



*The Institute for
Interconnecting
and Packaging
Electronic Circuits*

IPC-ML-960

Qualification and Performance Specification for Mass Laminated Panels for Multilayer Printed Boards

IPC-ML-960

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

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- Focus on end product performance
- Include a feed back system on use and problems for future improvement

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

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Lamination Task Group of the IPC Rigid Printed Boards Committee are shown below, it is not possible to include all of those who assisted in

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Qualification and Performance Specification for Mass Laminated Panels for Multilayer Printed Boards

1.0 SCOPE

This specification covers qualification and performance of rigid mass laminated panels for use in multilayer printed boards.

1.1 Purpose The purpose of this specification is to provide requirements for qualification and performance of rigid mass laminated panels for use in multilayer printed boards which will be fabricated for industry and government use to the requirements of IPC-RB-276. When mass laminated panels are to be used in Class 2 or Class 3 multilayer printed boards intended for military usage, they **shall** be fabricated by a mass laminator who has been qualified by the final board fabricator to the applicable requirements of IPC-RB-276. This does not apply to boards intended for non-deliverable hardware.

1.2 Classification This specification recognizes that the mass laminated panels supplied by the vendor will be used to produce multilayer printed boards which will be subject to classification by intended end use. Three general classes have been established to reflect progressive increases in sophistication, functional performance requirements and testing/inspection frequency. It should be recognized that there may be overlap of equipment categories in different classes. The user has the responsibility to specify in the contract or purchase order the performance class required for each product and **shall** indicate any exceptions to specific parameters, where appropriate.

Class 1 General Electronic Products Includes consumer products, some computer and computer peripherals, as well as general military* hardware suitable for applications where cosmetic imperfections are not important and the major requirement is function of the completed printed board.

Class 2 Dedicated Service Electronic Products Includes communications equipment, sophisticated business machines, instruments and military* equipment where high performance and extended life is required and for which uninterrupted service is desired but not critical. Certain cosmetic imperfections are allowed.

Class 3 High Reliability Electronic Products Includes the equipment for commercial and military* products where continued performance or performance on demand is critical. Equipment downtime cannot be tolerated and must function when required such as in life support items or

weapon systems. Printed boards in this class are suitable for applications where high levels of assurance are required and service is essential.

***Note:** Where special military requirements exist, they will be noted in the document.

Requirements in this specification have been separated so that performance of the mass laminated panels may be tested to any one of the three classes. The use of one class for a specific attribute does not mean that all other attributes must meet the same class. Selection should be based on minimum need; however, crossover between classes or other separation requires a complete definition of test requirements in the procurement documentation.

Note: Unless otherwise specified, military electronics **shall** be Class 3 and mass laminated panels furnished under this specification for military usage **shall** be fabricated by a mass laminator who has qualified by inspection in accordance with paragraph 4.3.

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

1.3.1 Acceptability when limiting values are specified Specified limiting values of 63.5 mm [2.5 in] maximum, 63.50 mm [2.50 in] maximum, 63.500 mm [2.500 in] maximum are taken to mean that, for the purposes of determining conformance to this specification, an observed value **shall** be rounded off to the nearest 2.5 mm [0.1 in], 0.25 mm [0.01 in] and 0.025 mm [0.001 in], respectively, and then compared to the specified limiting value.

1.3.2 Rounding Convention When measurements are made to greater precision than is required by this specification, it becomes necessary to round results to a specified value in order to determine conformance. The following rounding convention **shall** be used.

The figure in the last place to be retained **shall** be kept unchanged when the figure in the next place:

- is less than 5 or,
- is 5 followed by no other figures or only by zeroes, and the figure in the last place retained is even.

The figure in the last place to be retained **shall** be increased by 1 when the figure in the next place:

- is more than 5 or,
- is 5 followed by no other figure or only by zeroes, and the figure in the last place to be retained is odd or,
- is 5, followed by any figure or figures other than zero.

The final rounded figure **shall** be obtained from the most precise value available and not from a series of successive roundings.

1.4 Statistical Process Control (SPC) This specification requires the implementation of statistical process control per the requirements of IPC-PC-90. (See para. 4.8)

1.5 Interpretation “**shall**,” the emphatic form of the verb, is used throughout this specification whenever a requirement is intended to express a provision that is binding. 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 presented in bold character.

2.0 APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of issuance of this specification, form a part of this specification to the extent specified herein. Subsequent issues of, or amendments to, these documents **shall** become a part of this specification unless otherwise stated.

2.1 IPC¹

IPC-T-50 Terms and Definitions

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

IPC-L-108 Specification for Thin Metal Clad Base Materials for Multilayer Printed Boards

IPC-L-109 Specification for Resin Impregnated Fabric (Prepreg) for Multilayer Printed Boards

IPC-L-115 Specification for Rigid Metal Clad Base Materials for Printed Boards

IPC-CF-148 Resin Coated Metal Foil for Multilayer Printed Boards

IPC-MF-150 Metal Foil for Printed Wiring Applications

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

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

IPC-D-325 Documentation Requirements for Printed Boards, Printed Board Assemblies, and Related Support Drawings

IPC-A-600 Acceptability of Printed Boards

IPC-AI-642 Users Guidelines for Automated Inspection of Artwork, Inner Layers, and Unpopulated Printed Boards

IPC-TM-650² Test Methods Manual

2.4.8 Peel Strength, Metal Foil

2.4.22 Bow and Twist, Rigid Printed Wiring Materials

IPC-QL-653 Qualification for Test Laboratories for Boards

IPC-R-700 Suggested Guidelines for Modification, Rework and Repair of Printed Boards and Assemblies

IPC-SF-818 General Requirements for Electronic Soldering Fluxes

2.2 Military³ Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

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

MIL-STD-480 Configuration Control, Engineering Changes-Deviations and Waivers

MIL-P-13949 Plastic Sheet, Laminated, Copper-Clad (For Printed Wiring)

MIL-F-14256 Flux, Soldering, Liquid (Rosin Base)

MIL-STD-45662 Calibration Systems Requirements

MIL-P-55110 Printed Wiring Boards, General Specification for

2.3 Other Publications

2.3.1 Underwriter's Laboratories (UL)⁴

UL 746E Standard Polymeric Materials, Materials Used in Printed Wiring Boards

1. IPC documents are available from IPC, 2215 Sanders Road, Northbrook, IL 60062-6135

2. For convenience, all IPC-TM-650 test methods referenced herein are reprinted at the end of this standard.

3. Military documents are available from: Standardization Order Desk, Building 4D, 700 Robbins Ave., Philadelphia, PA 19111-5094

4. U. L. documents are available from: Underwriter's Laboratories, 333 Pfingsten Road, Northbrook, IL 60062

2.3.2 American Society for Quality Control (ASQC)⁵

ASQC Q94 Quality Management and Quality System Elements—Guidelines

3.0 REQUIREMENTS

3.1 General Mass laminated multilayer panels furnished under this specification **shall** meet or exceed all the requirements of the specific class of this specification as required by the contract or purchase order. Design features and applicable coupon configuration **shall** be per IPC-D-275. Panels furnished under this specification **shall** be as specified on the master drawing, and they **shall** be processed in such a manner as to be uniform in quality and free from defects in excess of those allowed in this specification.

3.1.1 Master Drawing The master drawing **shall** be prepared in accordance with IPC-D-325 and IPC-D-275, and **shall** also contain all information pertinent to the mass laminate panel layout, including pinning hole location with respect to panel edges and dimensional features such as board placement and test coupon location with respect to the drill pinning holes. The user **shall** supply the mass laminator with a drilled, sample blank with drill pinning holes for registration verification.

3.1.2 Deviations and Waivers Deviations and waivers **shall** be submitted to the user or, if a military contract, to the controlling government agency or contracting officer per MIL-STD-480. Approval of the deviation or waiver **shall** be obtained prior to incorporation of the changes in the product. If this specification is referenced on the master drawing, any permanent deviations or waivers **shall** be incorporated in the master drawing and **shall** state where the deviation applies.

For military requirements, no waivers of testing for Quality Conformance (Group A) testing are allowed by any contract, procurement document, or master drawing.

3.1.3 Production Master The mass laminator is responsible for the accuracy of the production master or the information in the data base from which the production master is generated when either the production master or database is provided to the mass laminator. The production master or database must include all layers of the multilayer printed board. Verification of compatibility with specifications, master drawings and patterns, and the specific manufacturing facilities and processes used, are the responsibility of the mass laminator, and he **shall** ensure that the end product panel meets the requirements of the master drawing. When the positions of appropriate test coupon patterns are

specified on the procurement document or the master drawing, their locations on the production master **shall** not be changed.

3.2 Terms and Definitions The definitions of all terms used herein **shall** be as specified in IPC-T-50 and as defined below.

3.2.1 Foil Lamination A process for making multilayer printed boards using surface layers of copper foil laminated in a single operation with bonding materials.

3.2.2 Cap Lamination A process for making multilayer printed boards with surface layers of copper clad laminate laminated in a single laminating operation with bonding materials.

3.2.3 Mass Laminated Multilayer Panel A multilayer printed board at an intermediate stage of production, where inner layers have been processed and laminated to produce a panel containing alternate layers of conductive and insulating materials. The two outside conductive layers have not been processed by the mass laminator but are ready for NC drilling and final processing by the user.

3.2.4 Qualification Testing Testing performed to demonstrate the manufacturer's ability to meet all the requirements of the specification invoked by the user.

3.2.5 Quality Conformance Inspection Inspections and tests intended to demonstrate that the product being manufactured meets or exceeds the requirements of the performance document invoked.

3.3 Conflict In the event of conflict between this specification and the approved master drawing, the master drawing **shall** take precedence. Approved purchase orders, contracts and/or printed board specifications may also take exceptions to this specification. Applicable documents (See Para. 2.0) are modified in this specification and are only applicable as specified herein.

3.4 Qualification and Performance When required, manufacturers of mass laminated multilayer panels to the requirements of this specification **shall** be qualified per paragraph 4.3 and as specified by the user. Qualification approval **shall** be maintained throughout the life of the contract. Other qualifying requirements may apply as agreed upon by the manufacturer and the user. Separate qualification is not required for mixed material types, but the manufacturer **shall** be qualified for each material type used in the mix. Mixing of material types may not be allowed by U.L. for U.L.-listed equipment.

5. ASQC documents are available from: The American Society for Quality Control, 310 West Wisconsin Avenue, Milwaukee, WI 53201

3.4.1 Quality Assurance Program When required by the user, a quality assurance program for boards furnished under this specification **shall** be established and maintained in accordance with ASQC Q94, or as otherwise agreed on between user and manufacturer, and **shall** be monitored by the qualifying activity.

3.4.1.1 SPC Implementation Unless excepted by the contract or purchase order, the manufacturer **shall** have a strategic plan of action with milestones for implementation of SPC in accordance with IPC-PC-90.

The strategic plan **shall** be submitted at the time of the request to build qualification samples. Unless otherwise specified, audit of SPC implementation **shall** take place within one year after the date of qualification approval. The manufacturer may petition the qualifying activity to start a program to reduce end-product testing as soon as the audit is completed provided that evidence of correlation exists between conformance testing and SPC.

3.5 Material Mass laminated multilayer panels **shall** be fabricated from the laminate materials specified in MIL-P-13949, IPC-L-108, IPC-L-109, IPC-L-115, or UL 746E, or the applicable specification. When Underwriter's Laboratories (UL) requirements are imposed, the material used must be approved by UL for use by the board manufacturer.

3.5.1 Rigid Metal Clad Laminates Rigid reinforced metal clad laminates **shall** be as specified on the master drawing. The type and copper thickness **shall** be as specified on the master drawing. The minimum thickness of the base material (without copper) **shall** be 0.05mm [0.002 in] provided that the resulting dielectric layer in the finished board meets the requirements of 3.10.2. A cap layer of copper may be laminated with prepreg or resin coated copper (see 3.2.2). For military requirements the material **shall** be natural in color.

3.5.2 Rigid Unclad Laminates Rigid reinforced unclad laminates **shall** be in accordance with MIL-P-13949, IPC-L-108, IPC-L-115, or as specified on the master drawing.

3.5.2 Preimpregnated Bonding Material (Prepreg) Preimpregnated (B-Stage) bonding material (Prepreg) **shall** be as specified on the approved master drawing and **shall** be in accordance with MIL-P-13949 or IPC-L-109. Prepreg **shall** be selected to be compatible with the innerlayer laminates.

3.5.3 Metal Foil Metal foil **shall** be in accordance with IPC-MF-150. 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 in accordance with

IPC-CF-148 may be used for cap foil applications.

3.6 Visual Examination Inner layers for mass laminated multilayer panels **shall** be examined in accordance with the following test method. They **shall** be of uniform quality and **shall** conform to paragraphs 3.6.1 through 3.6.4. Visual examination of the circuits for visual, dimensional or workmanship attributes **shall** be conducted at 1.75x min. (approximately 3 diopters). When required by contract or other specification, 4x magnification **shall** be used; however, depth and width of field will be limited. Where a measurement is required to determine acceptance or rejection of an observed inconsistency (referee test) on either a metal or laminate surface, 10x max. (approximately 36 diopters) magnification **shall** be used.

Automated inspection technology is allowed (see IPC-AI-642).

3.6.1 Edges Sheared edges **shall** be acceptable unless otherwise specified. No loose fibers **shall** be permitted.

3.6.2 Laminate The as-received mass laminated multilayer panels **shall** show no visual signs of delamination, blisters, voids, cut, tears, or any other defects in excess of that permitted below. When examined after completion of processing by the user to the requirements of IPC-RB-276, surface and subsurface imperfections in the mass laminated panels are permitted to the extent indicated in the following paragraphs.

3.6.2.1 Laminate Imperfections Measling, crazing, blistering, and haloing **shall** be evaluated in accordance with IPC-A-600.

Gelation particles (if not carbonized) are acceptable for all classes.

Foreign material is acceptable if it is clear or translucent. Opaque foreign material **shall** be located at least 0.25 mm [0.010 in] from the nearest conductor. If foreign material is located between conductors, it **shall** not bridge more than 50% of the space; in non-circuitry areas, its longest dimension **shall** not exceed 0.8 mm [0.032 in].

3.6.2.2 Subsurface Laminate Imperfections Resin starvation or any subsurface metallic inclusion is acceptable provided it does not bridge more than 25% of the spacing between conductors or plated-through holes, while maintaining minimum conductor spacing, and the total area affected does not exceed 1% of the board area on each side.

Mottled appearance or color variation in bond enhancement treatment is acceptable. Missing treatment **shall** not be more than 10% of the metal area and a single missing treatment spot **shall** be no more than 45 sq mm [0.070 sq in].