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Qualification and Performance Specification for High Frequency (Microwave) Printed Boards

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July 2016

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IPC-6018D

Qualification and Performance Specification for High Frequency (Microwave) Printed Boards

Developed by the High Speed/High Frequency Board Performance Subcommittee (D-22) of the High Speed/High Frequency Committee (D-20) of IPC

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

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Qualification and Performance Specification for High Frequency (Microwave) Printed Boards

1 SCOPE

1.1 Scope This specification covers end product inspection and test of high frequency (microwave) printed boards for microstrip, stripline, mixed dielectric and multilayer stripline applications with or without buried/blind vias, and metal cores.

The printed board may contain embedded active or passive circuitry with distributive capacitive planes, capacitive or resistive components conforming to IPC-6017. The printed board may contain build up High Density Interconnect (HDI) layers.

1.2 Purpose The purpose of this specification is to provide requirements for qualification and performance of high frequency (microwave) printed boards.

1.3 Performance Classification and Types

1.3.1 Classifications This specification establishes acceptance criteria for the performance classification of high frequency printed boards based on customer and/or end-use requirements. Printed boards are classified by one of three general Performance Classes as defined in IPC-6011.

1.3.1.1 Requirement Deviations Requirements deviating from these heritage classifications **shall** be as agreed between user and supplier (AABUS).

1.3.1.2 Space and Military Avionics Requirement Deviations

Space and military avionics performance classification deviations are provided in the IPC-6018DS Addendum and are applicable when the addendum is specified within the procurement documentation.

1.3.2 Printed Board Type This specification will define eight types of high frequency (microwave) printed boards.

Type 1 – Single Sided

Type 2 – Double Sided

Type 3 – Homogeneous Dielectric Multilayer Construction

Type 4 – Mixed Dielectric Multilayer

Type 5 – Homogeneous Dielectric Multilayer with blind and/or buried vias

Type 6 – Mixed Dielectric Multilayer with blind and/or buried vias

Type 7 – Metal and/or composite backed printed boards, single sided or double sided

Type 8 – Multilayer metal and/or composite backed or core printed boards with or without blind and/or buried vias

1.3.3 Selection for Procurement For procurement purposes, Performance Class **shall** be specified in the procurement documentation.

The documentation **shall** provide sufficient information to the supplier so that he can fabricate the printed board and ensure that the user receives the desired product. Information that should be included in the procurement documentation is to be in accordance with IPC-2611 and IPC-2614.

The procurement documentation should specify the thermal stress test method to be used to meet the requirement of 3.6.1. Selection **shall** be from those depicted in 3.6.1.1, 3.6.1.1.1, 3.6.1.2 and 3.6.1.3. If not specified (see 6.1), the default **shall** be per Table 1-1.

During the selection process, the user should take into consideration the following when determining the appropriate thermal stress test method:

- Wave solder, selective solder, hand solder assembly processes (see 3.6.1.1 and 3.6.1.1.1)
- Conventional SnPb reflow processes (see 3.6.1.2)
- Lead-free reflow processes (see 3.6.1.3)

IPC-6016, a sectional performance specification for HDI printed boards, was canceled by the IPC. Relevant HDI conformance and acceptance criteria has been transferred to this revision of this specification.

The addition of IPC-2221 Appendix A conformance coupons (beginning with Revision B of the design standard) by the printed board manufacturer to the manufacturing panel **shall** be AABUS.

1.3.3.1 Selection (Default) The procurement documentation **shall** specify those requirements that are a result of the selection process within this specification. This includes all references to “AABUS”. If the requirement selection is not made in accordance with the procurement documentation, Ordering Data (see 6.1), Customer Drawing and/or supplier control plan (SCP), then the default requirement in Table 1-1 **shall** apply.

Table 1-1 Default Requirements

Category	Default Selection
Performance Class	Class 2
Final Finish	Finish X (Electrodeposited tin lead, fused or solder coated) or alternate Finish ENIG allowed on designs (drawings) with Initial Release on or after January 01, 2021.
Minimum Starting foil	1/2 oz. For all internal and external layers except for Type 1 which shall start with 1 ounce. For plated HDI layers – ¼ oz. for all layers (internal or external)
Copper foil type	Electrodeposited
Hole Diameter tolerances Plated, components Plated, via only Non-plated	(±) 100µm [3,937 µin] (+) 80 µm [3150 µin], (-) no requirement, may be totally or partially plugged (±) 80 µm [3,150 µin]
Conductor Width Deviation	Class 2 deviation per 3.5.1.1
Conductor Spacing Deviation	Class 2 deviation per 3.5.1.2
Dielectric Separation	90 µm [3,543 µin] minimum per 3.2.1.1
Lateral Conductor Separation	100 µm [3,937 µin] minimum
Marking Ink	Contrasting color, nonconductive
Solder Mask	Not applied if not specified
Solderability Test	Category 2 for SnPb and Category A for Pb-free of J-STD-003, tin-lead solder per 3.3.6
Thermal Stress Test	IPC-TM-650, Method 2.6.8, Condition A per 3.6.1.1
Solder Mask Specified	Class T of IPC-SM-840 if class not specified
Test Voltage, Isolation Resistance	Per IPC-9252

1.3.3.2 Selection System Optional The following product selection identifier system is provided for clarification of the build type.

Quality Specification, the generic quality specification

Specification, the base performance specification

Type, the product type per 1.3.2

Plating process, the plating process per 1.3.4.2

Final Finish, the final finish code per 1.3.4.3

Selective Finish, the selective finish code adder per 1.3.4.3, enter “-” when no selective finish is required.

Product classification, the product classification per 1.3.1 or performance specification sheet

Technology Adder, the technology adder is specified in Table 1-2. Add multiple codes as required

Table 1-2 Technology Adder Examples

Technology Code	Technology
HDI	HDI build-up features
VP	Via Protection
WBP	Wire Bondable Pads
AMC	Active Metal Core
NAMC	Nonactive Metal Cores
HF	External Heat frame
EP	Embedded Passives per IPC-6017
VIP-C	Via-in-Pad Conductive Fill
VIP-N	Via-in-Pad Nonconductive Fill

1.3.4 Material, Plating Process and Final Finish

1.3.4.1 Laminate Material

Laminate material is identified by numbers and/or letters, classes, types as specified by the appropriate specification listed in the procurement documentation.

1.3.4.2 Plating Process The copper plating process which is used to provide the main conductor in the holes is identified by one number as follows:

- 1) Acid copper electroplating only
- 2) Pyrophosphate copper electroplating only
- 3) Acid and/or pyrophosphate copper electroplating
- 4) Additive/electroless copper
- 5) Electroless Nickel underplate with acid and/or pyrophosphate copper electroplating

1.3.4.3 Final Finish and Coatings The final finish/coating can be one of the finishes/coatings specified below or a combination of several platings and is dependent on assembly processes and end-use. If required, the thickness **shall** be specified in the procurement documentation. If not specified, the thickness **shall** be as listed in Table 3-3. Coating thickness may be exempted in Table 3-3 (i.e., tin-lead plate or solder coating). Designators for final finish are as follows:

S	Solder Coating	(Table 3-3)
T	Electrodeposited Tin-Lead, (fused)	(Table 3-3)
X	Either Type S or T	(Table 3-3)
TLU	Electrodeposited Tin-Lead (unfused)	(Table 3-3)
b1	Lead-free Solder Coating	(Table 3-3)
G	Gold Electroplate for Edge Printed Board Connectors	(Table 3-3)
GS	Gold Electroplate for Areas to be Soldered	(Table 3-3)
GWB-1	Gold Electroplate for areas to be wire bonded (ultrasonic)	(Table 3-3)
GWB-2	Gold Electroplate for areas to be wire bonded (thermosonic)	(Table 3-3)
N	Nickel for Edge Printed Board Connectors	(Table 3-3)
NB	Nickel as a Barrier to Copper-Tin Diffusion	(Table 3-3)
OSP	Organic Solderability Preservative	(Table 3-3)
HT OSP	High Temperature OSP	(Table 3-3)
ENIG	Electroless Nickel Immersion Gold	(Table 3-3)
ENEPIG	Electroless Nickel/Electroless Palladium/Immersion Gold	(Table 3-3)
DIG	Direct Immersion Gold	(Table 3-3)
NBEG	Nickel Barrier/Electroless Gold	(Table 3-3)
IAG	Immersion Silver	(Table 3-3)
ISn	Immersion Tin	(Table 3-3)
C	Bare Copper	(Table 3-3)
SMOBC	Solder Mask over Bare Copper	(3.2.8)
SM	Solder Mask over Non-Melting Metal	(3.2.8)
SM-LPI	Liquid Photoimageable Solder Mask over Non-Melting Metal	(3.2.8)
SM-DF	Dry Film Solder Mask over Non-Melting Metal	(3.2.8)
SM-TM	Thermal Mask Solder Mask over Non-Melting Metal	(3.2.8)
Y	Other	(3.2.7.11)

1.4 Terms and Definitions Terms and definitions **shall** be in accordance with IPC-T-50, and as defined in 1.4.1 through 1.4.6.

1.4.1 White Spots Subsurface white or translucent spots occurring in woven glass PTFE at the glass knuckles after processing. This differs from measles and crazing in that the resin is not fractured.

1.4.2 Hybrid (Composite) Printed Board Mixed dielectric multilayer printed board.

1.4.3 As Agreed Between User and Supplier (AABUS) Indicates additional or alternate requirements to be decided between the user and the supplier in the procurement documentation. Examples include contractual requirements, modifications to purchase documentation and information on the drawing. Agreements can be used to define test methods, conditions, frequencies, categories or acceptance criteria within a test, if not already established.

1.4.4 High Density Interconnects (HDI) Designs with an average of 20 electrical connections/cm² (130 electrical connections/in²) on both sides of the printed board. These designs typically have vias (≤ 0.15 mm [0.006 in.]), conductor width and spacing ≤ 100 μ m [0.004 in.], via in SMT pads, and/or thin dielectric thickness where microvias (see 3.2.6) are employed.

1.4.5 Back-Drilling A method of reducing the overall length of any plated hole by drilling out a portion of the plated hole from either side to a predetermined depth, for purposes of signal integrity or circuit isolation (See Figure 1-1).

Figure 1-2 provides an example of a “shallow back-drill” where the external layer is pierced and approximately 0.05 – 0.127 mm [0.002 – 0.005 in.] of the barrel is drilled out in order to prevent shorting of the plated via to any component/chassis placed directly above or below the back-drill side.

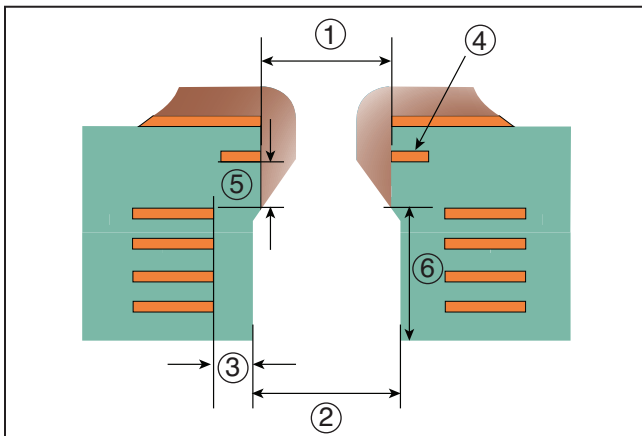


Figure 1-1 Example of a Back-drilled Hole (Not To Scale)

Note 1. Primary drilled hole diameter.

Note 2. Back-drill hole diameter.

Note 3. Distance between nearest conductive feature and back-drill hole.

Note 4. Target Layer (e.g., Must Not Cut Layer).

Note 5. Stub length (excluding target layer copper thickness).

Note 6. Back-drill depth.

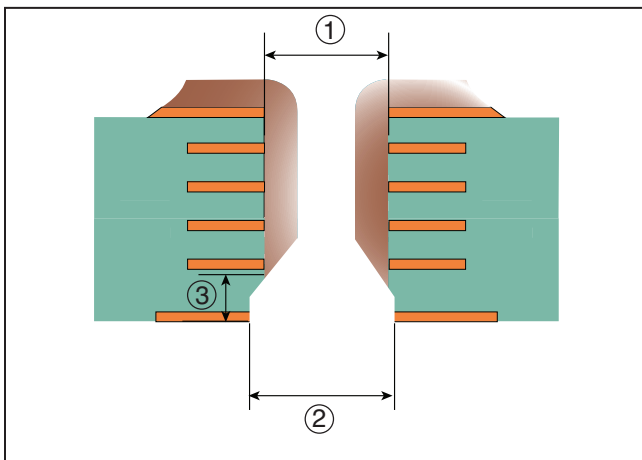


Figure 1-2 Example of a Shallow Back-drill

Note 1. Primary drilled hole diameter.

Note 2. Back-drill hole diameter.

Note 3. Back-drill depth.

1.4.6 Design Data Data which is communicated to a printed circuit board fabricator and may include mechanical information, electrical design information and requirements concerning end item performance, item end-use environment, item configuration, materials, components, and processes.

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

The words “should” and “may” are used whenever it is necessary to express nonmandatory provisions.

“Will” is used to express a declaration of purpose. To assist the reader, the word “**shall**” is present in bold characters.

The examples shown in the photographs and/or illustrations in this specification are sometimes exaggerated to make the referenced imperfection more apparent. The relationship between the text and the examples is not always parallel; it would be difficult to find many cases so specific that they would always match the acceptance criteria. When photographs or illustrations contained in this standard are not consistent with discussion in the written text, the written text takes precedence and should be followed.

1.6 Presentation All dimensions and tolerances in this specification are expressed in hard SI (metric) units and parenthetical soft imperial (inch) units. Users of this specification are expected to use metric dimensions. All dimensions greater than or equal to 1.0 mm [0.0394 in] will be expressed in millimeters and inches. All dimensions less than 1.0 mm [0.0394 in] will be expressed in micrometers and microinches.

1.7 Design Data Protection Design data is property owned by an organization or business entity. When design data is known to or in the custody of the printed board fabricator or their agents, it **shall** be protected as-specified by the procurement documentation.

If not specified in procurement documentation, the printed board fabricator **shall** nonetheless have internal policies and procedures for protection of the design data.

An optional protocol is defined in 3.10.16.

1.8 Revision Level Changes Changes made to this revision of the IPC-6018 are indicated throughout by gray shading of the relevant subsection(s). Changes to a figure or table are indicated by gray-shading of the Figure or Table header.

1.9 Master Drawing Printed boards **shall** meet the requirements of the approved master drawing. RF Microwave portions of the printed board should comply with IPC-2252, and non-RF portions of the printed board **shall** comply with IPC-2221. In the event of conflict between the design guides and the approved master drawing, the master drawing **shall** govern and a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Tolerances and dimensions not specified on the master drawing **shall** revert to those in this document.

2 APPLICABLE DOCUMENTS

The following documents, of the issue in effect on the date of contract agreement, form a part of this specification to the extent provided herein.

2.1 IPC¹

IPC-WP-023 IPC Technology Solutions White Paper on Performance-Based Printed Board OEM Acceptance: Via Chain Continuity Reflow Test: The Hidden Reliability Threat

IPC-A-47 Composite Test Pattern 10 Layer Phototool

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

IPC-CF-152 Composite Metallic Material Specification for Printed Wiring Boards

IPC-A-600 Acceptability of Printed Boards

IPC-TM-650 Test Methods Manual²

2.1.1 Microsectioning, Manual and Semi or Automatic Method

2.1.9 Surface Scratch Examination Metal Clad Foil

2.3.15 Purity, Copper Foil or Plating

2.3.25 Detection and Measurement of Ionizable Surface Contaminants

2.4.1 Adhesion, Plating

2.4.15 Surface Finish, Metal Foil

2.4.18.1 Tensile Strength and Elongation, In-House Plating

2.4.21 Land Bond Strength, Unsupported Component Hole

2.4.22 Bow and Twist

2.4.28.1 Adhesion, Solder Resist (Mask), Tape Test Method

2.4.36 Rework Simulation, Plated-Through Holes for Leaded Components

2.4.41.2 Coefficient of Thermal Expansion, Strain Gage Method

2.5.7 Dielectric Withstand Voltage, PWB

2.5.5.7 Characteristic Impedance and Time Delay of Lines on Printed Boards by TDR

2.6.1 Fungus Resistance, Printed Wiring Materials

2.6.3 Moisture and Insulation Resistance, Rigid Boards

2.6.3.7 Surface Insulation Resistance

2.6.4 Outgassing, Printed Boards

2.6.5 Physical Shock, Multilayer Printed Wiring

2.6.7.2 Thermal Shock, Continuity and Microsection, Printed Boards

2.6.8 Thermal Stress, Plated-Through Holes

2.6.9 Vibration, Rigid Printed Wiring

2.6.25 Conductive Anodic Filament (CAF) Resistance Test (Electrochemical Migration Test)

2.6.27 Thermal Stress, Convection Reflow Assembly Simulation

IPC-QL-653 Certification of Facilities that Inspect/Test Printed Boards, Components and Materials

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

IPC-SM-840 Qualification and Performance Specification of Permanent Solder Mask

IPC-1602 Standard for Printed Board Handling and Storage

¹ www.ipc.org

² IPC Test Methods are available on the IPC Web site (www.ipc.org/html/testmethods.htm)

IPC-2141	Controlled Impedance Circuit Boards and High Speed Logic Design
IPC-2221	Generic Design Standard for Printed Boards
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards
IPC-2251	Design Guidelines for Electronic Packaging Utilizing High Speed Techniques
IPC-2252	Design and Manufacturing Guide for RF/Microwave Circuit Boards
IPC-2611	Generic Requirements for Electronic Product Documentation
IPC-2614	Sectional Requirements for Board Fabrication Documentation
IPC-4101	Specification for Base Materials for Rigid and Multilayer Printed Boards
IPC-4103	Specification for Base Materials High Speed/High Frequency Applications
IPC-4203	Adhesive Coated Dielectric Films for Use as Cover Sheets for Flexible Printed Circuitry and Flexible Adhesive Bonding Films
IPC-4552	Specification for Electroless Nickel/Immersion Gold (ENIG) Plating for Printed Circuit Boards
IPC-4553	Specification for Immersion Silver Plating for Printed Boards
IPC-4554	Specification for Immersion Tin Plating for Printed Circuit Boards
IPC-4556	Specification for Electroless Nickel/Electroless Palladium/Immersion Gold (ENEPIG) Plating for Printed Circuit Boards
IPC-4562	Metal Foil for Printed Wiring Applications
IPC-4563	Resin Coated Copper Foil for Printed Boards Guideline
IPC-4761	Design Guide for Protection of Printed Board Via Structures
IPC-4781	Qualification and Performance Specification of Permanent, Semi-Permanent and Temporary Legend and/or Marking Inks
IPC-4811	Specification for Embedded Passive Device Resistor Materials for Rigid and Multilayer Printed Boards
IPC-4821	Specification for Embedded Passive Device Capacitor Materials for Rigid and Multilayer Printed Boards
IPC-6011	Generic Performance Specification for Printed Boards
IPC-6017	Qualification and Performance Specification for Printed Boards Containing Embedded Passive Devices
IPC-6018DS	Space and Military Avionics Applications Addendum to IPC-6018 Qualification and Performance Specification for Rigid Printed Boards
IPC-7711/21	Rework, Modification and Repair of Electronic Assemblies
IPC-9151	Printed Board Process, Capability, Quality and Relative Reliability (PCQR ²) Benchmark Test Standard and Database
IPC-9252	Requirements for Electrical Testing of Unpopulated Printed Boards
IPC-9691	User Guide for the IPC-TM-650, Method 2.6.25, Conductive Anodic Filament (CAF) Resistance Test (Electrochemical Migration Test)

2.2 Joint Industry Standards³

J-STD-001	Requirements for Soldered Electrical and Electronic Assemblies
J-STD-003	Solderability Tests for Printed Boards
J-STD-006	Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications
J-STD-609	Marking and Labeling of Components, PCBs and PCBAs to Identify Lead (Pb), Pb-Free and other Attributes
JP002	Current Tin Whiskers Theory and Mitigation Practices Guideline

2.3 Federal⁴

QQ-S-635	Military Standard Steel Plate, Carbon
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2.4 ASTM International⁴

ASTM-B-152	Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
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³ www.sae.org

⁴ www.astm.org

- ASTM-B-488** Standard Specification for Electrodeposited Coatings of Gold for Engineering Use
- ASTM-B-579** Standard Specification for Electrodeposited Coatings of Tin-Lead Alloy (Solder Plate)
- ASTM-D-3165** Strength Properties of Adhesion in Shear by Tension Loading of Laminated Assemblies
- ASTM-E-345** Standard Test Methods of Tension Testing of Metallic Foil

2.5 Underwriters Lab⁵

- UL 94** Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

2.6 National Electrical Manufacturers Association⁶

- NEMA LI-1** Industrial Laminated Thermosetting Product Standard

2.7 American Society for Quality⁷

- H1331** Zero Acceptance Number Sampling Plans
- Z1.4** Sampling Procedures and Tables for Inspection by Attributes

2.8 AMS³

- SAE-AMS-QQ-A-250** General Specification for Aluminum and Aluminum Alloy, Plate and Sheet
- SAE-AMS-2451** Plating, Brush General Requirements
- SAE-AMS-4505** Copper Alloy (Brass), Sheet, Strip, and Plate

2.9 American Society of Mechanical Engineers⁸

- ASME B46.1** Surface Texture (Surface Roughness, Waviness and Lay)

3 REQUIREMENTS

3.1 General Printed boards furnished under this specification **shall** meet or exceed all the requirements of IPC-6011 and the specific Performance Class as required by the procurement documentation. Design features **shall** be per IPC-2221; further design guidance can be found in IPC-2141, IPC-2251 and IPC-2252. Descriptions and purposes of test coupons are documented in IPC-2221 and its related appendices. Impedance coupon configurations and guidance can be found in IPC-2141. Printed boards which must meet other special requirements beyond those specified in Section 3 **shall** be as specified by the procurement document and / or the drawing.

3.2 Materials Used in this Specification

3.2.1 Laminates and Bonding Material for Multilayer or Mixed Dielectric Printed Boards Rigid metal clad laminates, rigid unclad laminates and bonding material (prepreg or bonding film) should be selected from IPC-4101, IPC-4103, IPC-4203, or NEMA LI-1. The specification sheet number, metal cladding type and metal clad thickness (weight) **shall** be as specified in the procurement documentation. Embedded passive materials should be as specified in the procurement documentation including dielectric, conductive, resistive and insulating characteristics as applicable. When specific requirements such as flammability requirements shown on UL 94 for laminate and bonding materials are required, it is necessary to specify those requirements in material procurement documents.

3.2.1.1 Dielectric Layer Thickness The minimum and maximum dielectric layer thickness **shall** be as defined on the master drawing. Measurements **shall** be peak to peak as shown in Figure 3-44.

3.2.2 External Bonding Materials The material used to adhere external heat sinks or stiffeners to the printed board **shall** be selected from IPC-4101, IPC-4103, IPC-4203 or as specified in the procurement documentation.

3.2.3 Other Dielectric Materials Photoimageable dielectrics should be specified in the procurement documentation. Other dielectric materials may be specified in the procurement documentation.

3.2.4 Metal Foils Copper foil **shall** be in accordance with IPC-4562. Foil type, foil grade, foil thickness, bond enhancement treatment and foil profile should be specified on the master drawing if critical to the function of the printed board. Resin coated copper foil **shall** be in accordance with IPC-4563. Resistive metal foil **shall** be in accordance with the applicable specification and the procurement documents.

⁵ www.ul.com
⁶ www.nema.org
⁷ www.asq.org

3.2.5 Metal Core/Backed The metal core substrate **shall** be specified on the master drawing as shown in Table 3-1.

Table 3-1 Metal Core Substrate

Material	Specification	Alloy
Aluminum	SAE-AMS-QQ-A-250	As specified
Steel	QQ-S-635	As specified
Copper	ASTM-B-152 or IPC-4562	As specified
Copper-Invar Copper	IPC-CF-152	As specified
Copper-Moly-Copper	IPC-CF-152	As specified
Brass	SAE-AMS-4505	As Specified
Other	As specified	

3.2.6 Base Metallic Plating Depositions and Conductive Coatings The thickness of the plating/final finish coatings **shall** be in accordance with Table 3-3. The copper plating thickness for the surface, PTHs, via holes, blind vias, buried vias and microvias **shall** be as specified in Table 3-4, Table 3-5 and Table 3-6. The thickness for specific use platings **shall** be as specified in Table 3-3. The plating thickness for final finishes or combinations thereof selected from those listed in 1.3.4.3 **shall** be as specified in Table 3-3. Fused tin-lead plating or solder coating only requires visual coverage and acceptable solderability testing per J-STD-003. Coverage of platings and metallic coatings does not apply to vertical conductor edges. Conductor surfaces may have exposed copper in areas not to be soldered within the limits of 3.5.2.10.1.

For purposes of copper plating minimum requirements, a microvia is defined as a blind structure (as plated) with a maximum aspect ratio of 1:1 when measured in accordance with Figure 3-1, terminating on or penetrating a target land, with a total length of no more than 250 μm [0.00984 in] measured from the structure's capture land foil to the target land.

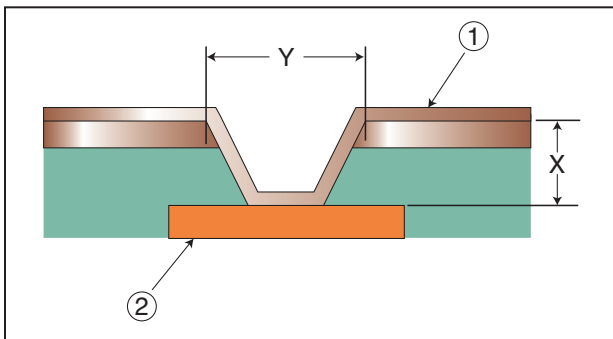


Figure 3-1 Microvia Definition

Note 1. Capture Land.

Note 2. Target Land.

Note 3. X/Y = Microvia Plating Aspect Ratio, with $X < 0.25 \text{ mm}$ [0.00984 in] and aspect ratio $< 1:1$.

3.2.6.1 Electroless Copper Depositions and Conductive Coatings

Electroless depositions and conductive coatings **shall** be sufficient for subsequent plating processes and may be either electroless metal, vacuum deposited metal, or metallic or non-metallic conductive coatings.

3.2.6.2 Electrodeposited Copper Electrodeposited copper plating **shall** meet the following criteria. Frequency of testing **shall** be in accordance with Table 4-4.

- When tested in accordance with IPC-TM-650, Method 2.3.15, the purity of copper **shall** be no less than 99.50%.
- When tested in accordance with IPC-TM-650, Method 2.4.18.1, using 50 - 100 μm [1,969 - 3,937 μin] thick samples, the tensile strength **shall** be no less than 248 MPa [36,000 PSI] and the elongation **shall** be no less than 12%.

3.2.6.3 Fully Additive Electroless Copper Depositions Additive/electroless copper platings applied as the main conductor metal **shall** meet the requirements of this specification. Deviations **shall** be AABUS.

3.2.7 Final Finish Depositions and Coatings - Metallic and Non-Metallic

3.2.7.1 Electrodeposited Tin The allowance of and the requirements for use of electrodeposited tin **shall** be AABUS. It is recommended that the user refer to JEDEC/IPC JP002 for guidance on potential mitigation practices that may delay the onset of, or prevent, tin whisker formation.

3.2.7.2 Electrodeposited Tin-Lead Tin-lead plating **shall** meet the composition (50-70% tin) requirements of ASTM B-579. Fusing is required unless the unfused option is selected wherein the thickness specified in Table 3-3 (Code TLU) applies.

3.2.7.3 Hot Air Solder Leveling (HASL)/Solder Coating The solder coating **shall** be as specified on the master drawing and the procured solder used for coating **shall** meet the requirements of J-STD-006.

The frequency of analysis for the HASL solder pot to the limits of Table 3-2 as reprinted from IPC-J-STD-001 below **shall** be determined on the basis of Statistical Process Control (SPC) data or monthly analyses. Records containing the results of all analyses and solder bath usage (e.g., total time in use, amount of replacement solder, or area throughput) **shall** be maintained for a minimum of one year for each process/system. The percentage of each element in an alloy **shall** be determined by any standard analytical procedure with sufficient resolution. The tolerance and impurity levels of the alloy **shall** conform to limits of Table 3-2. If contamination exceeds the limits, intervals between the analyses, replacement or replenishment **shall** be shortened.