4.2 When studying tin-lead solders, it is sometimes helpful to use etchants specifically designed to reveal those alloy's microstructures (see 6.5, Reference 2).

6.5 Additional references on metallographic laboratory practice.

1. *Metallographic Polishing by Mechanical Means*, L.E. Samuels, American Society for Metals, 1982, ISBN: 0-87170-135-9.
2. *Metallographic Etching*, Gunter Petzow, American Society for Metals, 1978, ISBN 0-87170-002-9.
3. *Mettallography Principles and Practice*, George F. Vander Voort, McGraw-Hill, 1984, ISBN: 0-07-0669780-8.
4. *Metals Handbook Desk Edition*, Edited by Howard E. Boyer and Timothy L. Gall, American Society for Metals, 1985, ISBN: 0-87170-188-X.

ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

2215 Sanders Road
Northbrook, IL 60062-6135

IPC-TM-650
TEST METHODS MANUAL

Number **2.1.1.2**	
Subject **Microsectioning—Semi or Automatic Technique Microsection Equipment (Alternate)**	
Date **7/93**	Revision
Originating Task Group	

1.0 Scope This procedure is an alternate method for preparing multiple metallographic specimen(s) using microsection equipment. The specimen(s) is(are) for evaluation for quality of the laminate system, plated-through holes (PTHs), the copper foils, platings, and/or coatings. The same basic procedure may be used for examination of other areas on the product.

Note: This microsection technique is a process and not a test method.

Note: SAFETY The use of the materials listed in Section 4.0 may be limited or forbidden in some environments. Please review the Material Safety Data Sheet (MSDS) for the materials being used.

2.0 Applicable Documents

IPC-MS-810 Guidelines for Semi-Automatic Microsection

IPC-RB-276 Qualification and Performance Specification for Rigid Printed Boards

3.0 Test Specimens Remove the required specimen(s) from the product to be tested. Allow sufficient clearance to prevent damage to the area and PTHs to be examined. The recommended clearance from the pad edge to the cut surface is 2.54 mm [0.100 in]. Abrasive cut-off wheels can cut closer to the sample without damaging the area to be examined.

4.0 Apparatus

- sample removal method (see IPC-MS-810 for best method)
- sample alignment tools
- mount molds
- mounting surface
- vacuum/pressure system (optional)
- release agent (optional)
- potting material (recommended maximum cure temperature is 200°F)
- explosion proof fume hood for mounting material
- microsection equipment (see IPC-MS-810 for purchasing guidelines)
- metricated abrasive paper P100–P1200 (American grit range: 100–600)
- polishing cloths
- diamond abrasive (1–9 micron) or oxide abrasive (3–0.1 micron)
- polishing lubricant
- micro-etch solution
- micro-etch applicator (optional)
- engraver (optional)

5.0 Procedure and Evaluation

5.1 Procedure

5.1.1 The semi or automatic microsection technique is a process and not a test method. Microsectioning needs to be viewed as a process with quality criteria as each major step is completed. This procedure specifies the quality criteria that must be met to make microsections that can consistently find the defects (or anomalies) of concern. The customer should not specify the process steps and materials but the quality criteria for surface preparation of the specimen.

5.1.2 Preparation of Specimen(s) Remove the specimen from the PWB or panel such that the tooling pin holes or target PTHs are not damaged. Complete any thermal testing required by the customer.

5.1.3 Inspect Tooling Pin System Inspect the tooling pin holes or slots to verify they are not plugged or damaged. Clear plugged tooling pin holes with a tool that will not change its dimensional location or enlarge the hole. A drill bit of the same hole diameter is recommended.

Inspect the tooling pins for foreign material adhering to them. Clean the pin surface as required. Discrard any pins that are bent or the surface scarred.

5.1.4 Load Specimen On Tooling Pins The pins align the target PTHs on a common plane. This common plane assures all the PTHs will grind to the center of the hole at the same instance.

Push the tooling pins into the tooling holes or slots. The pins must fit snugly.

5.1.5 Potting the Specimen(s) The potting material must have a low shrink rate, and the cure temperature must be less than 93°C [200°F] at the center of the mount to prevent false failures. Mold release may be applied to the mount to permit easy removal of the cured mounting material (optional). Thoroughly mix the potting material without trapping air and pour into the mold. Assure the tooling pins do not shift position or rise up while pouring and/or curing of the potting material. If necessary to avoid voids in the finished mount and to insure adequate hole filling, evacuate the mount before cure using a vacuum system. Allow the potting material to cure and return to ambient temperature before removing from the mount. Remove the hardened mounts from their molds (as applicable).

5.1.6 Traceability The mount/specimen must be permanently marked in such a manner to ensure traceability back to the PWB or panel. If the mounts are cured within the mount holder, traceability is not required until the mounts are removed from the holder.

5.1.7 Mount Quality The minimum qualities the mount must exhibit are no gaps between the potting material and the specimen, the PTHs filled with material, and no bubbles in the potting material in the areas of examination.

5.1.8 Grind Process Set-Up.

5.1.8.1 Tooling Stops The mount holder has tooling stops to allow the equipment to grind a set distance. These stops must be calibrated for each abrasive paper grit to assure the scratches from the previous step are removed. See IPC-MS-810 for a detailed discussion and examples.

5.1.8.2 Grind Pressure The equipment's pressure setting is the direct force on a load cell. To determine the pressure on each mount, divide the pressure setting by the surface area of the mounts being processed. See IPC-MS-810 for a detailed discussion and examples.

The recommended pressure setting for 6 mounts at 38.1 mm [1.5 in] diameter is 351.5 g/sq. cm (5.0 psi) with the wheel RPMs between 300–600.

5.1.8.3 Other Variables Recommended variables to be familiar with are length of time the abrasive paper removes material efficiently, scratch size the abrasive paper causes on the specimen(s) surface, and water quality (undissolved particles that can cause scratches; i.e. calcium deposits).

5.1.9 Grind the Mounts Be liberal with the amount of water used to promote efficient removal of material by the abrasive paper. The hardness of the specimen will dictate the number of rough and fine grind steps needed to reach near the center of the hole. The rough grind grits P180-P240 (American 180-240) are used to enter the edge of the PTH, and the fine grind grits P800-P1200 (American 400-600) are used to grind near the center of the hole. The distance to stop short of the center is determined by the scratch size of the last grind step used.

A recommended grinding process from which to start development is:

	Step 1	Step 2	Step 3
Abrasive grit size	P180	P 400(opt)	P1000
RPM	200–300	200–300	200–300
Pressure (g/sq.cm)	351.5	351.5	351.5
Time	15 seconds after the stops touch		

5.1.9.1 Clean the Mounts Clean the mount surface with a mild hand soap to remove the abrasive grit. This is especially important when the same mount holder is used for grinding and polishing. Be careful not to scratch the surfaces to be evaluated while cleaning.

5.1.10 Grind Quality The minimum qualities the mount must exhibit are:

1) The target PTHs are ground to the center of the PTHs as defined by the customer's specification.
2) Only fine grind scratches apparent on the mount when viewed at 100X magnification.
3) No gap between the potting material and the specimen(s).
4) No residual abrasive paper grit material on the mount surface.
5) The ground surface has only one plane of material removal. If the mount has several planes of material removal, portions of the sample will not polish since the odd surface never touches the polishing cloth.

5.1.11 Polish Process Setup The tooling stops are recessed or removed from the mount holder during polishing. The reason is the polish process removes a negligible amount of material and will not change the flatness of the surface. The number of polish steps is determined by the hardness of the specimen(s), distance to the center of the hole, and scratch size of the last fine grind step. There may be multiple intermediate polish steps but only one final polish step.

5.1.12 Intermediate Polish Steps The intermediate steps must remove the fine grind scratches and prepare the surface for the final polish step. The recommended process settings for 6 mounts at 38.1 mm [1.5 in] diameter is less than 351.5 g/sq. cm (5.0 psi), a medium to hard polish cloth, short nap surface, and low wheel RPM (100–200). Additional variables that must be considered are volume of lubricant, lubricant types, abrasive size, abrasive type (diamond or oxide), and process time.

A recommended polish process from which to start development is:

	Step 1	Step 2	Step 3
Type of cloth	Napless	Napless	Nap
Type of polish abrasive	Diamond	Diamond	Diamond
Polish abrasive size	6 micron	1 micron	1 micron
Time	—	—	30 sec max.
Pressure (g/sq. cm)	351.5 or less	351.5 or less	351.5 or less

5.1.12.1 Clean the Mount(s) The mounts must be cleaned between each polish step. The reason is to prevent contaminating the next polish step with the current grit size. If the polish step is contaminated, the step will produce undesirable scratches. Clean the mounts with mild hand soap, rinse with water, and dry. Do not scratch the surface to be evaluated when cleaning.

5.1.13 Final Polish the Mounts The final polish step removes the scratches from intermediate polishing and prepares the surface for evaluation. The recommended process setting for the same surface areas as 5.1.12 are a medium to soft polish cloth, low wheel RPM (100-200), and low pressure setting 351.5 g/sq. cm (5.0 psi) or less. Additional variables that must be considered are volume of lubricant, type of nap surface on polish cloth, and process times. The type of abrasive used must be diamond (maximum rated size: 1.0 micron) or colloidal silica.

Warning

If a high nap polish cloth is used too long in the final polish, the inspectors ability to see defects can be hampered. This step must be engineered for short process times (30 seconds or less) with a careful balance of lubricant to prevent copper rounding.

5.1.13.1 Clean the Mount This last clean step must remove all the contaminants as described in 5.1.12.1 and the polish lubricant. The lubricant film will prevent even microetching of the specimen(s).

5.1.14 Traceability If the mounts are cured in the mount holder, remove the mounts. The mount/specimen must be permanently marked in such a manner to ensure traceability back to the PWB or panel.

5.1.15 Polish Quality The surface qualities of a properly prepared microsection mount are:

1. The target PTHs are ground to the center of the PTH as defined by the customer's specifications.
2. No scratches larger than 1.0 micron on the metal surface to be examined (i.e. copper).
3. No smear of metals (i.e. copper, tin/lead, nickel) over other metals, board base material, and/or potting material.
4. No rounding of metal surfaces (i.e. copper) in the PTH.
5. No gaps between the specimen(s) and potting material.

Rounding of metal surfaces is apparent as the material edge being out of focus at 100X magnification on the metallograph or shaded a charcoal black color.

5.2 Evaluation Method

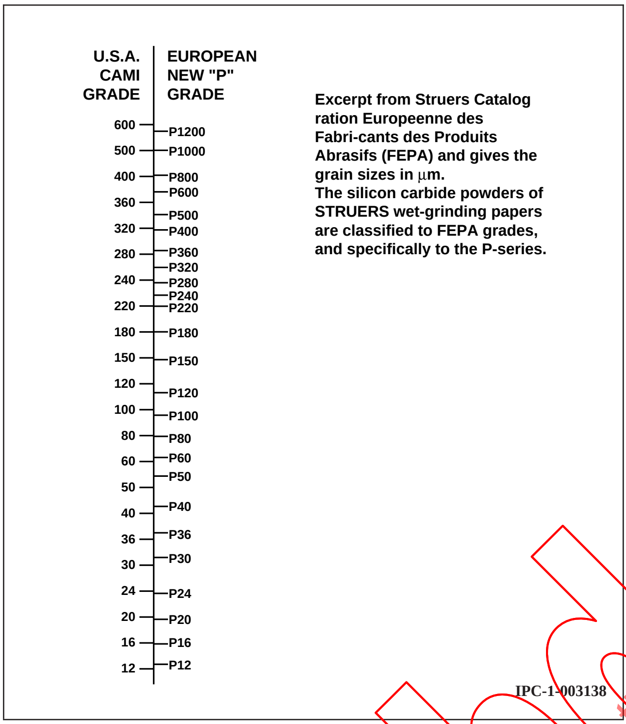
5.2.1 Separation Evaluation Evaluate the PTHs for innerlayer separation prior to microetch. Any observations need to be re-inspected after etch. The separations noted in the unetched and microetched conditions will not necessarily correlate one to one.

5.2.2 Microetch the Specimen Swab or dip the specimen into a suitable microetching solution and rinse with running water. The recommended etching solutions and formulations are listed in IPC-MS-810. The etch time will vary with the type of etchant chosen to microetch the sample.

5.2.3 Evaluation Evaluate the average thickness of the plated metals and determine PTH quality per the customer's specifications.

6.0 *Notes*

6.1 Diamond Polish The diamond polish media is preferred over alumina for PWB's being evaluated to IPC-RB-276



Excerpt from Struers Catalog ration Europeenne des Fabri-cants des Produits Abrasifs (FEPA) and gives the grain sizes in µm. The silicon carbide powders of STRUERS wet-grinding papers are classified to FEPA grades, and specifically to the P-series.

Figure 1 Abrasive paper grit size (American vs. European)

Class 2 and 3 products. Diamond media substantially reduces the risk of metal smear and rounding. Diamonds provide a sharper definition of copper surfaces to evaluate for separation of conductive surfaces.

6.2 Etchants The two most common microetchants for copper are ammonium hydroxide/hydrogen peroxide and sodium dichromate etchant. Both have benefits and drawbacks that must considered when making a choice (See IPC-MS-810).

6.3 Abrasive Paper The abrasive grit size has different designators (Metricated versus American). Figure 1 tabulates the correlation between grades.

6.4 See IPC-MS-810 for photomicrographs illustrating acceptable and unacceptable polish quality.

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IPC-TM-650
TEST METHODS MANUAL

Number **2.4.1**	
Subject **Adhesion, Tape Testing**	
Date **8/97**	Revision **D**
Originating Task Group **Rigid Board T.M. Task Group (7-11d)**	

1.0 Scope This test method uses pressure sensitive tape to determine the adhesion quality of platings, marking inks or paints, and other materials used in conjunction with Printed Boards.

2.0 Applicable Documents

Commercial Item Description (CID) A-A-113 Tape, Pressure Sensitive, Adhesive.

3.0 Test Specimens Any preproduction, first article, or production printed board. A minimum of three tests should be performed for each evaluation.

4.0 Apparatus or Material

4.1 Tape A roll of pressure sensitive tape 3M Brand 600 1/2 inch wide or a tape as described in (CID AA-113), Type 1, Class B, except that the tape may be clear.

5.0 Procedure

5.1 Test Press a strip of pressure sensitive tape, 50mm [2.0 in] minimum in length, firmly across the surface of the test area removing all air entrapment. The time between application and removal of tape shall be less than 1 minute. Remove the tape by a rapid pull force applied approximately perpendicular (right angle) to the test area. An unused strip of tape must be used for each test.

5.2 Evaluation Visually examine tape and test area for evidence of any portion of the material tested having been removed from the specimen.

5.3 Report The report should note any evidence of material removed by this test.

6.0 *Notes*

6.1 If plating overhang breaks off (slivers) and adheres to the tape, it is evidence of overhang but not an adhesion failure.

6.2 If foreign material (oil, grease, etc.) is present on the test surface the results may be affected.

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IPC-TM-650
TEST METHODS MANUAL

Number **2.4.8**	
Subject **Peel Strength of Metallic Clad Laminates**	
Date **12/94**	Revision **C**
Originating Task Group **MIL-P-13949 Test Methods Task Group (7-11b)**	

1.0 Scope This test method is designed to determine the peel strength of metallic cladding when tested in the following conditions, ‘‘as received,’’ after thermal stress, and after exposure to processing chemicals; and to evaluate the base laminate material after the peel strength test is completed for degradation due to the conditioning.

2.0 Applicable Documents

IPC-TM-650

Method 2.4.8.1, Peel Strength, Metal Foil (Keyhole Method for Thin Laminates)
Method 5.8.3, Peel Strength Test Pattern

3.0 Test Specimens

3.1 Size and Configuration Specimens shall be 50.8 mm x 50.8 mm [2.0 x 2.0 in] by the thickness of the laminate. Cladding test strips shall be as specified (see 5.1.2).

3.2 Quantity and Sampling At least 2 specimens per clad side per each test condition (see 5.2) shall be taken at random from the laminate lot. They may be taken from samples used for other QA testing or inspection. One specimen per side shall be used for crosswise and one specimen per side for lengthwise testing.

4.0 Apparatus or Material

4.1 Tensile Tester A tensile strength tester equipped with a load cell, capable of measuring to the nearest 0.0045 kg [0.01 lbs], and light load wire or chain and clamp at least 457 mm [18.0 in] long (its weight is included in the load cell calculation). The clamp jaws must cover the entire width of each peel strip. Any equipment or apparatus having the described accuracy, precision, and reproducibility may be used.

4.2 Solder Pot A solder bath or pot capable of maintaining solder at the specified temperature when measured 25.4 mm [1.0 in] below the surface. Type Sn60 or Sn63 solder shall be used.

4.3 Specimen Hold-down A suitable hold-down clamping system equivalent in performance as that defined in IPC-TM-650, Method 2.4.8.1.

4.4 Chemicals A minimum of two ounces of the following processing solutions:

4.4.1 Organic chemical stripper, such as Methylene Chloride, or equivalent

4.4.2 Sodium Hydroxide 10 gr/liter

4.4.3 Boric Acid 30 gr/liter and Sulfuric Acid 10 gr/liter

4.4.4 Organic degreaser, such as isopropyl alcohol, or equivalent.

4.5 Hot fluid bath, capable of being maintained at the specified temperature, when measured 25.4 mm [1.0 in] below the surface.

4.5.1 Dow Silicone Fluid No. 704, or equivalent.

4.6 Dow Silicone Grease, Compound 4, or equivalent.

4.7 Data Collection For qualification testing, a recording system capable of permanent data retention must be incorporated into the test apparatus.

4.8 Etching system capable of complete removal of metallic cladding.

4.9 Measuring device capable of measuring from 0.000 to 12.7 mm [0.5 in] to within ± 0.0025 mm [0.0001 in].

4.10 Etch Resist Materials or Systems

4.10.1 Platers tape, or equivalent, to act as etch resist for strip formation of the specified widths (see 5.2.1.1, 5.2.2.1, and 5.2.3.1).

4.10.2 Photoresist system (printing, developing, and stripping).

5.0 Procedure

5.1 Specimen Preparation

5.1.1 Cut the specimens from the laminate sample. Specimens shall be taken no closer than 25.4 mm [1.0 in] from the edge of the laminate sheet as manufactured.

5.1.2 Specimens shall be prepared with at least four resist strips of the width specified (see 5.2.1.1, 5.2.2.1, 5.2.3.1), etched, cleaned and processed using standard industry practices and equipment. For qualification and referee testing the specimen shall be photoimaged in accordance with the artwork shown in Method 5.8.3 of IPC-TM-650 except that tab ends are optional. Specimens shall be etched so that the conductor strips on one specimen are in one direction per Figure 1. Double clad laminate shall have each side tested using separate specimens. The opposite side cladding shall be either fully removed or left fully clad. For referee testing the cladding on the opposite side shall remain. Separate specimens for both the warp and fill directions are required for each side.

5.1.3 Thin specimens may be provided with support by bonding them to a rigid substrate base, or may be tested with the aid of the keyhole fixture (see Figure 2). For referee testing of laminates less than 0.51 mm [0.020 in], the specimens shall be bonded to a rigid substrate or laminate.

Note: Peel values can be affected by the adhesive used to bond the specimen to the rigid substrate. It is imperative that the best adhesive be found for the type of materials being bonded to least influence the true peel strength value.

5.1.4 For referee testing and qualification, specimens shall be preconditioned by baking at 125°C [257°F] for 4 ± 0.5 hours.

5.2 Measurements

5.2.1 Condition A Peel Strength: As Received

5.2.1.1 A minimum of two 3.18 mm [0.125 in] test strips per specimen shall be peeled. For qualification testing four 3.18 mm [0.125 in] strips per specimen shall be peeled.

5.2.1.2 Adjust the measurement system to compensate for the weight of the wire and clamp.

5.2.1.3 Peel the test strip back at the tab end (if present) no more than 12.7 mm [0.5 in]. Attach the clamp to the peeled back end of the test strip.

5.2.1.4 Fasten specimen with hold down fixture so that an unencumbered vertical pull can be exerted. The end of the test strip should be in a vertical position ready for testing. The wire connecting the clamp to the tensile tester must be free to pull vertically within ± 5° angle.

5.2.1.5 Start tester and apply force in the vertical direction at the rate of 50.8 mm [2.0 in]/minute, until at least a 25.4 mm [1.0 in] peel is completed (see Note 6.1).

5.2.1.6 Observe and record the minimum load as defined by Figure 1. Measure the actual width of the test strip and record with the minimum load.

5.2.1.7 If the full width of the test strip does not peel, the results shall be discarded and another strip tested.

5.2.2 Condition B Peel Strength: After Thermal Stress

5.2.2.1 A minimum of two 3.18 mm [0.125 in] test strips per specimen shall be peeled. For qualification testing four 3.18 mm [0.125 in] strips per specimen shall be peeled.

5.2.2.2 Apply a thin coating of silicon grease to specimens and float on solder maintained at 288°C ± 5.5°C [550°F ± 10°F] for 10 seconds, +1, -0.

5.2.2.3 Cool specimens to laboratory ambient temperature, Clean the grease off and perform steps 5.2.1.2 through 5.2.1.7.

5.2.3 Condition C Peel Strength: After Exposure to Processing Chemicals

5.2.3.1 A minimum of two 0.79 mm [0.032 in] test strips per specimen shall be peeled. For qualification and conformance four 0.79 mm [0.032 in] strips per specimen shall be used.

5.2.3.2 Immerse in organic stripper as specified in 4.4.1 for 75 ±5 seconds at 23 ±2°C [73.4 ±3.6°F].

5.2.3.3 Dry specimens 15 ± 5 minutes at 125 ± 5°C [257 ± 9°F].

5.2.3.4 Immerse in a solution of 10 gr/liter sodium hydroxide at 90 ± 5°C [194 ± 9°F] for 5 ±1 minutes.

5.2.3.5 Rinse in hot tap water at 50–55°C [122–131°F] for 5 ± 1 minutes.

5.2.3.6 Immerse for 30 ±5 minutes in a solution of 10 gr/liter sulfuric acid (sp. gr. 1.836) and 30 gr/liter boric acid solution at 60 ± 5°C [140 ± 9°F].

5.2.3.7 Rinse in hot water at 55 ± 5°C [131 ± 9°F] for 5 ± 1 minutes.

5.2.3.8 Dry for 30 ± 5 minutes at 125 ± 5°C [257 ± 9°F].

5.2.3.9 Immerse in a hot oil bath maintained at 220 ± 5°C [428 ± 9°F] for 40 ± 5 seconds.

5.2.3.10 Immerse in degreaser as specified in 4.4.4 at 23 ± 2°C [73.4 ± 3.6°F] for 75 ± 5 seconds to remove hot oil.

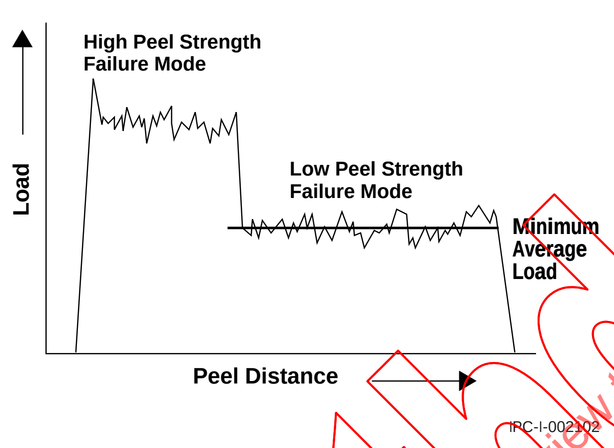

Figure 1 Multiple Failure Modes

5.2.3.11 Air dry specimens and perform steps 5.2.1.2 through 5.2.1.7.

5.2.4 Determination of Degradation Examine the specimens using normal or corrected 20/20 vision. Record and report the presence of any base laminate degradation, including loss of surface resin, discoloration, resin softening, delamination, blistering, propagation of imperfections, measling, crazing, or voids.

5.3 Calculation and Report

5.3.1 Calculate the peel strength as per the formula:

$$\text{lbs/in} = \frac{L_M}{W_S}$$

where:

L_M = Minimum Load

W_S = Measured width of peel strip

5.3.2 Record and report each individual peel strength value. Average the individual peel strength values for each side and each grain direction of the laminate sampling. For example, if the sampling plan calls for one specimen per side and per grain direction, there will be at least two values to be averaged from four different specimens.

5.3.3 Report any presence of laminate degradation as observed in 5.2.4

6.0 *Notes*

6.1 Test strip breakage may be caused by either a bond greater than the tensile strength of the foil, or foil brittleness. Where superior bond is shown (value at break above specification) the value at break may be used instead of minimum peel. The average reported shall indicate that the value is greater than average.

6.2 For metallic cladding less than one oz thickness, copper plating or solder coating may be used to build up to 0.035 ± 0.0035 mm [0.0014 ± 0.00014 in] to provide strip strength.

6.3 Environmental aspects of chemicals as specified in 4.4.1 and 4.4.4. Based on industry and government policies toward chemicals which are hazardous to worker health or of concern for ozone depletion, previous requirements for use of Methylene Chloride and 1,1,1 Trichloroethane have been replaced with equivalents.

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IPC-TM-650
TEST METHODS MANUAL

Number
2.4.21.1

Subject
Bond Strength, Surface Mount Lands Perpendicular Pull Method

Date
5/91

Revision
C

Originating Task Group
Printed Board Test Methods (7-11d)

1 Scope This test method is used to determine the bond strength (breakaway strength) of surface mount lands from substrate materials by a perpendicular pull and force measurement. It is designed to test solderable metals on any type of substrate in a variety of surface mount land sizes. The surface finish shall be the same as the board it represents.

This test may be imposed in the as received condition during maximum use temperatures, after exposure to commonly used solvents, after high humidity, and after extended aging.

It is important to note this perpendicular test provides entirely different results than tests where the test leads are soldered parallel to the plane of the land and bent perpendicular for testing.

2 Applicable Documents

IPC-D-275 Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies

3 Test Samples/Specimens

3.1 Qualification Standard surface mount lands (full variety) as shown in Figure 1 (IPC-D-275, Coupon N). Unless otherwise specified, a minimum of five of each land size shall be tested for qualification.

3.2 Production Standard quality conformance circuitry coupon, N, as shown in IPC-D-275. For production, a minimum of three lands of each size used on the board shall be tested.

3.3 Materials and Configurations Tested

3.3.1 Printed boards and substrate materials used for surface mount printed boards

3.3.2 Finishes used on surface mount lands on printed boards, such as tin-lead platings or coatings, gold platings, etc.

3.3.3 All surface mount land sizes

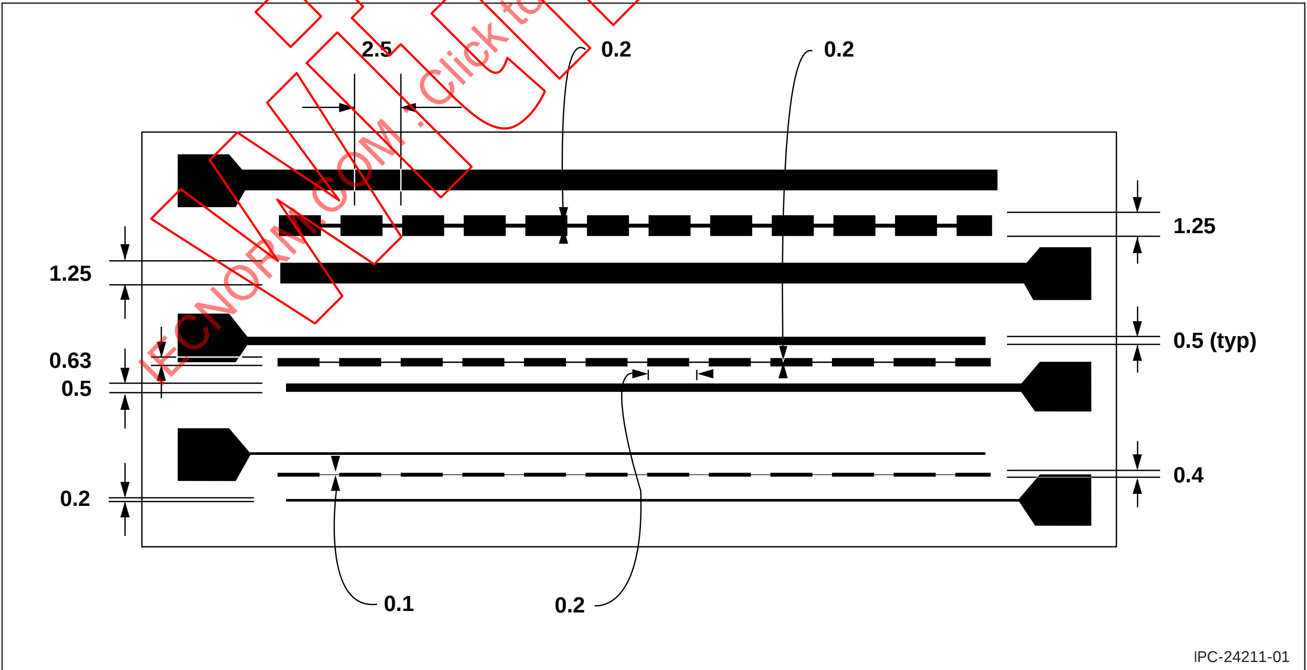

Figure 1 Coupon N, surface mounting bond strength, mm, nominal

4 Apparatus

4.1 Force Testers All force testers must have maximum force retention capability. All force testers must have capacity from 0 kg to 14 kg. Suggested force testers include the following:

4.1.1 Hand Held—Ametek Accurforce Cadet Digital Force Gauge, or equivalent

4.1.2 Hand Held—Ametek L-20 Force Gauge (Dial Indicator), or equivalent

4.1.3 Automatic—Unite-O-Matic with Houston Instruments 2000 Recorder, Instron, Tinius-Olson with Recorders, or equivalent

4.2 A standard pin made of steel core (1018 wire), which has been copper clad with a thickness of 0.038 mm minimum copper covered by a solder coating consisting of 63% (by weight) of tin, with the remaining lead, and a thickness of between 7 µm and 10 µm.

Standard test pins are pre-tinned.

Measurements are:

Overall Length	30 mm
Head Diameter	1.6 mm
Shaft Diameter	0.5 mm

4.3 Soldering Iron 60-watt soldering iron capable of producing a tip temperature of 232°C to 260°C

4.4 Optical inspection aid, cable of 10x magnification minimum, or equivalent

5 Test

5.1 Preparation

5.1.1 Measure the dimensions of the surface mount lands using magnifications not less than 10x (10x to 30x preferred). Calculate and record the surface area of the land before soldering the headed pin.

For production testing, use three of each land size used on the associated board.

For qualification testing, use five of each land size shown in Coupon N of IPC-D-275.

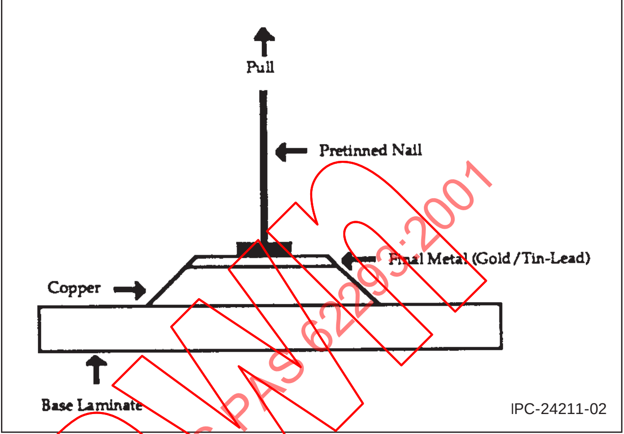

Figure 2 Pin Soldered to Land

5.1.2 Pre-clean the specimen and standard test pin using 75% by volume isopropyl alcohol and 25% by volume distilled water.

5.1.3 With the soldering iron, develop a tip temperature of 232°C to 260°C and solder the pin head onto the center of the surface mount land. Soldering of the pin head shall be accomplished by the use of fixturing or any other means of ensuring a 90° ± 5° perpendicularity of the pin with respect to the surface of the land (see Figure 2).

5.1.4 The iron shall be applied to the pin and the land and shall be applied only as long as necessary to perform the soldering operation.

5.2 Procedure

5.2.1 Upon completion of the soldering, place the specimens either in the base specimen receptacle of the automatic tensile tester or the hand held tester (see Figure 3). Testing is at ambient room temperature, 18°C to 30°C, unless a specified use temperature is designated.

5.2.2 Clamp the loose end of the pin in the jaws of the tester.

5.2.3 Pull the pin perpendicular at an approximate rate of 50 mm per minute until failure occurs or the force exceeds the specified value required for this test (perpendicular is considered within 5% of 90°).

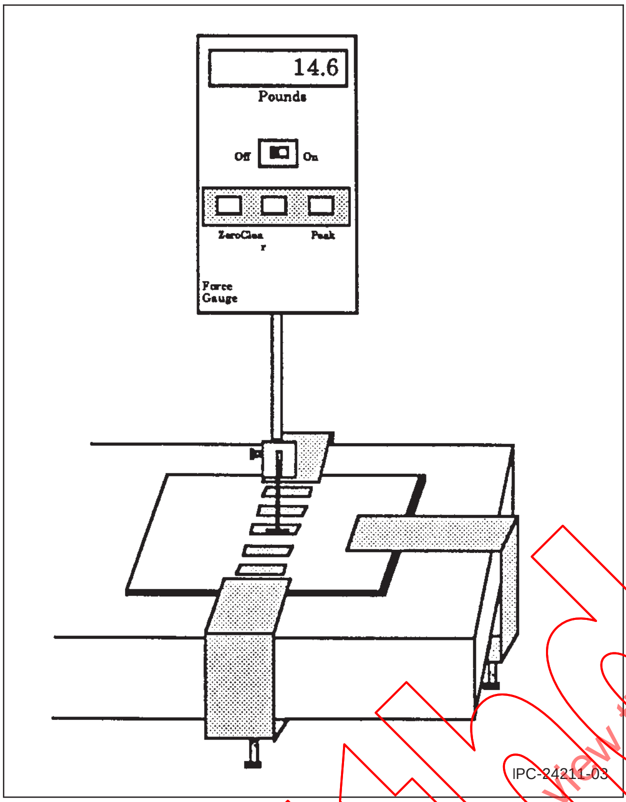

Figure 3 Pull Tester

5.3 Evaluation

5.3.1 Record the force in units as measured by the force tester required to produce the bond failure or the measured force that exceeds the specified value. Force units are those measured by the force test equipment.

5.3.2 Examine the conductor square area with 10X to 30X magnification to determine failure mode. Each conductor land shall be classified into one of the following categories:

A) No failure of the bond of the surface mount land from the substrate was observed and the specimen withstood the specified required force per surface area as stated in the appropriate specification.

B) Separation of the surface mount land from the substrate

C) The land remained bonded to the substrate and the standard test pin broke.

D) The solder joint failed by the standard test pin pulling off the land.

E) The solder joint pulled off the land (poor wetting).

5.3.3 Breaking off of a test pin or a test pin pull out shall not be considered as a failure, but a new standard pin shall be soldered onto a new land and pull tested. If failures continue to occur at non-land/substrate areas, a larger, stronger pin may be used to determine exact values of the land/substrate interface bond strength.

5.3.4 Specimens that fail to meet the requirements should be photographed, if desired, to be included in a test report.

6 *Notes*

6.1 The Square Area Concept One of the most significant variables encountered is the difficulty in comparing bond strength test results with the large variety of land sizes.

By calculating the surface area on each land, one can group sizes to develop accurate evaluations for a wide variety of land sizes.

6.2 Variables to be considered are:

- Variable land sizes on a given board (surface areas)
- Base material or substrate
- Foil formations (dendrites)
- Finished metals (fused T-L and gold, nickel, etc.)
- Operator variables
- Soldering techniques
- Mode of failure (land removal vs. test nail break, etc.)

6.3 Suggested sources for standard headed pin:

IPC
2215 Sanders Road
Northbrook, IL 60062-6135
(847) 509-9700

6.4 The test data that was generated as part of the development of this test method may be found in ''Preliminary IPC Round Robin Study on Bond Strength (Breakaway) Test of Surface Mount Lands.'' Copies of this report are available through the IPC office. Further studies are being planned by the IPC Test Methods Subcommittee. The subcommittee also requests that any test data or any suggestions in improving this method be submitted to the IPC office.

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IPC-TM-650
TEST METHODS MANUAL

Number **2.4.22**	
Subject **Bow And Twist**	
Date **12/87**	Revision **B**
Originating Task Group **Printed Board Test Methods (7-11d)**	

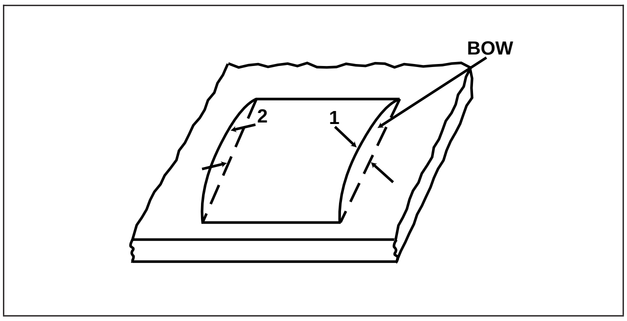

Figure 1

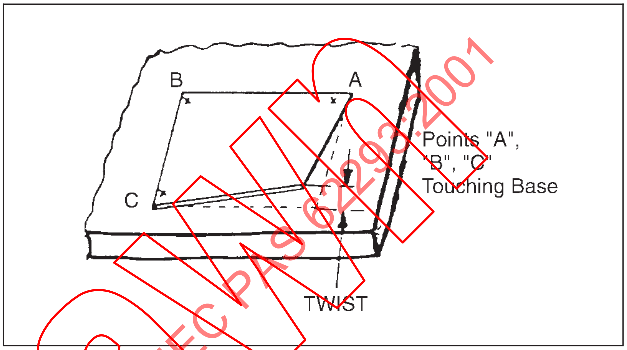

Figure 2

1.0 Scope Four procedures are presented to determine the bow and twist of either cut to size panels or finished rigid printed circuit boards including single and double sided, multilayer and the rigid segments of rigid flex printed circuits.

1.1 Definitions

1.1.1 Bow is defined in IPC-T-50 as ''The deviation from flatness of a board characterized by a roughly cylindrical or spherical curvature such that if the board is rectangular its four corners are in the same plane (see Figure 1).''

1.1.2 Twist is defined in IPC-T-50 as ''The deformation of a board parallel to a diagonal of a rectangular sheet such that one of the corners is not in the plane containing the other three corners (see Figure 2).''

2.0 Applicable Documents

IPC–T–50 Terms and Definitions

3.0 Test Specimen

3.1 Specimens

3.1.1 Cut-to-size panels

3.1.2 Finished boards (single side, double sided, multilayer, rigid/flex finished board or coupons)

4.0 Apparatus

4.1 Precision surface plate

4.2 Standard metrology height dial indicator gauge

4.3 Thickness measurement feeler gauges

4.4 Standard pin gauges

4.5 Leveling jacks

4.6 Gauge blocks

4.7 Shims of suitable thickness

4.8 Linear measuring devices of suitable accuracy

4.9 One inch micrometer

5.0 Procedures

5.1 Procedure No. 1 (Bow) (As illustrated in Figure 1)

5.1.1 Place the sample to be measured on the datum surface with the convex of the sample facing upwards. For each edge, apply sufficient pressure on both corners of the sample to insure contact with the surface. Take a reading with the dial indicator at the maximum vertical displacement of this edge denoted as R1 in Figure 3.

Repeat this procedure until all four edges of the sample have been measured. It may be necessary to turn the sample over to accomplish this. Identify the edge with the greatest deviation from the datum. This is the edge to be measured per paragraph 5.1.2 and 5.1.3.

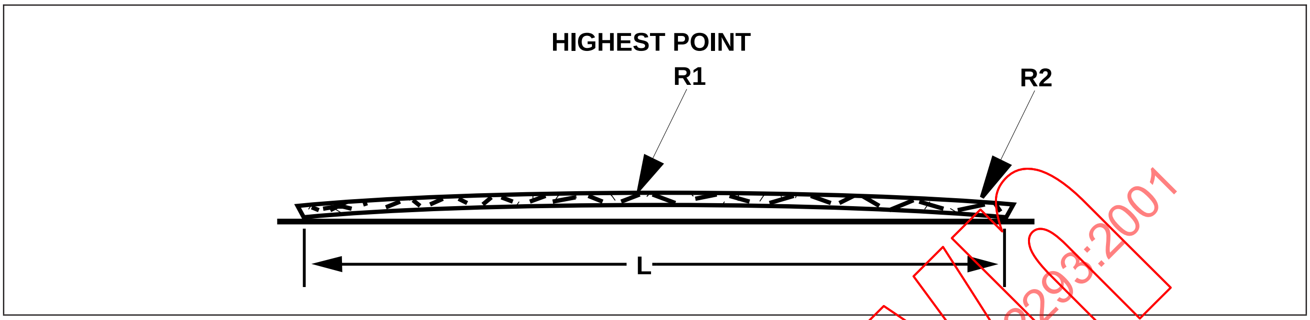

Figure 3

5.1.2 Take a reading with the dial indicator at the corner of the sample contacting the datum surface, or determine R2 by measuring the thickness of the sample with a micrometer (denoted R2 in Figure 3).

5.1.3 Apply sufficient pressure so that the entire edge contacts the datum surface. Measure the length of the edge and denote as ''L''.

5.1.4 Calculate bow for this edge as follows:

$$\text{Percent Bow} = \frac{R1 - R2}{L} \text{ X } 100$$

The result of this calculation is the % of bow.

Repeat the procedure for the other three edges and record the largest value % of bow for the sample.

5.2 Procedure No. 2 (Twist)

5.2.1 Place the sample to be measured on the datum surface with any three corners of the sample touching the surface. Apply sufficient pressure to insure that three corners are in contact with the datum surface. Take a measurement from the datum surface to the lifted corner and record the reading.

Repeat this procedure until all four corners of the sample have been measured. It may be necessary to turn the sample over to accomplish this. Identify the corner with the greatest deviation from the datum. This is the corner to be measured per paragraph 5.2.2 and 5.2.3.

5.2.2 Place the sample to be measured on the datum surface with three corners touching the surface, insert suitable shims under the raised corner so that it is just supported. When the correct shim thickness is used the three corners will be in contact with the datum surface without applying pressure to any corner.

5.2.3 Without exerting any undue pressure on the sample, take a reading with the dial indicator at the maximum vertical displacement (denoted R1 in Figure 4) and record the reading.

Without disturbing the sample, take a reading with the dial indicator on the topic surface of the sample at the edge contacting the datum surface or determine R2 by measuring the thickness of the sample with a micrometer.

Note: For fabricated boards, both readings must be made on base material.

5.2.4 Measure the diagonal of the sample (for rectangular boards) and record the reading. For nonrectangular boards measure from the corners exhibiting displacement diagonally to the point on the opposite end of the board.

5.2.5 Calculation

5.2.5.1 Deduct R2 reading from R1 reading (this value is divided by 2 in the formula defined in 5.2.5.2 because of the method of measurement) doubles the vertical defection.

5.2.5.2 Divide the measured deviation (para. 5.2.5.2) by the recorded length and multiply by 100. The result of this calculation is the % of twist.

$$\text{Percent Twist} = \frac{R1 - R2}{(2)\ (\text{Length})} \text{ X } 100$$

5.3 Procedure No. 3 Twist Referee Test

5.3.1 Place the sample to be measured on the datum surface with the two lower opposite corners touching the datum surface or on raised parallel surfaces of equal height from the datum surface (Figure 5A).

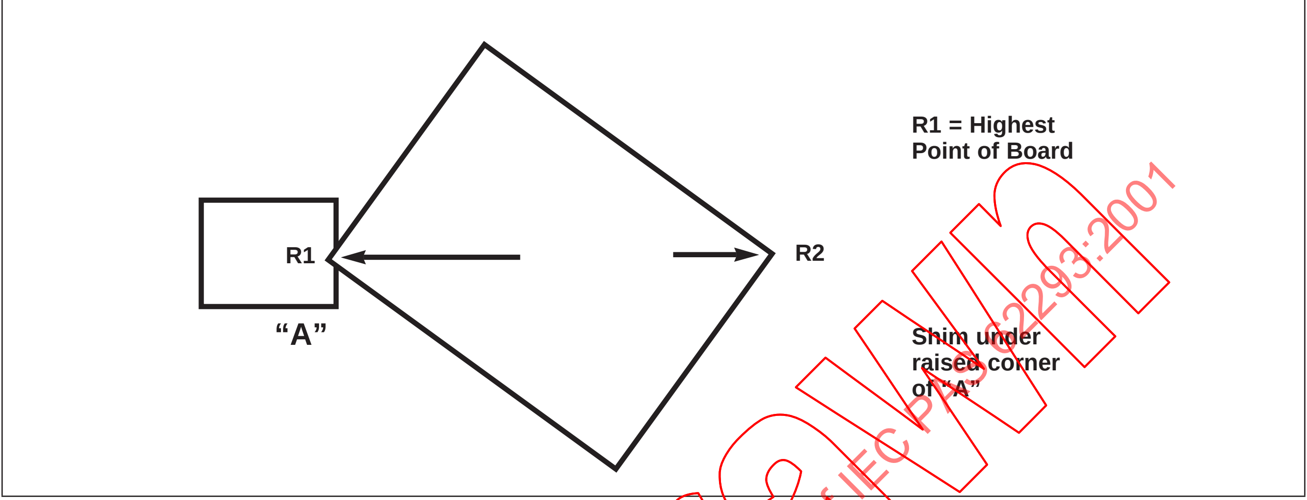

Figure 4

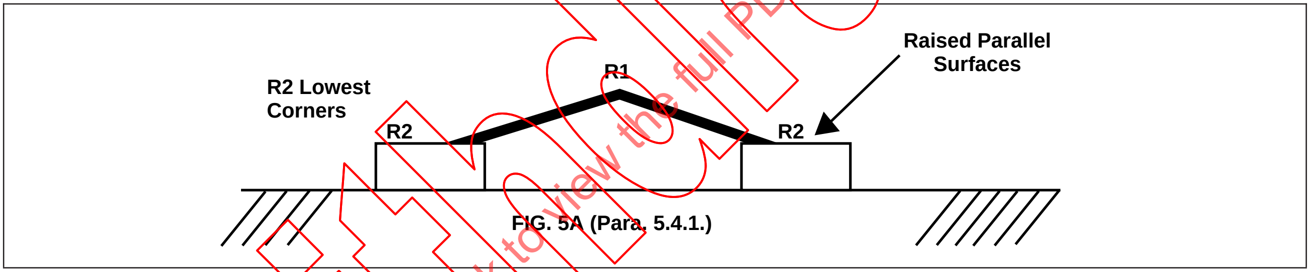

Figure 5a

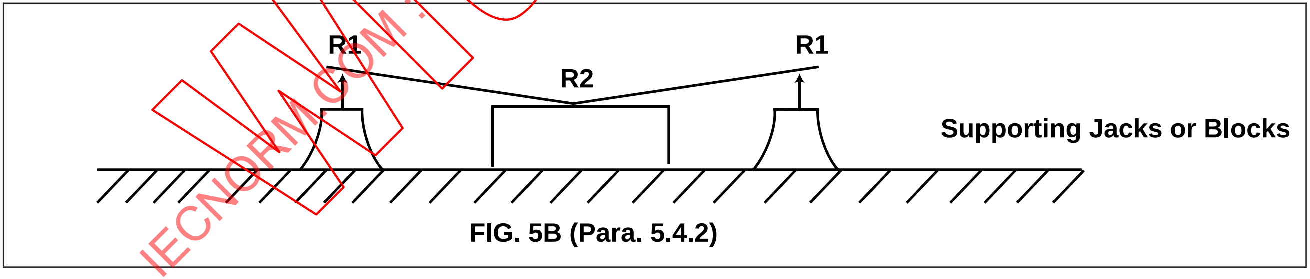

Figure 5b

5.3.2 Support the other two corners with leveling jacks or other appropriate devices ensuring that the two raised corners are of equal height from the datum surface. This may be checked by using the dial indicator (Figure 5B).

5.3.3 With the dial indicator, measure the highest raised portion on the board and record the reading as R1 (Figure 5C).

5.3.4 Without disturbing the sample, take a reading with the dial indicator on one of the corners contacting the surface (R2) and record the reading (Figure 5C).

5.3.5 Measure the diagonal of the sample (for rectangular boards) and record the reading. For nonrectangular boards measure from the corner exhibiting maximum displacement diagonally to the point on the opposite end of the board.

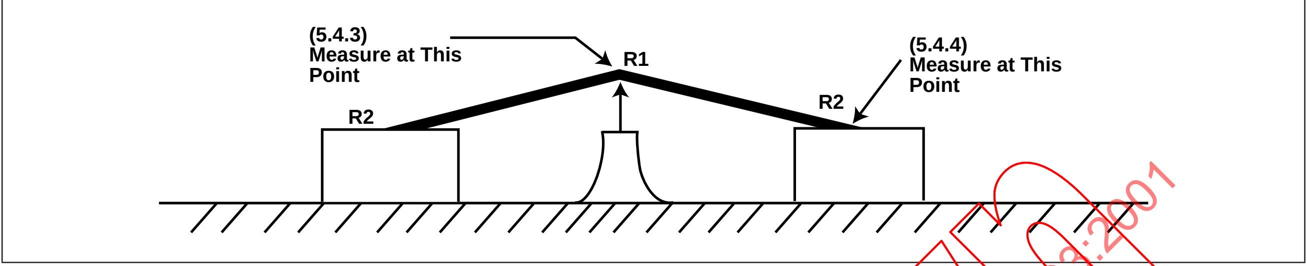

Figure 5c

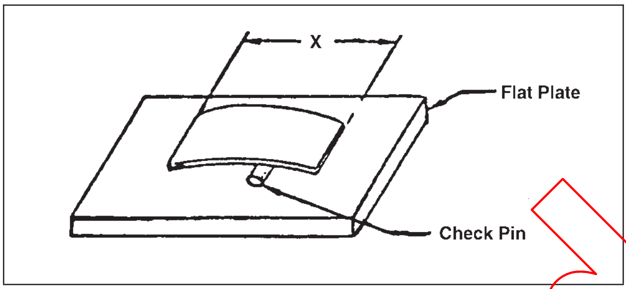

Figure 6

5.3.6 Calculation

5.3.6.1 Deduct the measurement R2 from the measurement R1. This difference is denoted as twist.

5.3.6.2 Divide the measured deviation (para. 5.3.6.1) by the recorded length and multiply by 100. The result of this calculation is the % of twist.

$$\text{Percent Twist} = \frac{R1 - R2}{L} \times 100$$

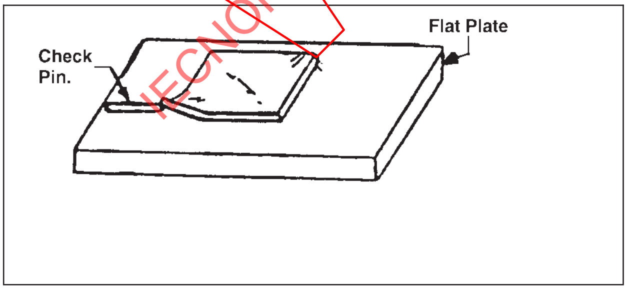

Figure 7

5.4 Procedure 4, Production Testing (Bow and Twist)

Having previously determined the maximum allowable deviation of a board from a flat plane, the following GO-NO GO procedures may be used.

5.4.1 With both corners of an edge touching the datum surface and using a suitable known dimensional standard such as a pin gauge or feeler gauge, conforming to the maximum allowable deviation (5.4), attempt to insert the gauge between the raised portion of the board and the datum surface (Figure 6).

5.4.2 Attempt to insert gauge conforming to the allowable surface dimension between the raised edge of the board and the datum (Figure 7).

5.4.3 If the gauge does not enter the gap, the board will have met the bow/twist criteria.

5.5 Notes

5.5.1 Forms of distortion other than as defined in this test method (such as multiple convolutions) cannot be evaluated accurately by these test methods and therefore should receive special attention.

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IPC-TM-650
TEST METHODS MANUAL

Number **2.5.7**	
Subject **Dielectric Withstanding Voltage, PWB**	
Date **8/97**	Revision **C**
Originating Task Group **Rigid Board T.M. Task Group, 7-11d**	

1.0 Scope The dielectric withstanding voltage test (also called high-potential, over potential, voltage breakdown, or dielectric strength test) consists of the application of a voltage higher than rated voltage for a specific time between mutually isolated portions of a PWB or between isolated portions and ground. This is used to prove that the PWB can operate safely at its rated voltage and withstand momentary over potentials due to switching, surges, and other similar phenomena. Although this test is often called a voltage breakdown or dielectric strength test, it is not intended that this test cause insulation breakdown or that it be used for detecting corona, rather it serves to determine whether insulating materials and/or conductor spacings are adequate.

2.0 Applicable Documents None

3.0 Test Specimen The test specimen shall be comprised of a minimum of two conductor lines per conductive layer, sufficient to allow a voltage to be applied between adjacent conductor patterns both between conductive layers and on the same conductive layer (see note 6.1).

4.0 Apparatus or Material

4.1 A high voltage source capable of supplying the specified voltage with a tolerance of ± 5% (see note 6.2).

4.2 A voltage measuring device with an accuracy of 5%. If leakage current measuring capability is required, the device shall be capable of detecting the leakage current to within 5% of the requirement.

4.3 Soft bristle brush

4.4 Deionized or distilled water (2 megohm-cm minimum resistivity recommended)

4.5 Isopropyl alcohol

4.6 Drying oven

5.0 Procedure

5.1 Specimen Preparation (see note 6.3)

5.1.1 Positive, permanent, and non-contaminating identification of test specimen is of paramount importance.

5.1.2 Visually inspect the test specimens for any obvious defects, as described in the applicable performance specification. If there is any doubt about the overall quality of any test specimen, the test specimen should be replaced and this replacement noted.

5.1.3 Solder single stranded (to simulate discrete component axial leads) polytetrafluroethylene (PTFE) insulated wires in each of the connection points of the test specimens. These wires will be used to connect the test patterns of the test specimens to the high voltage source.

5.1.4 Wet test lead terminals with deionized or distilled water and scrub with a soft bristle brush for a minimum of 30 seconds. During the remainder of the test specimen preparation, handle test specimens by the edges only (see note 6.4).

5.1.5 Spray rinse thoroughly with deionized or distilled water. Hold test specimen at an approximate 30° angle and spray from top to bottom.

5.1.6 Wet test lead terminals with clean isopropyl alcohol and agitate for a minimum of 30 seconds. Scrub with a soft bristle brush to remove flux residue.

5.1.7 Rinse cleaned area thoroughly with fresh isopropyl alcohol.

5.1.8 Dry test specimens in a drying oven for a minimum of three hours at an oven temperature of between 49 to 60°C (120 to 140°F).

5.1.9 Allow the test specimens to cool to room temperature. (see note 6.5)

5.2 Test (see note 6.6)

5.2.1 Raise the test voltage from zero to one of the following specified test condition values (see note 6.2) as uniformly as possible, at a rate of approximately 100 volts DC per second. If the test condition is not specified Condition A shall be the default.

Condition A: 500+15/-0 volts DC
Condition B: 1000+25/-0 volts DC

5.2.2 Maintain the test voltage at the specified value for a period of 30+3/-0 seconds.

5.2.3 Upon completion of the test, the test voltage shall be gradually reduced to avoid surges.

5.3 Evaluation Examine the test specimens and note any evidence of inadequate insulating materials and/or conductor spacing (i.e., visually inspect for flashover, sparkover or breakdown between conductor patterns or between conductor patterns and mounting hardware).

6.0 *Notes*

6.1 Recommended test specimens include ''Y'' test patterns (also referred to as ''E'' test coupons) or ''comb patterns.'' Production printed boards may also be used as test specimens.

6.2 Performance specifications should specify the high voltage test condition and any deviations to this test method. If no test condition is specified, use test condition A.

6.3 This test method may be performed on test specimens which have previously been prepared and tested for moisture and insulation resistance.

6.4 Alternative cleaning procedures may be implemented if there is a concern that scrubbing will adversely affect test results, i.e., when the test specimens have very fine spacing and/or are plated with soft metals (tin/lead, gold, etc.).

6.5 Insulating compound (conformal coating) may be applied to the test specimens following soldering and cleaning. Any coating application and cure shall be as specified by the coating supplier.

6.6 The testing process outlined in section 5.2 should be used for qualification testing. For in-plant quality conformance testing, the following testing modifications may be chosen:

6.6.1 At the option of the customer, reduced time with a possible correlated higher test voltage may be used.

6.6.2 At the option of the customer, an AC test voltage may applied.

6.6.3 At the option of the customer, the test voltage may be applied instantaneously.

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IPC-TM-650
TEST METHODS MANUAL

Number **2.6.3**	
Subject **Moisture and Insulation Resistance, Printed Boards**	
Date **8/97**	Revision **E**
Originating Task Group **Rigid Board T.M. Task Group, 7-11d**	

1.0 Scope This test method is to determine the degradation of insulating materials by examination of the visual and electrical insulation resistance properties of printed board specimens after exposure to high humidity and heat conditions. This method allows testing with (Method A) or without (Method B) Conformal Coating. When not specified, Method A is the default method.

2.0 Applicable Documents

MIL-I-46058 Insulating Compound, Electrical (For Coated Printed Circuit Assemblies)

IPC-CC-830 Qualification and Performance, Insulating Compounds for Printed Circuits Assemblies

3.0 Test Specimens

3.1 Test specimens shall be comprised of a minimum of two conductor lines per conductive layer, sufficient to allow resistance testing between adjacent conductor patterns both between layers and on the same layer. See Note 6.1 for examples of test specimen patterns recommended for this test method.

4.0 Apparatus or Material

4.1 A clean test chamber capable of programming and recording an environment of temperature ranging between 25 ± 2°C (77 ± 4°F) and 65 ± 2°C (149 ± 4°F), and 85 to 93% relative humidity.

4.2 A power supply capable of producing a standing bias potential of 100 volts DC with a tolerance of ± 10%.

4.3 A resistance meter capable of reading high resistance at the voltage described in the procurement documentation.

4.4 Solder or Flux-Cored Solder Flux shall be removable in a manner which will not adversely affect the test specimen.

4.5 Soft Bristle Brush.

4.6 Deionized or distilled water (2 megohm-cm, minimum resistivity recommended).

4.7 Isopropyl alcohol.

4.8 Drying oven(s) capable of maintaining 50 ± 5°C (122 ± 9°F) and 125 ± 5°C (248 ± 9°F).

4.9 Insulating compound (conformal coating) which conforms to MIL-I-46058 or IPC-CC-830.

4.10 Equipment necessary to apply and cure conformal coating.

5.0 Procedure

5.1 Specimen Preparation

5.1.1 Mark specimen with positive, permanent, and non-contaminating identification.

5.1.2 Visually inspect the test specimens for any obvious defects, as described in the applicable performance specification. If any test specimen is non-compliant, the test specimen should be replaced and the replacement noted.

5.1.3 Solder single stranded (to decrease the opportunity for flux contamination from the wire) insulated wire which is not affected by the test environment to each of the connection points of the test specimens. These wires will be used to connect the test patterns of the test specimens to the power supply and for insulation resistance testing.

5.1.4 Clean test lead terminals with isopropyl alcohol and scrub with a soft bristle brush for a minimum of 30 seconds. During the remainder of the test specimen preparation, handle test specimens by the edges only. (See Note 6.2.)

5.1.5 Spray rinse thoroughly with fresh isopropyl alcohol. Hold test specimen at an approximate 30° angle and spray from top to bottom.

5.1.6 Rinse cleaned area thoroughly with fresh deionized or distilled water. Hold test specimen at an approximate 30° angle and spray from top to bottom.

5.1.7 Dry test specimens in a drying oven for a minimum of three hours at an oven temperature of between 50 ± 5°C (122 ± 9°F). (See Note 6.3.)

5.1.8 Specimen preparation for **METHOD B** is now completed, continue the procedure with paragraph 5.2.

5.1.9 METHOD A - Application of Conformal Coating. Continuation of Sample Preparation Apply coating to the appropriate area of the test specimen, in a manner concurrent with user's production techniques or as specified by the coating supplier.

5.1.10 After the application of coating, the test specimens are to be cured, as specified by the coating supplier.

5.1.11 After curing, stabilize to ambient temperature.

5.2 Test

5.2.1 Take the initial insulation resistance measurements at laboratory ambient temperature. Apply the voltage specified in the procurement documentation on the test specimen's test points as specified in paragraph 5.2.2 with the resistance meter, and take the reading after measurement stabilization.

5.2.2 Test points on the test specimens shall be connected in a manner that will allow adjacent conductor patterns, both between conductor layers and on the same conductor layer, to alternate between the positive (+) and negative (–) terminals of the power supply or resistance meter.

5.2.3 Place test specimens in chamber in a vertical position and under a condensation drip shield. Connect the DC voltage source to the test specimen test points as indicated in paragraph 5.2.2. Apply a 100 ± 10 volts DC polarization voltage to all test specimens.

5.2.4 Expose test specimens to one of the following specified test conditions: (See Note 6.4.)

(a) Class 1 35 ± 5°C (95 ± 9°F), 85 to 93% relative humidity, for 4 days (static).

(b) Class 2 50 ± 5°C (122 ± 9°F), 85 to 93% relative humidity, for 7 days (static).

(c) Class 3 20 cycles of temperature ranging from 25+5/-2°C (77+9/-4°F) to 65 ± 2°C, 85 to 93% relative humidity, 160 hours total.

5.2.4.1 Temperature cycling The following constitutes one complete cycle (for the class 3 test condition).

(a) Start test at 25+5/-2°C (77+9/-4°F), and raise temperature at 65 ± 2°C (149 ± 4°F), over a time span of 150 ± 5 minutes.

(b) Maintain temperature at 65 ± 2°C (149 ± 4°F) over a time span of 180 ± 5 minutes.

(c) Lower temperature from 65 ± 2°C (149 ± 4°F) to 25+5/-2°C (77+9/-4°F) over a time span of 150 ± 5 minutes.

There shall be no delay between cycles. Polarizing voltage shall be maintained throughout the 20 cycle period. The humidity may drop a minimum of 80% relative humidity when going from high to low temperature. See Figure 1 for a graphical illustration of temperature cycling.

5.3 Measurement

5.3.1 Disconnect 100 volts DC polarized voltage source before taking any insulation resistance measurement. Insulation resistance shall be read as specified in paragraph 5.2.1. Voltage polarity for measurement should be identical to that of the polarizing voltage.

5.3.2 Final resistance measurements shall be made after removal of specimen from the chamber, and after 1 hour and before 2 hours stabilization at laboratory ambient temperatures.

Any reasons for deleting values, i.e., scratches, condensation, bridged conductors, etc., must be noted.

5.4 Evaluation

5.4.1 Each test specimen shall be evaluated for insulation resistance quality for its class, following and/or during the initial, wet and/or dry conditions, as applicable.

5.4.2 After completion of all electrical testing, the test specimens shall be examined for evidence of mealing, blistering, delamination, or other forms of degradation, following 24 hour stabilization at laboratory ambient temperatures.

6.0 *Notes*

6.1 Test Pattern Examples

6.1.1 Y'' Patterns There are a variety of ''Y'' test patterns (also referred to as ''E'' test coupons) in various specifications

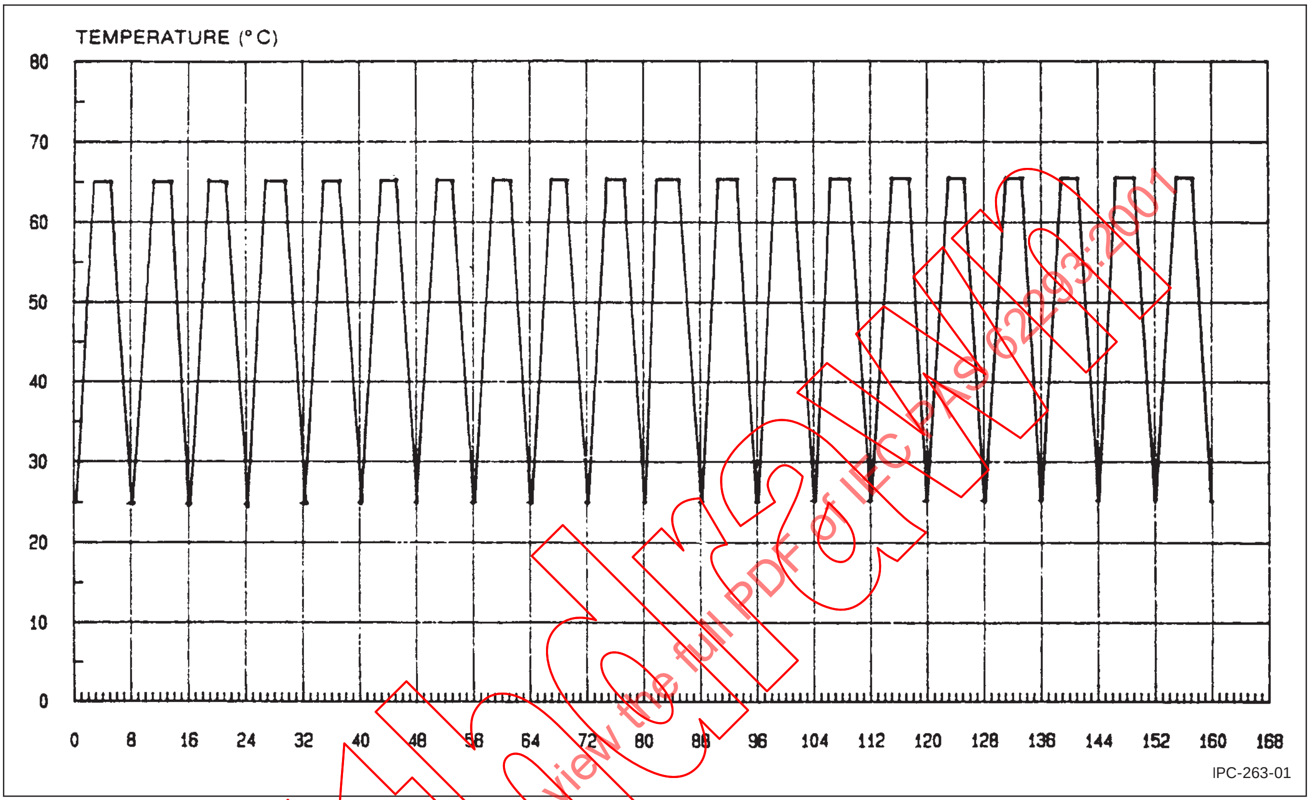

Figure 1 **Moisture and Insulation Resistance Test Graph**

within the industry. See Figure 2 for an illustration of ''Y'' pattern test coupons.

6.1.2 Comb Patterns Various ''comb patterns'' can be properly tested following the procedures in this document. The test points for comb patterns such as in Figure 3 are 1 to 2, 2 to 3, 3 to 4, and 4 to 5. Test points 1-3-5 are connected to the positive (+) terminal, and test points 2-4 are connected to the negative (–) terminals of the resistance meter.

6.1.3 Production Board Testing Occasionally, production boards must be tested in lieu of test patterns. When this is required, one must use good judgment and select adjacent conductors for wiring terminal lands for testing, because conductor spacing and placement can affect test results.

6.2 Documented alternative cleaning procedures may be implemented. As an example, if there is a concern that scrubbing will adversely affect test results, i.e., when the test specimens have very fine spacing and/or are plated with soft metals (tin/lead, gold, etc.).

6.3 If printed boards are to be stored before coating, place the boards in a dry non-contaminating environment.

6.4 Performance specifications should specify the method of test specimen preparation, test condition class, and any deviations to this test method.

6.5 The test chamber should be constructed out of materials that will not corrode or add ionic contamination to the test environment.

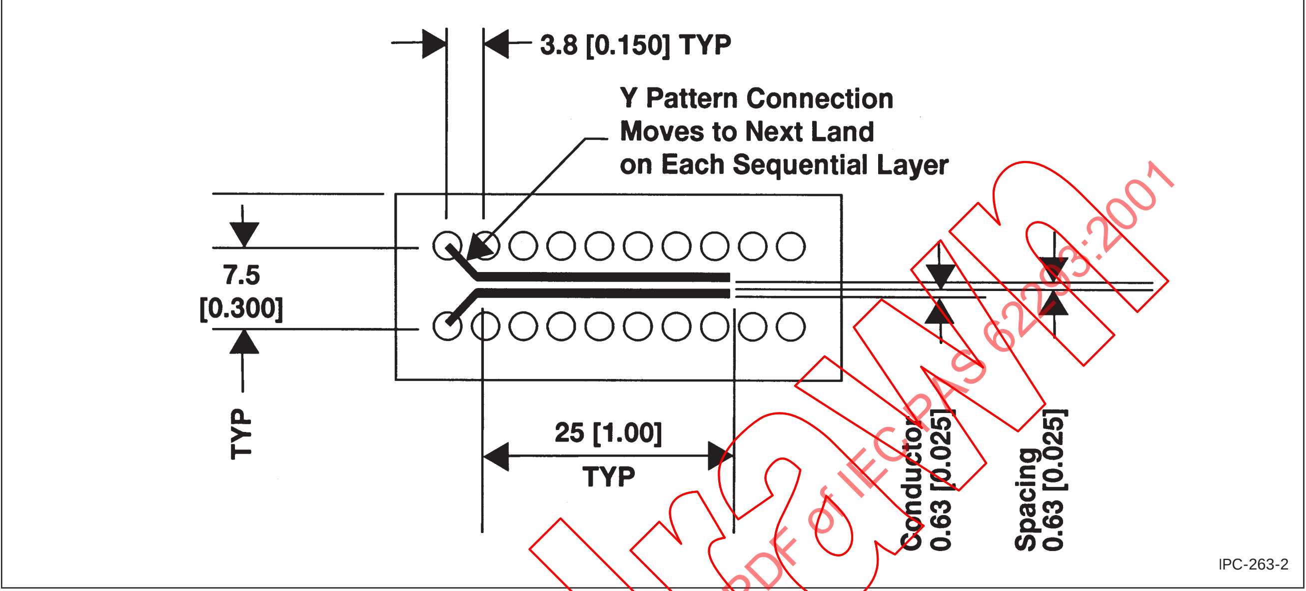

Figure 2 Insulation Resistance Coupon E (See Table 7-3)

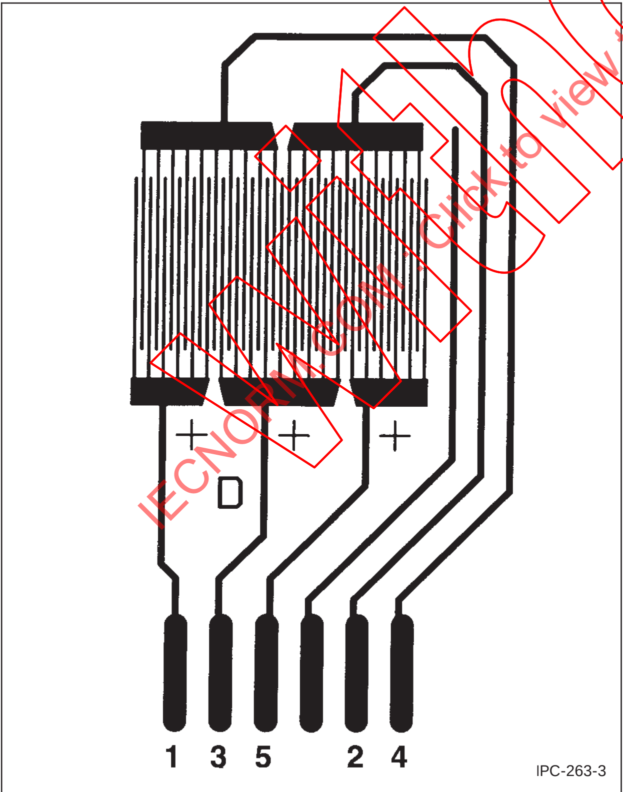

Figure 3 Typical "Comb Pattern" (from IPC-B-25A)

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IPC-TM-650
TEST METHODS MANUAL

Number **2.6.7.2**	
Subject **Thermal Shock, Continuity and Microsection, Printed Board**	
Date **8/97**	Revision **A**
Originating Task Group **Rigid Board T.M. Task Group, 7-11d**	

1.0 Scope This method is to determine the physical endurance of printed boards to sudden changes of temperature. It is designed to expose specimens to a series of high and low temperature excursions to cause physical fatigue.

2.0 Applicable Documents

IPC-D-275 Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies.

3.0 Test Specimen Coupon D from IPC-D-275 or other suitable test coupon (see 6.1a).

4.0 Apparatus

4.1 An automatically controlled dual temperature environmental test chamber or other dual chamber apparatus capable of maintaining –65, –55, –40 or 0°C + 0 –5°C [–85, –67, –40, +32°F + 0 –9°F] in the low temperature chamber and 70, 85, 105, 125, 150 or 170 +5 –0°C [158, 185, 221, 257, 302 or 338 +9 –0°F] in the high temperature chamber.

NOTE: The temperature extremes (high and low) that are required is dependent on the base material of the specimen that is to be tested (see 6.1b and the temperatures listed in Table 2). The recovery capacity of the test chambers shall be such that the internal chamber temperature shall reach the specified temperature within 2 minutes after the specimen(s) have been transferred to the test chamber. Test conditions, if not otherwise stated in the applicable performance specification (see 6.1b), shall meet the requirements of Table 2.

4.2 An electrical resistance meter capable of accuracies of 0.5 milliohm or better with Kelvin (4 terminal) type leads. A Kelvin type double bridge or potentiometer of the specified accuracy may also be used (See 6.2).

5.0 Procedure

5.1 Preparation Wire up test specimen with Kelvin-type leads at the points where measurements will be made.

5.1.1 Operate chamber (or chambers) and allow to stabilize at the high and low temperature required. Clamp or suspend test specimen in the approximate center of the high temperature chamber. Test specimens shall be placed approximately 13 mm [0.5 inches] apart and aligned in a manner to permit maximum heat transfer to test specimen(s).

5.2 Test

5.2.1 Thermal Shock Cycle

5.2.1.1 The test specimens shall be subjected to 100 temperature cycles in accordance with Table 1.

5.2.1.2 Transfer time between chambers shall be less than 2 minutes. The thermal capacity of the test chamber used shall be such that the ambient temperature shall reach the specified temperature within 2 minutes after the test specimen has been transferred to the appropriate chamber.

5.2.1.3 Interconnection resistance measurements shall be taken before the test, during the first cycle at high temperature, and during the last cycle at high temperature.

5.3 Evaluation The maximum change in resistance between the first and 100th cycle shall be evaluated for acceptability to the requirements of the applicable performance specification (see 6.1c). After testing, a minimum of 3 plated-through holes shall be microsectioned and shall be evaluated for acceptability to the requirements of the applicable performance specifications.

6.0 Notes

6.1 The following details are to be specified in the applicable performance specification:

a. Test specimen, if other than specified in 3.0.

b. Test condition, if other than specified in 4.1.

c. Maximum allowable change in resistance.

6.1.1 Unless otherwise specified by the applicable performance specification, the following base material types/temperature ratings are recommended.