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BSI Standards Publication

Qualification and performance specification of permanent solder mask and flexible cover materials

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

QUALIFICATION AND PERFORMANCE SPECIFICATION OF PERMANENT SOLDER MASK AND FLEXIBLE COVER MATERIALS

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2010 - December

Qualification and Performance Specification of Permanent Solder Mask and Flexible Cover Materials

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April 2007

A standard developed by IPC

Association Connecting Electronics Industries

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IPC-SM-840E

Qualification and Performance Specification of Permanent Solder Mask and Flexible Cover Materials

Developed by the Solder Mask Performance Task Group (5-33B) of the Cleaning and Coating Committee (5-30) and the Covercoat Materials Task Group (D-13B) of the Flexible Circuits Committee (D-10) 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 of Permanent Solder Mask and Flexible Cover Materials

1 SCOPE AND DESIGNATION

1.1 Scope This specification **shall** define the criteria for and method of obtaining the maximum information about and confidence in cured permanent solder mask and cover material under evaluation with the minimum of test redundancy.

This specification **shall** establish the requirements for:

- The evaluation of solder mask and cover materials
- The conformance of solder mask and cover material properties
- The qualification of the solder mask and cover material via the appropriate test substrate
- The qualification assessment of the solder mask and cover material in conjunction with the production printed board process

1.2 Purpose This specification **shall** establish the requirements, based on applicable test methods and conditions, for the evaluation of a solder mask and cover material and for the determination of the acceptability of use on a printed board. These same requirements **shall** also be used to qualify a printed board production process based on conformance criteria defined by the reliability requirements of the end use environment. Acceptability and/or verification criteria of the production printed board **shall** be determined in accordance with the applicable performance requirements (e.g., IPC-6012, IPC-6013, IPC-6018, etc.).

The solder mask materials described herein, when applied to the printed board substrate are intended to prevent and/or minimize the formation and adherence of solder balls, solder bridging, solder build-up and physical damage to the printed board substrate. The solder mask material **shall** retard electromigration and other forms of detrimental or conductive growth.

The cover materials described herein, when applied to the printed board substrate, **shall** provide a flexible dielectric protective layer over the etched conductors and other conductive features. The cover materials are intended to prevent and/or minimize the formation and adherence of solder balls, solder bridging, solder build-up and physical damage to the printed board substrate. The cover materials **shall** retard electromigration and other forms of detrimental or conductive growth.

NOTE: The determination of compatibility between solder mask and cover materials and post soldering products and processes is beyond the scope of this specification. The use of Test Methods specified herein to determine the compatibility and the requirement to do so **shall** be as agreed between user and supplier (AABUS).

This specification **shall** list the base requirements for solder mask and cover materials and their production processes. The solder mask and cover material **shall** be cured per the manufacturer's recommended process in accordance with those conditions specified for that product. Additional requirements or deviations from these requirements **shall** be AABUS.

1.3 Classes This specification provides four classes of requirements, T, FT, H, and FH to reflect functional performance requirements and testing severity based on industry/end use requirements. Qualification to a particular class **shall not** be extended to cover any other class.

Note: The reference of a single class does not preclude invoking or allowing specific requirements defined in other classes.

T — Telecommunication This includes computers, telecommunication equipment, sophisticated business machines, instruments, and certain non-critical military applications. Solder mask and cover material on printed boards in this class is suitable for high performance commercial and industrial products in which extended performance life is required but for which interrupted service is not life threatening.

H — High Reliability/Military This includes that equipment where continued performance is critical, equipment down-time cannot be tolerated and/or the equipment is a life support item. Solder mask and cover material on printed boards of this class is suitable for applications where high levels of assurance are required and uninterrupted service is essential.

FT — Flexible Printed Board Applications (Telecommunications) This applies to cover materials for flexible printed board applications used in Telecommunications applications.

FH — Flexible Printed Board Applications (High Reliability/Military) This applies to cover materials for flexible printed board applications used in High Reliability/Military Applications

Notes:

- ***Class Designations*** – Previous versions of this and other IPC specifications make reference to ''Class 1,'' ''Class 2,'' and ''Class 3'' end product classes. For all practical purposes there is no Class 1 solder mask. The requirements in this specification are not applicable for solder mask or cover material used in Class 1 end-product. Class 2 is equivalent to Class T/FT (Telecommunications). Class 3 is the equivalent of Class H/FH (Military/high reliability).
- Solder mask types were previously described as Type A for screen imaged (liquid) or coverlay for flex (dry), and type B for all types of photo defined solder mask (liquid or dry film). A Type B1 solder mask was identified as a liquid solder mask and a Type B2 solder mask was identified as a dry film solder mask.

1.4 Presentation Dimensions and tolerances **shall** be expressed in metric units. English units are shown in brackets [ ] and are not necessarily direct conversions or usable numbers. Reference information is shown in parentheses ( ). Deviations from this **shall** be AABUS.

1.5 Terms and Definitions The definition of terms **shall** be in accordance with IPC-T-50 and as stated in 1.5.1 through 1.5.19. Those terms marked with an asterisk (*) are in IPC-T-50, but are repeated here for clarity.

1.5.1 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.

For reference in this specification, the manufacturer of the solder mask or cover material is the supplier. The fabricator of the printed board with the solder mask or cover material applied is the user, unless within the context, the fabricator is supplying it to the end user, in which case, the fabricator is the supplier.

1.5.2 Blistering* Delamination in the form of a localized swelling and separation between any of the layers of a laminated base material, or between base material and conductive foil, or its protective coating.

1.5.3 Chalking (Cured Solder Mask or Cover Material)* When the solder mask is degraded such that fine particulates can be removed from the surface.

1.5.4 Color Change (Cured Solder Mask or Cover Material)* Any change from the original color after the solder mask or cover material has been cured and the legend and final finish have been applied.

1.5.5 CoC This is an acronym for Certificate of Compliance.

1.5.6 Covercoat* Material deposited as a liquid onto the printed board that subsequently becomes a permanent dielectric coating. (See ''Cover Material.'')

1.5.7 Coverfilm* Material deposited as a photoimageable film onto the printed board, made from i) a homogeneous, single component; ii) separate layers of generically similar chemistries; or iii) as a composite blend. (See ''Cover Material.'')

1.5.8 Cover Material* A thin dielectric material used to encapsulate circuitry, most commonly for flexible circuit applications. For the purpose of this document, the term of "Cover Material" **shall** be used interchangeably to describe either "Covercoat" or "Coverfilm" and does not include "Coverlay."

1.5.9 Crazing* (Conformal or Solder Mask or Cover Material) A network of fine cracks on the surface of or within the coating.

1.5.10 Delamination (Cured Solder Mask or Cover Material)* A separation between plies within a base material, between a base material and a conductive foil, or any other planar separation within a printed board.

1.5.11 FTIR This is an acronym for Fourier Transform Infra-Red (Spectroscopy).

1.5.12 Liquefaction (Cured Solder Mask or Cover Material)* When cured (solid) solder mask or cover material becomes partially to fully liquefied.

1.5.13 Peeling (Cured Solder Mask)* The loss of a portion of the solder mask or cover material from the printed board resulting from a lack of adhesion.

1.5.14 SAC 305 A solder alloy/paste comprised of 96.5% tin, 3% silver and 0.5% copper.

1.5.15 Softening (Cured Solder Mask or Cover Material)* A decrease in hardness as evidenced by a decrease in pencil (scratch) hardness test results.

1.5.16 Solder Mask For the purposes of this specification, the term solder mask **shall** refer to any type of permanent polymer coating material applied prior to assembly, but excluding marking (legend) inks and hole plugging materials.

1.5.17 Swelling (Cured Solder Mask or Cover Material)* An increase in volume, noted as an increase in solder mask or cover material thickness due to absorption of another material such as a solvent.

1.5.18 Tackiness (Solder Mask or Cover Material) A condition where a material or a surface will become degraded so as to become sticky, slightly adhesive, or gummy to the touch.

1.5.19 Wicking (Solder Mask or Covercoat)* A condition where wet solder mask or covercoat on the surface of a panel is drawn into the holes (via, mounting or component).

1.6 Revision Level Changes Changes that were incorporated in the current revision of this specification 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.

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 this specification and the listed applicable documents, this specification **shall** take precedence.

2.1 IPC[1]

IPC-A-25A-G-KIT Multipurpose 1 Sided Test Pattern[2]

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

J-STD-003 Solderability Tests for Printed Boards

J-STD-004 Requirements for Soldering Fluxes

J-STD-006 Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications

IPC-2221 Generic Standard on Printed Board Design

IPC-6012 Qualification and Performance Specification for Rigid Printed Boards

IPC-6013 Qualification and Performance Specification for Flexible Printed Boards

IPC-6018 Microwave End Product Board Inspection and Test

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

1. www.ipc.org
2. This product contains the electronic Gerber artwork files necessary for generating the IPC-B-25A test board.

IPC-TM-650 Test Methods Manual[3]

2.1.1 Microsectioning
2.1.1.2 Microsectioning – Semi or Automatic Technique Microsection Equipment (Alternate)
2.3.25 Detection and Measurement of Ionizable Surface Contaminants by Resistivity of Solvent Extract
2.3.25.1 Ionic Cleanliness Testing of Bare PWBs
2.3.28 Ionic Analysis of Circuit Boards, Ion Chromatography Method
2.3.38 Surface Organic Contaminant Detection Test
2.3.39 Surface Organic Contaminant Identification Test (Infrared Analytical Method)
2.3.42 Resistance to Solvents and Cleaning Agents – Solder Masks
2.4.3 Flexural Fatigue, Flexible Printed Wiring Materials
2.4.7.1 Determination of Machineability of a Solder Mask
2.4.28.1 Adhesion, Solder Mask, Tape Test Method
2.4.29 Solder Mask, Adhesion to Flexible Circuits
2.5.6.1 Solder Mask – Dielectric Strength
2.6.1 Fungus Resistance of Printed Board Materials
2.6.3.1 Solder Mask – Moisture and Insulation Resistance
2.6.7.3 Thermal Shock – Solder Masks
2.6.8 Thermal Stress, Plated-Through Holes
2.6.11 Solder Mask – Hydrolytic Stability
2.6.14 Solder Mask – Resistance to Electrochemical Migration
2.6.27 Thermal Stress, Convection Reflow Assembly Simulation

2.2 Underwriters Laboratories[4]

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

2.3 ASTM[5]

ASTM E595 Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

ASTM D2863 Oxygen Index Testing

ASTM 3363 Standard Test Method for Film Hardness by Pencil Test

ASTM F1683 Standard Practice for Creasing or Bending a Membrane Switch, Membrane Switch Flex Tail Assembly or Membrane Switch Component

2.4 Precedence of Documents When a requirement of a contract, purchase order or equivalent procurement documentation is in conflict with one specified herein, the requirement given on the contract, purchase order or equivalent procurement documents **shall** apply. When a requirement of an applicable specification is in conflict with one specified herein, the requirement given in this specification **shall** apply. Nothing in this specification however, supercedes applicable laws and regulations.

3 REQUIREMENTS

3.1 Qualification/Conformance This specification **shall** define the requirements for all groups of testing between the supplier, fabricator, and user to provide assurance of material consistency; procedures for material qualification; procedures for production process qualification and the overall conformance to all acceptance criteria. Deviations from these requirements **shall** be AABUS.

3.1.1 Material Qualification and Conformance The supplier of the solder mask or cover material **shall** be responsible for the evaluation, qualification and verification of conformance to the requirements defined in 3.1 for each formulation/variation of

3. Current and revised IPC test methods are available on the IPC web site (www.ipc.org\html\testmethods.htm)
4. www.ul.com
5. www.astm.org

solder mask or cover material specified. The required qualification tests **shall** be listed in Table 3–1, Column A. Where applicable, test results **shall** be reported relative to properties defined in the physical requirements section of this specification. The supplier **shall** specify the base film or base material, conductor surface final finish and class for each product qualified. Deviations from these requirements **shall** be AABUS.

3.1.2 Printed Board Process Qualification and Assessment The fabricator **shall** be responsible for the assessment and selection of the process to be used based on the class and end-use application. The fabricator **shall** be responsible for the qualification of the stated process per the required tests listed in Table 3–1, Column B. Deviations from these requirements or responsibilities **shall** be AABUS.

3.1.3 Requalification The fabricator **shall** be responsible for the requalification of the process for any material change from the original formulation used for the initial qualification samples. This also includes formulations changes, where applicable in accordance with 3.2.1. Deviations from these requirements **shall** be AABUS.

3.2 Materials The solder mask, cover material and/or printed boards to be coated **shall** be free from deleterious substances, and formulated or prepared to meet the designated requirements of this specification. The solder mask supplier **shall** be responsible for providing objective evidence that the supplied solder mask or cover materials have been processed per the supplier instructions to assure a level of cure that meets the acceptance criteria.

The materials used for touch-up of discontinuities **shall** be allowed, provided that all the requirements specified herein have been met.

3.2.1 Formulation Change Formulation changes **shall** require a new name or product designation and requalification. The extent of the name change is up to the supplier, but the change in the name or designation must be prominently displayed and/or obvious to the fabricator or user.

3.2.1.1 Formula Variations Constituting Material Change Any of the following variations in the formulation of a material originally qualified by a supplier, constitutes a material change:

- Changes exceeding ± 2% in the formula weight of any non-volatile ingredient from the ingredient's original formula weight.
- Elimination of a non-volatile ingredient.
- Addition of a new non-volatile ingredient.
- Changes in type of dye or pigment, excluding coloring dye or pigment within a defined, tested range of lowest (none) and highest (supplied) loading levels of the specific coloring materials.
- Any change in the mask that results in a change in the FTIR spectral response of the cured solder mask or cover material.
- Addition, deletion or change in composition of ''inert'' materials in the formulation such as matting agent(s), excluding a change in quantity of a single "inert" material already present in the formulation within a defined, tested range of lowest (none) and highest (supplied) loading levels of that specific inert material. Change to more than one material is considered a formulation change.

3.2.1.2 Formula Variations Not Constituting Material Change The following do not constitute a change in formulation and do not require requalification:

- Changes of less than ± 2% in the formula weight of any non-volatile ingredient from the ingredient's original formula weight.
- Changes in volatile components (solvents) where the residual amount in the tack dried coating (under recommended drying conditions) is less than 1% of the dried weight.
- Changes in the % solids vs. volatiles of the solder mask or cover material as supplied to fabricator.

3.2.2 Compatibility The solder mask or cover materials **shall** be suitable for application and use on printed boards and **shall** be chemically, physically, environmentally, and electrically compatible with materials of construction. These materials **shall not** cause deterioration of materials used in printed board assemblies or components mounted/connected thereon. The material **shall not** corrode any metal being covered.

3.2.2.1 Compatibility Confirmation Confirmation of compatibility of a solder mask or cover material with any item or substance not specified herein **shall** be the responsibility of the fabricator/user for each such item or substance.

Table 3–1 Requirements of Qualification

Requirement	Paragraph	Test Method		Testing	
		IPC-TM-650 Test Method	Other	Column A Supplier	Column B Fabricator
Cure	3.2.5.1	None		X	X
Non-Nutrient	3.2.6	2.6.1		X	N/R
Visual Requirements	3.3.1	None		X	X
Discoloration	3.3.3	None		N/R	AABUS
Dimensional Requirements	3.4	None		N/R	X
Thickness	3.4.1	2.1.1 2.1.1.2		N/R	X
Pencil Hardness	3.5.1	None	ASTM D3363, Scratch Hardness Test	X	X
Adhesion to Rigid Printed Boards	3.5.2.1	2.4.28.1		X	X
Adhesion to Flexible Printed Boards – Class F	3.5.2.2	2.4.29		X	X
Via Protection	3.5.2.3	2.4.28.1		N/R	X
Adhesion of Legend and Marking Materials	3.5.2.4	None		N/R	AABUS
Adhesion to Melting Metals	3.5.2.5	2.4.28.1		N/R	X
Adhesion of Layered or Double Coated Solder Mask	3.5.2.6	2.4.28.1 2.4.29		X	X
Machinability	3.5.3	2.4.7.1		X	X
Resistance to Fabrication Solvents, Cleaning Agents and Fluxes	3.6.1	None		N/R	X
Resistance to Solvents and Cleaning Agents	3.6.1.1	2.3.42		X	X
Resistance to Assembly Processes and Chemistry	3.6.1.2	None		N/R	AABUS
Hydrolytic Stability	3.6.2	2.6.11		X	N/R
Flammability – Class H	3.6.3.1	None	UL94	X	X
Flammability – Class T	3.6.3.2	None	UL94	X	X
Flammability – Class FT, FH	3.6.3.1 3.6.3.2	None	UL94	AABUS	AABUS
Flammability – Class T	3.6.3.2	None	ASTM D2863	X	X
Flammability – Class FT	3.6.3.2	None	ASTM D2863	AABUS	AABUS
Solderability	3.7.1	None	J-STD-003	X	X
Resistance to Tin-Lead Solder	3.7.2	2.6.8		X	X
Resistance to Lead Free Solder	3.7.3	2.6.8		X	X
Simulation of Lead Free Reflow	3.7.3.1	2.6.8		X	X
Dielectric Strength	3.8.1	2.5.6.1		X	AABUS
Insulation Resistance	3.8.2	2.6.3.1		X	X
Moisture and Insulation Resistance	3.9.1	2.6.3.1		X	X
Electrochemical Migration	3.9.2	2.6.14		X	X
Thermal Shock	3.9.3	2.6.7.3		X	AABUS

X = Testing Required. N/R = Testing Not Required.

3.2.3 Shelf Life The solder mask coating **shall** be applied and cured within the shelf life specified by the material supplier. Shelf life and storage requirements **shall** be specified by the solder mask supplier.

3.2.4 Color The color(s) of the cured solder mask or cover material **shall** be the standard color for the product type as qualified by the solder mask or cover material supplier. Clear, unpigmented solder masks and cover materials are acceptable.

3.2.5 Cure This specification **shall** establish the requirements for determining that an acceptable level of cure has been achieved.

3.2.5.1 Level of Cure An acceptable level of cure may be functionally determined by demonstrating compliance with some or all of the requirements in the applicable sections of 3.5 thru 3.9. The determination of the number of requirements for evaluation **shall** be AABUS.

3.2.5.2 Monitoring Tests Other test methods for monitoring level of cure or control of the curing process may also be used. Allowance of these alternative methods and their acceptability for use **shall** be AABUS.

3.2.6 Non-Nutrient The cured solder mask or cover material **shall not** contribute to or support biological growth when tested per IPC-TM-650, Method 2.6.1.

3.3 Visual Requirements Solder mask or cover material appearance **shall** be observed visually in all stages of evaluation, qualification, and conformance inspection with the aid of a magnifying lens rated between 1.75 and 10X magnification. Deviations from this requirement **shall** be AABUS.

3.3.1 Appearance The cured solder mask or cover material **shall** be uniform in appearance and free of foreign material, cracks, inclusions and peeling when inspected per the requirements of 3.3 or any other surface anomaly that would interfere with the assembly or operation of the printed board.

3.3.2 Discoloration (Metallic Surfaces) Discoloration of metallic surfaces under the cured solder mask or cover material **shall** be acceptable.

3.3.3 Discoloration (Solder Mask or Cover Material) Discoloration of solder mask or cover material upon exposure to soldering conditions **shall not** be considered as cause for rejection of the solder mask or cover material or the printed board. The degree of acceptable discoloration of the solder mask or cover material **shall** be AABUS.

3.4 Dimensional Requirements The cured solder mask or cover material **shall** visually cover all required surfaces. In cases of thin or clear (non-colored) solder mask or cover material, coverage **shall** be verified by cross section, where three random boards **shall** be chosen for cross section analysis.

3.4.1 Solder Mask or Cover Material Thickness The printed board fabricator **shall** confirm that the minimum thickness of the solder mask or cover material on the printed board is sufficient to meet the requirements of 3.8.1. The coating thickness **shall** be measured by any micrometer or indicator accurate to 2.5 µm [0.0001 in] or by microsection(s) prepared in accordance with IPC-TM-650, Method 2.1.1 or Method 2.1.1.2.

If a specific thickness or breakdown voltage is required or allowed, it **shall** be AABUS.

3.5 Physical Requirements

3.5.1 Pencil Hardness The cured solder mask or cover material **shall not** be scratched by a pencil which is softer than an ‘‘F’’ hardness when tested in accordance with ASTM D-3363, Scratch Hardness Test.

3.5.2 Adhesion The cured solder mask or cover material **shall** be tested to determine compliance to the applicable acceptance criteria for adhesion to rigid and flexible substrates. Determination of and deviation from these applicable requirements, as well as the use of alternate coupon patterns or production printed boards **shall** be AABUS.

3.5.2.1 Adhesion to Rigid Printed Boards The adhesion of the cured solder mask or cover material to the base film or material and non-melting metals **shall** be tested per IPC-TM-650, Method 2.4.28.1. The maximum percentage of cured solder mask or

cover material lifted from the surface of the base film, base material or conductive material of the checkered printed board pattern prior to and after subsequent exposure to solder per 3.7.2 or 3.7.3 **shall** be in accordance with Table 3–2.

Table 3–2 Adhesion to Rigid Printed Boards (IPC-B-25A Test Board and/or Production Printed Board)

Surface	Paragraph	Maximum Percentage Loss Allowed
		Class T/FT & H/FH
Bare Copper	3.5.2.1	0
Gold or Nickel	3.5.2.1	5
Base Laminate	3.5.2.1	0
Melting Metals (Tin-Lead Plating, Fused Tin-Lead and Bright Acid Tin)	3.5.2.5	10

3.5.2.2 Adhesion to Flexible Printed Boards For Class FT and Class FH, the adhesion of the cured solder mask or cover material to the base material and conductive surfaces **shall** meet the requirements of 3.5.2.1 and be tested per IPC-TM-650, Method 2.4.29, using a 3.18 mm [0.125 in] diameter mandrel. The test specimen base material **shall** be in accordance with IPC-4204/11-E1E20O CU-E2-HN/HN. The cured solder mask or cover material **shall not** exhibit evidence of cracks or delamination from the surface of the base material, conductors or lands of the flexible printed board after the completion of 25 cycles.

3.5.2.3 Via Protection The adhesion of the cured solder mask or cover material to the materials used to plug or tent holes to accommodate via protection **shall** be tested per IPC-TM-650, Method 2.4.28.1. The quality conformance test circuitry coupons **shall** each include a minimum of six (6) protected vias per coupon that are representative of the printed board design. The cured solder mask or cover material **shall** have no failures and meet the requirements of 3.5.2.1, 3.5.2.2 and 3.5.2.6. The solder mask or cover material application **shall not** be a cause of failure for the via structure it was designed to protect.

3.5.2.4 Adhesion of Legend and Marking Materials Solder mask or cover material cure acceptance criteria **shall not** be defined by adhesion requirements for legend inks and other marking materials applied in a subsequent operation. Definition of acceptance criteria for adhesion requirements of these materials to the cured solder mask or cover material and the required test methods **shall** be AABUS.

3.5.2.5 Adhesion to Melting Metals The adhesion of the cured solder mask or cover material over melting metals **shall** be tested per IPC-TM-650, Method 2.4.28.1. The maximum percentage of cured solder mask or cover material lifted from the surface of the melting metals of the checkered printed board pattern prior to and after subsequent exposure to solder per 3.7.2 and 3.7.3 **shall** be in accordance with Table 3–2.

When solder mask or cover material is required over melting metal surfaces, which can reflow during exposure to temperature, and in order to be able to meet the adhesion requirements of this specification, the maximum recommended conductor width where the mask or cover material completely covers the conductor **shall** be 1.27 mm [0.050 in].

When conductors of melting metal have a width larger than 1.27 mm [0.050 in], the design of the conductor **shall** provide a relief through the metal to the base laminate substrate. The relief should be at least 6.45 mm^2 [0.010 in^2] in size and located on a grid no greater than 6.35 mm [0.250 in].

When conductor areas of melting metal are to be left uncovered, the design for all class printed boards **shall** provide that the solder mask or cover material **shall not** overlap the melting metal by more than 75 µm [0.003 in]. Solder mask-to-land relationship **shall** meet the registration requirements stated on the master drawing.

3.5.2.6 Adhesion to other Solder Mask or Cover Materials When multiple layers of solder masks or cover materials are applied, the adhesion between layers **shall** meet the same requirements of 3.5.2.1 and 3.5.2.2. These requirements also apply to any touch-up performed.

3.5.3 Machinability The cured solder mask or cover material applied over the base laminate (not to include metal areas) **shall** be subjected to drilling, routing, sawing or punching in accordance with IPC-TM-650, Method 2.4.7.1. The cured solder mask or cover material **shall** show no evidence of cracks or tears more than that observed on the base laminate on which it was applied when visually examined without magnification.

3.5.4 Flexibility

3.5.4.1 Dynamic Applications – Flexural Endurance The cured cover material **shall** be subjected to flexural endurance testing in accordance with IPC-TM-650, Method 2.4.3. The radius and number of flex cycles **shall** be AABUS. The cover material **shall** be applied to the etched copper pattern of the test specimen and tested with the coating on the outside of the bend. The cured solder mask or cover material **shall** show no evidence of cracks or tears more than that observed on the base laminate or base film on which it was applied when visually examined without magnification.

3.5.4.2 Flex-to-Install Applications See 3.5.2.2 and IPC-TM-650, Method 2.4.29.

3.6 Chemical Requirements

3.6.1 Resistance to Fabrication Solvents, Cleaning Agents and Fluxes The cured solder mask or cover material **shall** be tested by the printed board fabricator for resistance to those solvents, cleaning agents, fluxes, or other chemicals which are encountered in the intended fabrication processes.

The testing of the solder mask or cover material to process materials outside the fabricator's process **shall** be AABUS.

3.6.1.1 Resistance to Solvents and Cleaning Agents The resistance to solvents and cleaning agents of the cured solder mask or cover material **shall** be determined by exposing the specimens to the conditions listed in IPC-TM-650, Method 2.3.42. Resistance to each agent **shall** be tested separately using new specimens for each agent tested. The cured coating **shall not** exhibit delamination, cracks, tackiness, swelling or permanent degradation in surface finish of the solder mask or cover material.

3.6.1.2 Resistance to Assembly Processes and Chemistry The resistance to the process chemistries and the compatibility with the assembly process **shall not** be part of the requirements definition for determining that the cured solder mask or cover material is acceptable for use. The responsibility for determining those compatibilities and allowance for use **shall** be AABUS.

3.6.2 Hydrolytic Stability The hydrolytic stability of the cured solder mask or cover material **shall** be determined by testing and conditioning requirements in accordance with IPC-TM-650, Method 2.6.11. There **shall** be no evidence of reversion as indicated by softening, chalking, blisters, cracks, tackiness, loss of adhesion or liquefaction.

3.6.3 Flammability The flammability performance of the cured solder mask or cover material **shall** be determined in accordance with UL 94.

3.6.3.1 Class H/FH The solder mask or cover material **shall not** raise the UL 94 flammability ''V" or "VTM'' number of the base laminate.

3.6.3.2 Class T/FT The solder mask or cover material **shall not** cause the UL 94 flammability ''V'' or "VTM" number to be raised by more than one, and the rating **shall** be at least V-1 or VTM-1. The oxygen index when tested in accordance with the requirements of ASTM D-2863 **shall** be ≥ 28%.

NOTE: VTM testing is used only for thin (12.7 µm [0.0005 in] or less) flexible constructions.

3.7 Soldering Requirements

3.7.1 Solderability The production printed boards and/or test coupons **shall** meet the solderability requirement when tested in accordance with J-STD-003. The application and curing of the solder mask or cover material **shall not** leave residues which adversely affect the solderability of the areas intended to be soldered.

3.7.2 Resistance to Tin-Lead Solder The ability of the cured solder mask or cover material applied on production printed boards and/or test coupons to resist adhesion of solder, **shall** be determined by a thermal stress test in accordance with IPC-TM-650, Method 2.6.8 (solder float) or IPC-TM-650 Method 2.6.27 (reflow simulation) and the following conditions:

- Flux **shall** be a ROM0 or ROM1 per J-STD-004
- Specimens **shall** be held after coating with flux for five minutes at ambient temperature
- Preheat per the flux suppliers' recommendation
- Temperature **shall** be per Test Condition B for IPC-TM-650, Method 2.6.8, or the 260 °C Reflow Profile for IPC-TM-650, Method 2.6.27.

Immediately after exposure to solder, the cured solder mask or cover material **shall** be visually inspected in accordance with 3.3 to detect the presence of solder adherence. The cured solder mask or cover material **shall** completely resist the adherence of solder.

3.7.3 Resistance to Lead Free Solder The ability of the cured solder mask or cover material to resist adherence of lead free solder **shall** be determined by testing per the requirements of 3.7.2 except the solder **shall** be SAC 305 per J-STD-006.

3.7.3.1 Simulation of Lead Free Reflow Samples that have been tested for resistance to lead free solder adherence per 3.7.3 are to be subjected to five additional solder floats per 3.7.3 at 260 ± 5 °C for 10 ± 1 seconds each. The samples **shall** maintain compliance with the requirements in 3.7.2.

3.8 Electrical Requirements

3.8.1 Dielectric Strength The solder mask or cover material **shall** meet or exceed the minimum value of 500 VDC per 25 µm [0.001 in] of thickness when tested in accordance with IPC-TM-650, Method 2.5.6.1. Thickness of solder mask or cover material less than 25 µm [0.001 in] **shall** meet an absolute minimum breakdown voltage of 500 VDC.

3.8.2 Insulation Resistance The insulation resistance of the production printed board **shall** be determined in accordance with the initial ambient temperature insulation resistance measurement of IPC-TM-650, Method 2.6.3.1. The sample/test coupon **shall** have a minimum insulation resistance of 500 Megohm, in either standard or production printed boards, before and after performing the resistance to solder test per 3.7.2 and 3.7.3.

3.9 Environmental Requirements

3.9.1 Moisture and Insulation Resistance The ability of a cured solder mask or cover material applied to a printed board to meet the required level of moisture and insulation resistance (both at test conditions and stabilized to ambient conditions within 1 to 2 hours after removal from the chamber) **shall** be determined by testing in accordance with IPC-TM-650, Method 2.6.3.1 and Table 3–3.

The tested specimens **shall** withstand the conditions listed in Table 3–3 without exhibiting blisters or delamination and meet the insulation resistance requirement.

Table 3–3 Moisture & Insulation Resistance

Class	Test Temperature	Test Humidity	Bias Voltage (VDC)	Test Voltage (VDC)	Duration	Test Pattern IPC-B-25A Board	Requirements (megohms)
T/FT	65 ± 2 °C	90 ± 3%	0	100	24 hours	E and F, C	500
H/FH	25 to 65 °C ± 2 °C	90 + 3/-5%	50	100	160 hours	D, C	500

3.9.2 Electrochemical Migration The ability of a cured solder mask or cover material applied to a printed board to prevent electrochemical migration, **shall** be determined by testing as specified in accordance with Table 3–4 and IPC-TM-650, Method 2.6.14. The tested specimens **shall not** exhibit evidence of electrochemical migration and **shall** meet the insulation resistance requirement per Table 3–4.

Table 3–4 Electrochemical Migration

Class	Test Temperature	Test Humidity	Bias Voltage (VDC)	Test Voltage (VDC)	Duration	Test Pattern IPC-B-25A Board	Requirements (megohms)
T/FT	85 ± 2 °C	85% minimum	10	45–100	500 hours	D, C	<1 decade drop in resistance
H/FH	85 ± 2 °C	90 ± 3%	10	10	168 hours	D, C	Resistance ≥ 2 megohms

3.9.3 Thermal Shock The ability of the cured solder mask or cover material applied to a printed board to withstand thermal shock for Class H applications, **shall** be determined by testing in accordance with IPC-TM-650, Method 2.6.7.3, for the

conditions shown in Table 3–5. The tested specimens **shall** be visually inspected and tested in accordance with the requirements of 3.3. The tested specimens **shall not** exhibit blisters, crazing or delamination. Prior to thermal shock testing, specimens **shall** be exposed to solder per 3.7.2 and 3.7.3.

The requirements to test for Class T in Table 3–5 **shall** be AABUS.

Table 3–5 Thermal Shock Conditions

Class	Temperature	Number of Cycles
H/FH or T/FT	−65 to +125 °C	100

4 QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Testing/Inspection The solder mask or cover material supplier, the printed board fabricator, the end user and other test and inspection facilities used **shall** be responsible for the applicable testing/inspection to verify that the requirements have been met for qualification per 3.1 in accordance with the requirements of 4.3.

4.1.1 Initial Qualification Testing The solder mask or cover material supplier **shall** be responsible for the testing indicated in Column A of Table 3–1 and Table 4–1 per the requirements of 3.1.1. This **shall** constitute initial qualification testing. Periodic testing to ensure continued performance of material properties **shall** be accomplished in accordance with 4.3.1.1.

The printed board fabricator and/or user **shall** be responsible for the testing indicated in Column B of Table 3–1 and Table 4–2 per the requirements of 3.1.2.

4.1.2 Test or Inspection Facilities Test or inspection facilities used to perform any of test or inspection procedures specified herein, **shall** meet all the requirements of IPC-QL-653. The acceptability of these test/inspection facilities and the allowance for their use **shall** be AABUS.

4.2 Qualification Inspection Qualification inspection per 3.1.1 and 3.1.2 may be performed at any of one or more locations as defined in 4.1. Because samples, equipment, procedures, systems and requirements may vary between locations, complete and precise reporting of the test details and verifying data is required.

4.2.1 Sample Size The test specimens **shall** be as specified in Tables 4–1 and 4–2, unless otherwise specified in the applicable test method. Deviations from the number or type of test specimens used **shall** be AABUS.

4.2.2 Inspection Routine The sample specimens **shall** be inspected as specified in the appropriate Column of Table 3–1. Deviations from these requirements **shall** be AABUS. A suggested sample utilization format is shown in Tables 4–1 and 4–2.

4.2.3 Failures One or more failures **shall** be cause for retesting, preferably after the mode of failure has been determined and corrected.

4.3 Quality Conformance Testing/Inspection Quality conformance testing of solder mask or cover material and system properties and production printed boards **shall** be accomplished by one of the following:

- Statistical process control of key process parameters that are historically correlated to solder mask or cover material performance requirements. The requirement to provide a Certificate of Compliance (CoC) stating said compliance **shall** be AABUS.
- Through testing of attributes as described in Table 4–2 if no statistical process controls are in place. The requirement to provide a CoC stating said compliance **shall** be mandatory.

4.3.1 Testing/Inspection of Product for Delivery All inspection related items **shall** refer back to the applicable performance requirements (e.g., IPC-6012, IPC-6013, IPC-6018, etc.). The use of material and process control documentation of key process parameters correlated to product performance testing and testing frequency requirements **shall** be AABUS.

4.3.1.1 Inspection of Solder Mask or Cover Material Properties After initial testing to verify solder mask or cover material properties in accordance with paragraph 3.1.1, batches of solder mask or cover material **shall** be tested for compliance to the original requirements at a frequency to assure continuing performance. A batch or lot, as far as practical, **shall** consist of all solder

Table 4–1 Sample Requirements/Suggested Test Sequence for Table 3–1, Column A
IPC-B-25A Standard Test Boards

Requirement		Separate Samples Required			
	Sample ID	Uncoated Board	Before Soldering	After Soldering[1]	No. Individual Samples
Visual	All	_	All	_	All
Machinability	A	_	3	3	3
Flexural Endurance		_	3	3	
Cure	A and B	_	_	_	See Note 3
Pencil Hardness	A	_	3	3	3
Adhesion – Rigid	B	_	3	3	3
Adhesion – Flex	Custom design	_	3	3	3
Hydrolytic Stability/Aging	Custom design	_	3	_	3
Dielectric Strength	Custom design	_	3	_	3
Resistance to Solvents and Cleaning Agents	B	_	5	_	B = 5
Solderability	A	_	3	_	A = 3
Resistance to Solder	B	_	3	_	B = 3
Insulation Resistance/Moisture and Insulation Resistance[2]					C=
• Class T/FT	C	6	6	6	18
• Class H/FH	C	1	1	1	3
Electrochemical migration					D =
• Class T/FT • Class H/FH	D	–	3 3	–	3 (Class T/FT) 3 (Class H/FH)
Thermal Shock					
• Class T/FT (Optional) • Class H/FH	A	–	–	3	A = 3
TOTALS per Sample ID A, B, C and D				Class T/FT = 38 Class H/FH = 28 Classes T/FT & H/FH = 47	

Note 1. Samples to be tested after exposure to soldering per 3.7.2 or 3.7.3.
Note 2. Same samples as used for Insulation Resistance.
Note 3. Cure must meet the requirements of 3.5.1, 3.5.2.1 and/or 3.5.2.2, 3.6.1, 3.7.1, 3.7.2 and 3.7.3

mask or cover materials, as applicable, provided by one continuous run or a combination of two or more continuous production runs offered for inspection at one time. Lot/batch identification is required.

4.4 Preparation of Specimens for Test

4.4.1 Standard Laboratory Conditions Standard laboratory conditions unless otherwise specified herein or in the individual test specification, **shall** be 23 ± 3 °C and a relative humidity of 55 ± 10%.

4.4.1.1 Permissible Temperature Variation in Environmental Chambers When chambers are used, specimens under test **shall** be located only within the working area, defined as follows:

a) Reference temperature variation within working area: The controls for the chambers **shall** be capable of maintaining the specified temperature within the working area within ± 2 °C.

b) Spatial temperature variation within working area: Chambers **shall** be so constructed that, at any given time, the temperature of any point within the working area **shall not** deviate more than 3 °C from the reference point, except for the immediate vicinity of specimens generating heat.

4.4.1.2 Reference Conditions Reference conditions as a base for calculations **shall** be per 4.4.1 with an atmospheric pressure of 760 millimeters of mercury.

Table 4–2 Sample Requirements/Suggested Test Sequence for Table 3–1, Column B
IPC-B-25A Boards – Production Process or Conformance Coupons Or Production Printed Boards

Requirement	Separate Samples Required				
	Sample ID[1]	Uncoated Board	Before Soldering	After Soldering[2]	No. Individual Samples
Visual	All	_	All	_	All
Machinability	A	_	3	3	A=3
Pencil Hardness	A	_	3	3	A=3
Adhesion Rigid	B	_	3	3	B= 3
Adhesion – Flex	Custom design	_	3	3	A=3
Dimensional					
• Visual	A	_	All	_	All
• Microsection	A	_	3	_	A=3
Via Protection (when required)	Custom design	_	_	3	3
Thermal Shock (when required)	A	_	_	3	A=3
Resistance to Solvents and Cleaning Agents	B	_	5	_	B = 5
Resistance to Assembly Processes and Chemistry	B	_	AABUS	_	AABUS
Solderability	A	_	3	_	A=3
Resistance to Solder	B	_	3	_	B=3
Cure	A and B	_	_	_	See Note 4
Insulation Resistance/Moisture and Insulation Resistance[3]					C=
• Class T/FT	C	6	6	6	18
• Class H/FH	C	1	1	1	3
Electrochemical Migration					D =
• Class T/FT	D	_	3	_	3 (Class T)
• Class H/FH	D	_	3	_	3 (Class H)
Flammability (UL test if not already approved through yellow card)	F	_	_	_	As Required for UL
				TOTAL	Class T/FT = 32 Class H/FH = 17 Classes T/FT & H/FH = 38

Note 1. IPC-B-25A boards, made from the same production materials and using the same manufacturing process, or quality conformance production coupons identified as specimens A through D, or printed boards.
Note 2. Samples to be tested after exposure to soldering per 3.7.2 or 3.7.3.
Note 3. Same samples as used for Insulation Resistance.
Note 4. Cure must meet the requirements of 3.5.1, 3.5.2.1 and/or 3.5.2.2, 3.6.1, 3.7.1, 3.7.2 and 3.7.3.

4.4.2 Specimen Selection The specimens **shall** be made with or without plated-through holes in accordance with the detailed requirements of 4.4.2.1 or 4.4.2.2. Deviations from this requirement or the use of other test specimens **shall** be AABUS.

4.4.2.1 IPC Test Pattern The IPC-B-25A Multipurpose Test board **shall** be used. See Figure 4–1 for details.

4.4.2.2 Industry Heritage "Y" Pattern The Standard ''Y'' Patterns **shall** be used. See Figure 4–2 for details.

4.4.3 Coating The solder mask or cover material **shall** be applied to the appropriate system specimen and cured in a manner consistent with solder mask or cover material supplier's recommendations. Deviations from these requirements **shall** be AABUS.

4.4.3.1 Cleanliness Prior to the application of solder mask or cover material, the printed board **shall** be cleaned to achieve an acceptable level of cleanliness per IPC-6012 or IPC-6013. The determination of cleanliness **shall** be per IPC-TM-650, Method 2.3.25, Method 2.3.25.1, Method 2.3.28, Method 2.3.38, or Method 2.3.39.

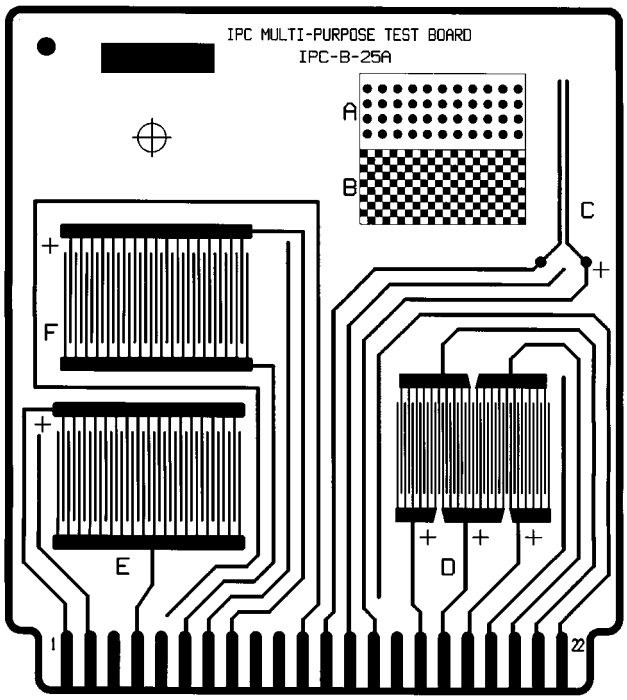

Figure 4–1 IPC-B-25A (Note: No solder mask or cover material shall be applied to contact fingers)

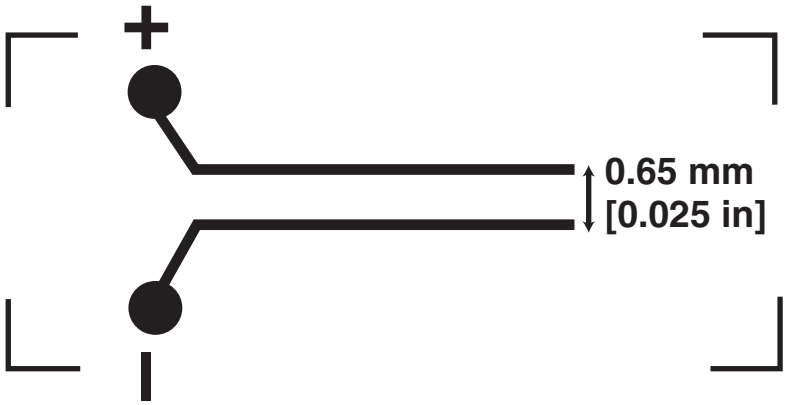

Figure 4–2 IPC-2221 Test Coupon E Layer 1 (“Y” Configuration)

4.4.4 Number The number of specimens required **shall** be of sufficient quantity to achieve statistical confidence and **shall** be, as a minimum, the three test specimens recommended for each test as specified in Tables 4–1 and 4–2.

5 PREPARATION OF SOLDER MASK OR COVER MATERIAL FOR DELIVERY

5.1 Preservation, Packaging and Packing Preservation, packaging and packing **shall** be in accordance with manufacturer practices and be labeled with solder mask or cover material description, manufacturer's part number and lot/batch control number and manufacturing date or expiration date, as well as any required CoC documentation. Deviations from these requirements **shall** be AABUS.

6 NOTES

The use of the information in the ''Notes'' section is intended for guidance only, and is not considered as contractually binding.

6.1 Specifying Solder Mask or Cover Material on Printed Boards Documents/drawings should specify the following for solder mask or cover material on printed boards where appropriate:

a) Title, number and revision level of this specification.

b) Primary class of solder mask or cover material specified per the requirements definition in 1.3.

c) Individual class requirements with deviations/ exceptions/modifications which may be required/allowed from the general class specified.

d) Special compatibility considerations as defined in 3.2.2 and 3.6.1.2.

e) Special requirements as defined in 6.2.

6.2 Class FT/FH Test Methods The following optional test methods can be used for Class FH/FT applications, AABUS. These tests can be performed by supplier and/or fabricator.

IPC TM-650, Method 2.4.3 Flexural Fatigue, Flexible Printed Wiring Materials

ASTM E595 Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

ASTM F1683 Standard Practice for Creasing or Bending a Membrane Switch, Membrane Switch Flex Tail Assembly or Membrane Switch Component

6.3 Special Requirements For optimum utilization, this specification allows for the incorporation of requirements that specifically relate to the end product and its application. For this reason, the user is urged to utilize this specification as a basis to construct a customized procurement specification in conjunction with his supplier and to consider the inclusion of special requirements in the procurement specifications, especially in the following areas:

- Custom test specimen per 4.2.1.
- Printed board assembly and operational requirements per 3.2.2 and 3.2.5.
- Compatibility issues per 3.2.2, 3.6.1 and 3.6.1.2.
- Minimum coating thickness.
- Degree of color change through processing.

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