

NOT MEASUREMENT
SENSITIVE

MIL-PRF-31032
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PERFORMANCE SPECIFICATION

PRINTED CIRCUIT BOARD/PRINTED WIRING BOARD, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments
and Agencies of the Department of Defense.

1. SCOPE

1.1 Statement of scope. This specification establishes the general performance requirements for printed circuit boards or printed wiring boards (hereafter designated printed board) and the verification requirements for insuring that these items meet the applicable performance requirements. Certification and qualification to this specification allows manufacturer's to apply the QML program to printed boards procured to non-QML documents such as MIL-P-55110 and MIL-P-50884 (see 6.3.4 and 6.5). The intent of this specification is to allow the printed board manufacturer the flexibility to implement best commercial practices to the maximum extent possible while still providing product that meets military performance needs (see 6.3.3). The principle concepts which allow this flexibility are as follows:

- a. The manufacturer forms an internal quality review system or organization referred to in this document as the Technical Review Board (TRB)(see 6.4.37). The TRB is responsible for the implementation of a quality management (QM) plan (see 6.4.31).
- b. A relationship is established between the manufacturer and the qualifying activity.

The process to implement this specification can be summarized as follows:

- a. Self-validation: The TRB verifies the implemented QM plan.
- b. Certification: The qualifying activity leads a team to validate the TRB's effectiveness in implementing their QM plan.
- c. Qualification: The manufacturer demonstrates capability to produce a printed board technology.
- d. Maintenance: The TRB keeps the qualifying activity informed on the status of its QM program.

1.2 Description of this document. The main body of this document describes the requirements for obtaining a Qualified Manufacturers List (QML)(see 6.4.26) listing. The appendices of this document are intended to aid the manufacturer in developing its verification program. Appendices A and D are not mandatory. Appendices B, C, and E are mandatory. Appendix A is guidance that describes a quality management approach using a TRB concept. Appendix B contains qualification procedure requirements. Appendix C contains the conformance inspection requirements. Appendix D is guidance that describes techniques for test optimization (see 6.4.38). Appendix E provides statistical sampling and basic test and inspection requirements. Sectional associated specifications (see 6.4.2) contain the performance requirements and verification methods for printed boards by technology. Detailed requirements, specific characteristics, and other provisions which are sensitive to the particular intended use of printed boards are to be specified in the printed board procurement documentation (see 6.4.18).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Defense Electronics Supply Center ATTN: DESC-ELST, Dayton, OH 45444-5764 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirement documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications. The following specifications form a part of this document to the extent specified herein. 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 (see 6.2).

SPECIFICATIONS

DEPARTMENT OF DEFENSE

MIL-PRF-31032/1 - Printed Wiring Board, Rigid, Multilayered, Woven E-Glass Reinforced Thermosetting Resin Base Material, With Plated Through Holes, For Soldered Part Mounting.

(Unless otherwise indicated, copies of the above specification is available from the Defense Printing Services Detachment Office, Building 4D (Customer Service), 700 Tabor Avenue, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following document forms a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issue of the documents cited in the solicitation (see 6.2).

INSTITUTE FOR INTERCONNECTING AND PACKAGING ELECTRONIC CIRCUITS (IPC)

IPC-T-50 - Terms and Definitions.

(Application for copies should be addressed to the Institute for Interconnecting and Packaging Electronic Circuits, 2215 Sanders Road, Northbrook, IL 60062-6135.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated specification), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General. The manufacturer of QML printed boards, in compliance with this specification, shall have and use production and verification facilities, and a QM program to assure successful compliance with the provisions of this specification and the associated specification. Adequacy of a printed board manufacturer to meet the requirements of this specification shall be determined by the qualifying activity. Only printed boards that meet all the requirements of this specification, the associated specification and of the printed board procurement documentation shall be marked as compliant and delivered. The QML certification mark (3.8.3) indicates compliance to all the performance provisions of this specification, the associated specification and the printed board procurement documentation. The requirements described herein or in the associated specification can be addressed by the TRB by using one of three different methods as follows:

- a. As specified herein or in the associated specification.
- b. Approval by the qualifying activity of an alternate method, which addresses the same quality and reliability concerns as defined by the requirement.
- c. Demonstration to the qualifying activity and validation team, when applicable, that the requirement is not applicable to the manufacturer's technology.

3.1.1 Conflicting requirements. In the event of conflict between the requirements of this specification and other requirements of the associated specification or the qualifying activity approved QM plan, the precedence in which documents shall govern, in descending order, is as follows:

- a. The applicable printed board procurement documentation. Ordering data (see 6.2) may be provided in the purchase order or contract; however, if any of the provisions of this specification, the associated specification or the QM program are not met, the resulting printed boards cannot be provided as compliant printed boards (i.e., printed boards cannot be "QML" or "Q" branded or certified to the associated specification).
- b. The qualifying activity approved QM plan.
- c. The associated specification.
- d. This specification.
- e. Specifications, standards, and other documents referenced in section 2.

NOTE: A QML manufacturer may modify, move or eliminate the verification methods of the associated specification under special criteria defined within this specification (see 4.5 and appendix D) and as defined in the manufacturer's QM plan.

3.2 Terms and definitions. For the purposes of this specification, the terms and definitions of IPC-T-50 and those contained in 6.4 herein shall apply and shall be used in the associated specification and applicable printed board procurement documentation wherever they are pertinent.

3.3 Printed board detail requirements. The individual item requirements for printed boards delivered under this specification shall be as specified in the associated specification and documented in the printed board procurement documentation.

3.3.1 Reference to associated specification. For the purposes of this specification, when the term "specified" is used without additional reference to a specific location or document, the intended reference shall be to the associated specification.

3.4 Certification of conformance. When specified by the printed board procurement documentation (see 6.2), a certificate of conformance for compliant printed boards shall be forwarded to the acquiring activity (see 6.4.1). Unless otherwise specified by the printed board procurement documentation (see 6.2), when a certificate of conformance for compliant printed boards is supplied, it shall include the following information, as a minimum:

- a. Manufacturer's name and address.
- b. Customer's name and address.
- c. Manufacturer's CAGE code.
- d. Printed board description (associated specification number and printed board procurement documentation number).
- e. Lot date code.
- f. Quantity of printed boards in shipment from manufacturer.
- g. Statement certifying printed board conformance to the associated specification and printed board procurement documentation and traceability.
- h. The date of transaction.
- i. The name of the company official approving the certificate of conformance. The manufacturer shall have a method for authenticating the approval of certificates of conformance for printed boards compliant to this document.

3.5 Quality management (QM) program. The printed board manufacturer shall have in place or shall implement a QM program (see appendix A).

3.5.1 Manufacturer's internal review system. A dedicated system of review, for the purposes of this document hereafter referred to as the Technical Review Board (TRB), shall be responsible for the implementation of the QM program, maintenance of all certified and qualified processes, process change control, reliability data analysis, failure analysis, corrective actions, QML printed board recall procedures, and qualification status of the technology.

3.5.2 Quality management (QM) plan. The manufacturer's QM plan shall reflect the major elements of the QM program (see appendix A). The QM plan shall be kept current and reflect all major changes.

3.5.3 Change control procedures. The manufacturer shall have a system for change management. This system shall include a process to monitor changes and the assessment of those changes as to the impact to customers (see appendix A).

3.6 Requirements for listing on a QML. To be listed on the QML, the qualifying activity will verify the manufacturer's compliance to the QML certification requirements (see 3.6.1) and the manufacturer shall demonstrate compliance to the QML qualification requirements (see 3.6.2).

3.6.1 QML certification. The manufacturer shall meet the minimum procedures and requirements in this section for QML certification of a process flow by which printed boards are fabricated and inspected. The qualifying activity will determine adequacy and compliance to the requirements as specified herein and will report its findings and recommendations to the manufacturer's TRB.

3.6.1.1 QM program implementation. The manufacturer shall implement the QM program in accordance with the requirements of the approved QM plan (see appendix A).

3.6.1.2 Manufacturer self-validation. The manufacturer shall perform a self-validation to determine compliance to the QM plan (see appendix A).

3.6.1.3 Qualifying activity on-site validation. The validation process will involve a qualifying activity review of the manufacturer's QM plan and self-validation results prior to an on-site visit of the manufacturer's facility(s). The manufacturer shall demonstrate to the qualifying activity that the QM program is being implemented in accordance with the QM plan during the validation survey and with each revalidation survey. Each portion of a QML manufacturer's process flow, including contract service operations, may be demonstrated independently, but the validation survey by the qualifying activity will assess a complete technology. The qualifying activity reserves the right to perform on-site validation surveys of any facilities/technologies that the manufacturer plans to add to its QML listing.

3.6.1.4 Letter of certification. At the conclusion of the validation process, the qualifying activity will issue a letter of QML certification to the manufacturer.

3.6.1.5 Revalidation surveys. Following initial certification, a validation team will periodically inspect the printed board manufacturer's facilities and equipment, review its processes and techniques, and validate the implementation of the QM program and records. The interval between on-site revalidation surveys shall be at the discretion of the qualifying activity. The qualifying activity will determine the interval based on the manufacturer's TRB and customer feedback, and other indications of the manufacturer's maintenance of the QML system.

3.6.2 QML qualification. Printed boards furnished under this specification shall be products that are manufactured by a manufacturer authorized by the qualifying activity for listing on the applicable QML (see 4.2 and 6.3).

3.6.3 QML listing. A notification of qualification will be issued upon successful completion of the qualification process and the approval of the qualification documentation by the qualifying activity. Issuance of the notification of qualification will coincide with listing of the manufacturing facility on the QML for the applicable technology.

3.6.4 Maintenance and retention of QML. In order to sustain qualification status after initial qualification, the manufacturer shall perform periodic conformance inspection or a TRB approved alternate assessment procedure as defined in the QM plan. Retention of QML status shall also be compliant with 3.9.

3.7 Conformance inspection. All printed boards delivered in accordance with this document shall be capable of meeting all performance requirements of the associated specification and printed board procurement documentation when verified in accordance with 4.3 herein.

3.7.1 Conformance inspection assessment. In the event the TRB determines that the conformance inspection requirements are not met, the TRB shall make an assessment of the printed boards and the qualifying activity shall be notified of the decision.

3.8 Marking. Marking of compliant printed boards and their associated test coupons shall be in accordance with the following requirements and the identification and marking provisions of the printed board procurement documentation. The marking shall be permanent, legible, complete, and shall meet the marking adhesion requirements of the associated specification. If any additional marking is used or required by the printed board procurement documentation, it shall in no way interfere with the marking required herein, and shall be visibly separated. Only the QML manufacturer is authorized to apply the QML brand.

3.8.1 Full marking. Unless otherwise specified by the printed board procurement documentation, the following full marking shall be placed on each printed board and test coupon strip:

- a. "QML" or "Q" brand (see 3.8.3).
- b. Part number.
- c. Lot date code (see 3.8.4).
- d. QML manufacturer's CAGE Code (see 3.8.5).
- e. Traceability (see 3.8.6).

3.8.2 Minimum marking. When the physical size of the printed board precludes the placement of the information specified in 3.8.1, the minimum marking shall be as specified in the printed board procurement documentation. In those cases where full marking requirements are not on the printed board, the full marking shall be placed on the unit package.

3.8.3 QML brand. All printed boards acquired to and meeting the requirements of this specification, the associated specification, the printed board procurement documentation, and that are produced by manufacturers approved for listing on QML-31032 shall bear the "QML" brand. The QML brand abbreviation "Q" may be used for small printed boards. The application of the QML brand shall constitute certification by the manufacturer that all requirements of the associated specification, the printed board procurement documentation and this specification have been satisfactorily met. In the event that a lot fails to pass inspection and is not dispositioned as scrap, the manufacturer shall remove or negate the QML brand, and all reference to this document from the sample(s) and also from all printed boards represented by the sample.

3.8.3.1 Reduction of specified requirements. The "QML" brand or its abbreviation shall not be used on any printed board acquired under contracts or orders which permit or require any changes that eliminates test or inspections not specified by the approved QM program and approved by the TRB. If any exceptions are taken to this specification or the associated specification (other than approved TRB modifications, see 3.1), the "QML" or "Q" brand shall not be used.

3.8.4 Lot date code. Unless otherwise specified by the acquiring activity, printed boards shall be marked by a unique code to identify the period during which printed boards in that production lot were manufactured. The marking method used and time of application of the lot date code shall be defined by the QM program. The first two numbers in the code shall be the last two digits of the number of the year, and third and fourth numbers shall be two digits indicating the calendar week of the year. When the number of the week is a single digit, it shall be preceded by a zero. Reading from left to right or from top to bottom, the code number shall designate the year and week, in that order (e.g., 9714 equals week 14 of 1997).

3.8.5 Manufacturer's CAGE Code. The QML manufacturer's designating CAGE code number shall be used only by the manufacturer to whom it has been assigned and only on those printed boards manufactured at the manufacturer's basic plant (see 6.4.3).

3.8.6 Serialization. Unless otherwise specified by the printed board procurement documentation, each printed board and its associated test coupon shall be marked with a serial number traceable to the production panel (see 3.9).

3.9 Traceability. Traceability shall be retained by the manufacturer for a minimum of three years after delivery of the compliant printed boards, and shall be readily available for review upon request of the acquiring activity or qualifying activity.

3.9.1 Printed board materials. Traceability shall be such that for each production lot of printed boards, all printed board materials specified or used shall be traceable to a material production lot, inspection lot, or other specified grouping.

3.9.2 Process traceability. Each printed board, or each group of printed boards that has been fabricated as a production lot, shall be identifiable such that the complete manufacturing history shall be traceable. The history should include, as a minimum, the performance date of all identified production process steps, the procedure specification, any rework steps, and the identification of the equipment used and operator performing the process steps.

3.9.3 Production lot. The manufacturer shall maintain production lot traceability for all printed boards. Each test coupon shall be identifiable with those corresponding printed boards produced on the same panel. All separated individual test coupons shall have their traceability maintained back to the production panel or qualification test vehicle from which the test coupons were separated.

3.9.4 Inspection lot. Inspection lot identification shall be maintained from the time the inspection lot is formed until the lot is dispositioned. Inspection lot traceability shall be maintained to the production lots from which it was formed and shall reflect the final inspection disposition of all printed boards in the inspection lot.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

- a. Qualification inspection (see 4.2).
- b. Conformance inspection (see 4.3).

4.2 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the qualifying activity (see E.5.2) on qualification test vehicles produced with material, equipment, and procedures that will be used in subsequent production. Qualification inspection shall be performed in accordance with the requirements of appendix B.

4.3 Conformance inspection. Conformance inspection shall demonstrate the printed boards conform to the performance requirements of the associated specification and the design requirements of the printed board procurement documentation. The requirements concerning conformance inspection shall be as specified in appendix C.

4.4 Process control. The manufacturer shall establish and maintain process production controls, quality controls and inspections at appropriately located points in the manufacturing process in accordance with the approved QM plan to assure continuous control of quality of materials, individual layers and assembled layers including contract service operations and testing. These controls and inspections shall be adequate to assure compliance with the printed board procurement documentation and quality requirements of printed boards manufactured to this specification and the associated specification.

4.4.1 Process monitoring. A process monitoring system shall be used by the manufacturer to control key processing steps to insure product yield and process reliability. The monitoring system can use various test vehicles, methods and measurement techniques. The critical operations to be monitored shall be determined by the manufacturer based on its experience and knowledge of its processes. The resulting data shall be analyzed by appropriate process control methods to determine control effectiveness.

4.5 Test optimization. Unless otherwise specified by the printed board procurement documentation, any specified verification test or inspection may be reduced, modified, moved or eliminated by the TRB provided the final printed board requirements are met. Regardless of any verification modifications, the manufacturer shall supply printed boards capable of passing any test or inspection prescribed in the applicable associated specification. Appendix D provides guidelines for test optimization.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be as specified in the printed board procurement documentation.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. Printed boards conforming to this specification are intended primarily for use in electronic and electrical equipment applications.

6.2 Acquisition requirements. Acquisition requirements should be in accordance with the associated specification and the printed board procurement documentation.

6.3 Certification and qualification.

6.3.1 Application for certification. Application for certification should be requested from the qualifying activity. For assistance and additional information concerning the certification process, please contact DESC-ELST, 1507 Wilmington Pike, Dayton, OH 45444-5764; or by facsimile (513) 296-6870.

6.3.2 Qualification. The activity responsible for QML-31032 is the Defense Electronics Supply Center, ATTN: DESC-ELST, 1507 Wilmington Pike, Dayton, OH 45444-5764. Additional qualification information is available from the qualifying activity.

6.3.3 Discussion. The foundation of QML is the instillment of quality management (QM) within the manufacturing environment. QM requires that all levels of management and non-management be actively involved in the commitment to quality. Also, a Technical Review Board (TRB) or TRB type system must be established to control, stabilize, monitor and improve the qualified technology. The TRB should have a QM plan that outlines how the manufacturing operation for a given technology is controlled, monitored, and improved. Key aspects of this plan are the establishment of process control, customer return programs, corrective action procedures, quality improvement and any other approaches used to control and improve printed board quality.

This document describes procedures and requirements for manufacturer's listing on QML-31032 for printed boards. The QML program enables the manufacturer to produce printed boards without the need for extensive end-of-manufacturing qualification testing and quality conformance inspection on each printed board design. End-of-manufacturing verification testing can be replaced with in-line monitoring and testing and process controls. Also, test vehicles in lieu of actual printed boards, such as the conformance inspection vehicle can be used to assess the technology.

The quality management philosophy, leading to QML, is a process by which a manufacturer acquires a process flow certification and qualification. Ongoing monitoring techniques will be used to maintain QML status. The process flow consists of facilities and procedures appropriate to accomplish the conversion of customer requirements, fabrication and testing of printed boards.

The associated specification identifies the generic performance requirements and the baseline tests and inspections used to verify each lot of printed boards. These tests and inspections can be reduced or changed by the manufacturers' TRB when data on the technology indicates that such changes are appropriate. The philosophy of QML incorporates the idea that high quality printed boards can be obtained without excessive testing or inspecting if the processes are properly monitored and controlled at each step of the process flow.

6.3.3.1 Validation process. Qualifying activity approval of the manufacturers's QM plan and program will result in QML certification and is a mandatory precondition to a QML-31032 listing. During the on-site validation, the qualifying activity will verify the adequacy of the manufacturer's QM program to achieve at least the same level of oversight as could be achieved by complying with appendix A.

6.3.4 Application of the QML program to other specifications or documents. MIL-PRF-31032 certified manufacturers may supply QML compliant printed boards to documents or drawings specifying QPL compliance, provided that they are qualified to the same technology (see 6.4.36) under a MIL-PRF-31032 associated specification and meet or exceed the design complexity for that specified QPL technology. The manufacturer should not claim or certify compliance to the QPL document, unless the printed boards are completely compliant to the QPL document requirements.

6.4 Terms and definitions.

6.4.1 Acquiring activity. The organizational element of the Government that contracts for articles, supplies, or services which may authorize a contractor or subcontractor to be its agent.

6.4.2 Associated specification. The associated specification specifies the characteristics to be tested (i.e., the visual, dimensional, chemical, mechanical, electrical and environmental performance requirements), the test methods and conditions (for verification) to be used and the requirements to be fulfilled for testing capability. The associated specification can be a MIL-PRF-31032 associated specification, an existing Department of Defense printed board specification, an older revision of an Department of Defense printed board specification, or a Non-Government Standard.

6.4.3 Basic plant. The basic plant is the QML listed facility(s) that assumes full responsibility for all aspects of production and quality. In the event that any portion of production or test is performed at or by a facility other than the basic plant, the basic plant will take whatever actions are necessary to assure the outside activity continually meets the QM plan requirements.

6.4.4 Certification. The process (including validation) by which the qualifying activity determines that the manufacturer is eligible to qualify.

6.4.5 Compliant printed board. Compliant printed boards meet all the requirements (including qualification) specified in the associated specification and printed board procurement documentation.

6.4.6 Conformance inspection vehicle. The test vehicle that is used to perform periodic conformance inspection. The conformance inspection vehicles do not have to be a part of a printed board or reside at a specific panel location, however, they can be incorporated into panels, within printed boards, exist separately, or any combination thereof.

6.4.7 Contract services. Any fabrication or testing performed outside the basic plant.

6.4.7.1 Fabrication. Contract services may be used to perform fabricating steps in accordance with processing procedures contained in the QM plan.

6.4.7.2 Test laboratory. Test or inspection facilities outside the basic plant may be used to perform lot conformance, periodic conformance and qualification testing.

6.4.8 Conversion of customer requirements (into manufacturer's internal instructions). A system where the manufacturer compares the customer's requirements to its in-house capabilities (with a feedback system to the design activity) and then initiates actions to deliver printed boards which meet the customer's needs.

6.4.9 Data. Factual information (measurements and/or statistics) recorded as evidence of capabilities and conformance to the prescribed limits. Physical data also may include physical evidence, such as tested (used) and unused test coupons or microsection mounts.

6.4.10 Facility. An organizational structure and collection of designated documentation, services, fabrication and test equipment used to support the manufacturing, testing and shipping of printed boards in accordance with a specific process flow.

6.4.11 Failure analysis. The process of examining printed boards to determine the cause of variations of characteristics found to be outside the required limits with the end result that failure modes, failure mechanisms, and failure activating causes will be identified.

6.4.11.1 Failure activating cause. The stresses or forces (chemical, electrical, environmental, physical, etc.,) which induce or activate a failure mechanism.

6.4.11.2 Failure mechanism. The process of degradation or chain of events which results in a particular failure mode.

6.4.12 Inspection lot. An inspection lot consists of a single or multiple production lots, accumulated over not more than 30 calendar days, offered for inspection at one time.

6.4.13 Lot conformance inspection. The inspections or tests that are performed for final lot acceptance on each inspection lot of printed boards. The detailed requirements for the lot conformance inspection tests are specified in the associated specification.

6.4.14 Noncompliant printed board. Printed boards produced to acquisition documents that take exception to any of the requirements, inspections, and tests specified herein and in the associated specification that are not specifically detailed and approved in the QM plan. Noncompliant printed boards cannot make reference to this document or to compliant printed board certification brands.

6.4.15 Percent defective allowable. Percent defective allowable is the maximum observed percent defective which will permit the lot to be accepted after the specified 100 percent inspection.

6.4.16 Periodic conformance inspection. The TRB scheduled periodic process control, process monitor, visual inspection or associated specification tests used to demonstrate and evaluate the process and technology in accordance with the manufacturer's approved QM plan. The test vehicle to be used, the parameters to be measured, the frequency of measurement, the number of sample measurements, the conditions of measurement, and the analysis of measurement data will vary as a function of the requirements, capability and criticality of the operation being measured.

6.4.17 Printed board part number. The term printed board part number refers to a printed circuit or wiring board of a single specific part number and classification for a printed board configuration. All samples of a printed board part number are to be electrically and functionally interchangeable with each other, have the same electrical and environmental test limits and use the same basic raw materials, and fabrication processes.

6.4.18 Printed board procurement documentation. Printed board procurement documentation consists of the purchase order or contract, the master drawing or detail specification or documentation, production drawings, artwork, or electronic database, as applicable. In the event of conflict between the purchase order or contract and the printed board master drawing, the purchase order or contract takes precedence. If the written purchase order and contract do not agree, the purchase order takes precedence.

6.4.19 Procedure. Documented steps of a process.

6.4.20 Process. Individual operations involved in the production of printed boards (i.e., conversion of customer requirements, manufacturing, rework, testing, and shipping).

6.4.21 Process control. Process control is the overall system in place to assure consistent process results. Examples of process control include documented procedures, operator training, equipment maintenance and calibration, verification of specified operating parameters (i.e., temperature, pressure, etc.). statistical techniques and process monitors.

6.4.22 Process flow. A process flow is that specific manufacturing line from conversion of customer requirements to shipping.

6.4.23 Process flow documentation index. A list of the specification or procedure titles, document numbers, and revisions which defines the QM program.

6.4.24 Process monitor. Process monitors are the physical verification of a operational parameter of a process output (i.e., plating thickness, ionic contamination, solder coat coverage, etc.).

6.4.25 Production lot. A production lot consists of panels of printed boards formed into lots at the start of printed board or, when applicable, panel fabrication for homogeneous processing as a group; i.e., same basic raw materials on the same production line, processed under the same manufacturing techniques and controls using the same type of equipment. Processing panels as a homogeneous group is accomplished by any of the following procedures, providing process schedules and controls are sufficiently maintained to assure identical processing in accordance with process instructions of all panels in the lot:

- a. Batch processing of all panels in the lot through the same equipment, machine or process steps simultaneously.
- b. Continuous or sequential processing (panel by panel or batch portions of panels) through the same equipment, machine or process steps.
- c. Parallel processing of portions of a production lot through multiple machines or process stations on the same process flow, provided process control assures and demonstrates correlation between stations and separately processed portions of the production lot.

6.4.26 QML. A list of manufacturers, by name and plant address, who have met the certification and qualification requirements stated herein. The listing includes identification of materials and processes. QML is the accepted abbreviation for the term Qualified Manufacturers List.

6.4.27 Qualification. The process by which a manufacturer demonstrates capability to produce a given technology.

6.4.27.1 Add-on qualification. The use of the qualification process to expand the QML listing for additional technologies.

6.4.28 Qualification test vehicle. Qualification test vehicles are manufacturer defined specimens used to simulate the production processes, materials, and construction techniques used in the manufacture of actual printed boards. Qualification test vehicles are defined based on the manufacturer's assessment of the most critical fabrication and material technologies. Qualification test vehicles can be actual production printed boards, test coupons specifically designed for this purpose, or other media used to establish the printed board manufacturer's capabilities. Qualification test vehicle are to be manufactured in an actual production environment by trained personnel using certified production methods and procedures with proper traceability records.

6.4.29 Qualifying activity. The preparing activity or its delegated agent that grants certification and qualification status to QML-31032.

6.4.30 Quality assurance. Quality assurance is a planned and systematic pattern of all actions necessary to provide confidence that products and services conform to the established technical requirements.

6.4.31 Quality management plan (QM plan). Document(s) which describe the manufacturer's quality policies and the means to accomplish those policies. The QM plan provides an overview of each aspect of the quality system and references the applicable internal procedures.

6.4.32 Quality management program (QM program). The TRB administered program for the interpretation of the requirements of this document and the associated specification.

6.4.33 Rework. The act of repeating one or more manufacturing operations, or performing alternative techniques in order to bring a product into compliance with applicable drawings and specifications.

6.4.34 Repair. The act of restoring the functional characteristics of a defective product without restoring the compliance with applicable drawing or specifications.

6.4.35 Self-validation. The performance of a periodic survey by the printed board manufacturer's designated personnel to evaluate compliance to the QM plan.

6.4.36 Technology. The materials, processes and design used to manufacture printed boards.

6.4.37 Technical Review Board. The organization(s) identified to develop and implement the QM plan.

6.4.38 Test optimization. The process used by the manufacturer to modify, reduce or eliminate testing using the best commercial practices available while still assuring all specified performance, quality and reliability requirements are met.

6.4.39 Validation survey. A step in the certification process by which a validation team determines on the basis of a on-site audit that a manufacturer's process flows are in compliance with the applicable requirements.

6.4.40 Validation team. Selected representatives from the Government (military services, preparing activity, qualifying activity or other government agencies) and industry (OEMs, customers, etc..) involved with certification activities.

6.5 Associated specification. The specific performance and baseline verification requirements for a printed board technology are specified in the associated specification for a particular technology and will be upgraded periodically to reflect the current state-of-the-art printed boards. Since this document covers the general requirements for certification and qualification of manufacturers, the items listed below should be covered in any associated specification that is used in conjunction with this document:

- a. Printed board classification technology designation.
- b. Performance requirements.
- c. Classification of inspection.
 - (1) Tests and inspections to be performed under qualification inspection.
 - (2) Tests and inspections to be performed under lot conformance inspection.
 - (3) Tests and inspections to be performed under periodic conformance inspection.
- d. Sequence of test, test method, test condition, limit, cycles, temperature, etc., when not specified, or if not specified in the applicable test method.
- e. Provisions for percent defective allowable, where applicable.

6.5.1 Substitutability. Printed boards that are processed and verified using an approved QM program, with procuring activity approval, are substitutable for QPL printed wiring boards of a similar technology, provided all design related parameters specified by the printed board procurement documentation (such as the physical dimensions, base material type and thickness, metal foil type, surface finish, etc.) are the same. The substitutable printed wiring boards are marked with the "QML" or "Q" certification brand, unless otherwise specified in the contract or purchase order.

6.5.2 Quality and reliability. Printed boards compliant to MIL-PRF-31032 associated specifications are required to meet or exceed the quality and reliability of Department of Defense specifications, such as MIL-P-55110, MIL-P-50884, MIL-P-55640, or MIL-P-82585. Printed boards compliant to MIL-PRF-31032 associated specifications are processed through the conversion of customer requirements (see 6.4.8 and A.4.4) system of this document to meet or exceed every individual performance requirements or acceptance criteria specified by the customer.

6.6 Printed board procurement documentation. The detailed master drawing portion of the printed board procurement documentation that describes the particular design, construction and materials should comply with the applicable documentation class of the applicable design standard or documentation with any printed board procured under this specification.

6.7 Subject term (key word) listing.

Certification
Lot conformance inspection
Panel acceptance plan
Conformance inspection vehicle
Periodic conformance inspection
Qualified Manufacturer Listing (QML)
Quality management (QM)
Technology Review Board (TRB)
Validation

THE QUALITY MANAGEMENT (QM) PROGRAM

A.1. SCOPE

A.1.1 Scope. This appendix is intended to be used by manufacturers in developing a QM program and cross-referencing its QM plan. The quality management program should demonstrate the methods used to assure conformance to the applicable requirements of this document, including the performance requirements and verification methods of the associated specification. Compliance with this appendix is not mandatory. However, manufacturers must be able to demonstrate a quality management system that achieves at least the same level of control as could be achieved by complying with this appendix.

A.2. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

A.3. QUALITY MANAGEMENT (QM) PROGRAM.

A.3.1 General. The printed board manufacturer should develop, implement and maintain a QM program in order to become eligible to be a qualified manufacturer of printed boards. The QM program should be tailored to the peculiarities of the manufacturer's over-all method of operation, but as a minimum, comply with the applicable requirements specified in A.3.2. The QM program should be documented in the QM plan.

A.3.2 QM plan. The QM plan should include the manufacturer's interpretation of how each requirement of this specification will be implemented. The QM plan detailing the QM program should be cross-referenced to the QM plan outline of A.3.2.1.

A.3.2.1 QM plan outline. The following should be addressed in the QM plan:

- a. TRB system, including structure, duties and methods (see A.4.1).
- b. Process flow (see A.4.2).
- c. Process flow documentation index (see 6.4.23).
- d. Functional organization chart (see A.4.3).
- e. Conversion of customer requirements (see A.4.4).
- f. Self-validation (see A.4.5).
- g. QML status summary and TRB reporting (see A.4.6).
- h. Documentation and data retention, storage and disposition (see 3.9).
- i. Continuous improvement (see A.4.7).
- j. Failure analysis (see A.4.8).
- k. Process control (see A.4.9).
- l. Corrective action (see A.4.10).
- m. Change control (see A.5).
- n. List of verification test and inspection methods.
 - 1. Test methods which will be performed at the basic plant.
 - 2. Test methods which will be performed at an outside test facility.
- o. Qualification testing (see A.4.11).
- p. Periodic conformance inspection (see A.4.12).
- q. Calibration (see E.5.1).
- r. Training (see A.4.13).
- s. Contract services (see A.4.14).

APPENDIX A

A.3.3 Change to the QM plan. After the TRB has approved the QM plan, it should be kept current and reflect all major changes. This includes updating the process flow. The TRB should not implement any change in certified material, process, or process flow (see 6.4.22) without concurrent change to the process control or quality assurance documents listed in the approved process flow documentation index (see 6.4.23).

A.4 QM PLAN DETAILS

A.4.1 Technical Review Board (TRB). The manufacturer should establish a TRB and develop the necessary procedures to govern its operation. The manufacturer will be responsible for ensuring that the actions of the TRB result in printed boards that meet all customer and performance requirements. As a minimum, the TRB operating procedure should address the following:

- a. Minimum organizational membership (see A.4.1.1).
- b. Duties and responsibilities (see A.4.1.2).

A.4.1.1 Organizational structure. The manufacturer's TRB should insure communication is established and maintained among representatives from conversion of customer requirements, technology development, fabrication, testing, quality assurance and contract service organizations. Records of the TRB deliberations and decisions should be maintained. These records should be made available to the qualifying activity.

A.4.1.2 Duties. The manufacturer's TRB should have methods in place for assessing the current status of the quality of its printed boards by review of the process control procedures and QM status of the manufacturer's process technology, test data (i.e., conformance inspection vehicle), the rate of printed board or lot failure, and the failure analysis results of printed board or lot failures and customer returns. The TRB should maintain records, available for qualifying activity review, of conditions found and the actions taken. The TRB should periodically inform the qualifying activity on the status of the QML technology and products. The TRB should also address the impact of key managerial/TRB personnel changes and business plans in order to evaluate any impact they may have on the QM program. When the quality data is called into question or indicates corrective action is required, the TRB should oversee evaluation and corrective action to preserve the manufacturer's qualified status and assure that defective printed boards are not shipped.

A.4.2 Process flow (see 6.4.22). All processes in the flow should be defined by documented procedures.

A.4.2.1 Rework. Rework operations should be controlled, documented and recorded in an equivalent manner to other processes.

A.4.3 Functional organization chart. This chart should show the lines of authority and responsibility of any organization associated with the QM program, including the TRB, quality assurance, and production organizations (including names of TRB members).

A.4.4 Conversion of customer requirements. This plan should establish the system for converting requirements in the printed board procurement documentation into the manufacturer's internal instructions and tools. The conversion of customer requirements plan should address the following:

- a. Printed board procurement documentation requirements.
- b. Associated specification requirements.
- c. Printed board design review procedures (established geometric, electrical, and design rules).
- d. Phototool generation procedure (see A.4.4.1).
- e. Testing capabilities.
- f. Printed boards built in accordance with approved process flow (certification).
- g. QML listing coverage (qualification).
- h. Lot conformance inspection procedures.
- i. Incoming inspection and vendor procurement documentation (see A.4.4.2).
- j. Traveler.
- k. Marking (see 3.8).
- l. Rework (see A.4.2.1).
- m. Printed board-to-test coupon correlation (see A.4.4.3).

APPENDIX A

A.4.4.1 Phototool requirements (when applicable). The phototooling used in the production of printed boards or panels should conform to the requirements of the printed board procurement documentation.

A.4.4.1.1 Production master. The acquiring activity 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 data base is provided to the printed board manufacturer. The printed board manufacturer should insure that the finished printed board conforms to the specified printed board detail requirements (see 3.3).

A.4.4.1.2 Panelization requirements. The panel position of test coupons should be as specified by the design standard specified by the printed board procurement documentation or TRB developed panel acceptance plan. Acquiring activity supplied phototooling not having the required number, proper placement of test coupons or having test coupons that do not conform to design parameters should be reprocessed to correct any deficiencies.

A.4.4.2 Incoming inspection. Procedures should be in place to insure conformance of the printed board material to the applicable printed board material acquisition documents or material specifications. Inspection reports, certificates of compliance and test data should be maintained on file for review by the qualifying activity.

A.4.4.2.1 Printed board material evaluation. Printed board material evaluation should be successfully completed prior to use in the production of printed boards. Printed board material acquisition documents should identify the printed board material characteristics required to assure printed board performance and fabrication or process capability.

A.4.4.2.2 Storage. The storage conditions (e.g., temperature, relative humidity, etc.) and length of storage time before reinspection of printed board materials used in compliant printed board fabrication should be in accordance with the vendor or material suppliers recommended storage instructions.

A.4.4.3 Test coupons. Test coupons should be evaluated for printed board representation during the conversion of customer requirements process. A method or procedure to verify correlation between test coupons and actual printed boards and panels should be approved by the TRB. A documented correlation between the test coupon and the printed boards it represents should be completed during conversion of customer's requirement to ensure proper printed board representation by the test coupon. This is necessary because of the printed boards variabilities introduced by test coupon location, design, and the panel processing. Selection of test coupons for testing should be in accordance with either the associated specification or an approved TRB developed panel acceptance plan. Acquiring activity requested test coupons (to be delivered with the shipment of printed boards) need to be added to the panel so as to increase total number of test coupons available; i.e., should be in addition to the minimum requirements stated in the associated specification, and do not count to satisfy the minimum number needed to perform lot conformance inspection. Acquiring activity furnished test coupons (unique design parameters) may not be capable of verifying the performance requirements of the associated specification.

A.4.5 Self-validation. This plan should establish the procedures, frequency and checklists used by the manufacturer to determine compliance to the QM program. The plan should cover, as a minimum, all items in the QM plan.

A.4.6 QML status. The manufacturer's TRB should make available data to the qualifying activity describing the condition of the QML manufacturer's process flow. The information in the QML status summary may be addressed in various ways, such as, copies of TRB meeting minutes, summary of major actions, etc. The following areas should be discussed and updated in each QML status:

- a. Summary of TRB activity.
- b. Self-validation results.
- c. Continuous improvement update.
- d. Process control.
- e. Corrective actions.
- f. Fabrication facility.
- g. Test facility.
- h. QML compliant printed boards shipped.

APPENDIX A

- i. Customer returns.
- j. Summary of inspection lot data, including part fallout and lot rejection.
- k. Summary of periodic conformance inspection and conformance inspection vehicle assessment.
- l. Future business plans.

The frequency of the QML status summary to the qualifying activity will be determined by the TRB, but should be as a minimum quarterly for the first year following the attainment of QML.

A.4.7 Continuous improvement. This plan should document the specific procedures to be followed by the manufacturer to assure continuous improvement in quality, and reliability of the process and the printed boards being produced.

A.4.8 Failure analysis. This plan should establish the procedures that a manufacturer self-imposes to test and analyze failed printed boards from all stages of manufacturing and/or customer returns. This plan should also identify corrective actions or specify the use of a corrective action plan based on the findings of the failure analysis.

A.4.9 Process control. This system should include goals and plans of implementation and measurement points (including location on applicable flow charts). This plan should define how all processes are controlled, including use of statistical tools, as applicable (see 4.4).

A.4.10 Corrective action. This plan should specify the steps followed by the manufacturer to correct any problems or process that is out-of-control or found to be defective.

A.4.11 Qualification process procedure. The manufacturer should establish a qualification process procedure which describes the qualification process and assigns responsibility for each activity. The procedure should include as a minimum:

- a. Development and documentation (i.e., drawings, travelers) of test vehicles.
- b. Testing sequences and conditions.
- c. Sample sizes and selection.
- d. Data recording and retention.
- e. Use of extra test vehicles for spares.
- f. Failure analysis and corrective action.
- g. Resubmission criteria.
- h. Reporting.

A.4.12 Periodic conformance inspection (see appendix C). This plan should be used as a tool for monitoring the quality and reliability of the manufacturer's technology and processes. The plan should address the test vehicles to be used, the parameters to be measured, the frequency of measurement, the number of sample measurements, the methods of measurement, and the analysis of resulting data.

A.4.13 Training. The training and testing practices, employed to establish, evaluate, and maintain the skills of personnel engaged in production, testing or inspection should be documented as to form, content and frequency. The manufacturer should define training requirements which assure operator knowledge of internal standards and proficiency to perform assigned tasks. The methods of updating operators to changes in internal standards and to assure continued proficiency should be addressed. Records showing the basis of operator acceptability should be on file including instruction and evaluations received. Records are required only for product related training as distinguished from safety, first aid, etc.

A.4.14 Contract services. This plan should specify how the manufacturer selects and monitors contract services. The plan should describe what actions are to be taken to assure the contract service continually meets the QM plan requirements.

A.5. CHANGE CONTROL.

A.5.1 General. The change control plan should describe the process by which a manufacturer monitors and addresses changes to the QML program and technology.

A.5.1.1 Change assessment. All changes to any certified part of a printed board manufacturer's process flow are to be governed by the manufacturer's TRB and made available for review by the qualifying activity. All changes should be documented as to the reason for the change with supporting data taken to justify the change, as appropriate. The decision as to the criticality of the change should be guided by the potential effect of the change on quality and performance of the resulting printed boards. For any change that merits consideration for requalification, the TRB and qualifying activity should decide if requalification is needed. Printed boards can be shipped following a change only upon approval of the TRB.

A.5.1.2 Classification of changes. Unless otherwise specified, changes should be categorized into either major or minor changes. The classification of changes should be as follows:

- a. Major: Major changes are those changes that may affect the performance, quality or reliability of the printed board. Major changes also include changes to the QM plan.
- b. Minor: Minor changes are changes that do not affect performance, quality of the printed board or are editorial in nature.

A.5.1.3 Change notification. Notification of major changes should be made concurrently to the qualifying activity. A summary of all other changes should be made in the QML status (see A.4.6).

A.5.2 Change control concerns and considerations. The following paragraphs outline areas of concern where a change may require action by the printed board manufacturer. These lists provide examples and are not all-inclusive.

A.5.2.1 Fabrication change.

- a. Fabrication process sequence or process limits.
- b. Fabrication process materials and chemicals or material and chemical specifications.
- c. Fabrication equipment or machines.
- d. Printed board materials (base materials, metal foils, finishes, adhesives, etc.).
- e. Process flow.
- f. Physical relocation of fabrication equipment.
- g. Addition of new fabrication.
- h. Additional contract services for fabrication processes.

A.5.2.2 Test or inspection change.

- a. Sample plans and lot formation.
- b. Lot conformance inspection procedures including manufacturer imposed tests.
- c. Periodic conformance inspection procedures including conformance inspection vehicle and how they are tested.
- d. Test and inspection procedures.
- e. Testing flow.

A.5.2.3 Test facility change.

- a. Physical relocation of test equipment.
- b. Addition of or change to a new test facility or equipment.

A.5.2.4 Miscellaneous changes.

- a. Key managerial (corporate and TRB) changes.
- b. Business plans (mergers, new technologies).
- c. Calibration procedures.

QUALIFICATION

B.1 SCOPE

B.1.1 Scope. This appendix establishes general requirements applicable to initial qualification and the qualification of additions and changes to materials and processes. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

B.2. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

B.3. QUALIFICATION.

B.3.1 General. Qualification testing shall be performed on qualification test vehicles that will demonstrate the manufacturers technology and processes. Capabilities listed on the QML will be for those materials and processes that are actually tested.

B.3.1.1 Qualification test vehicles. All certified processes and materials must be qualified. The manufacturer shall produce qualification test vehicles using the certified process flow and the specified technologies. The qualification test vehicles shall be manufactured in an actual production environment by trained personnel using approved methods and procedures with proper traceability records. The qualification test vehicles shall be of such complexity as to be representative of the technology to be supplied by the manufacturer.

B.3.2 Tests and inspections. Tests, test conditions, and sample sizes will be as specified in the associated specification. Additional or reduced testing, as may be dictated by the uniqueness of a particular technology or qualification requirements of the associated specification, may be authorized by the qualifying activity.

B.3.3 Initial qualification.

B.3.3.1 Qualification eligibility. The fabrication and testing of the qualification test vehicles may begin before certification is granted (see B.3.3.2). However retesting may be necessary if deficiencies and concerns found during the validation survey required changes to the process flows, fabrication, or tests and inspections.

B.3.3.2 Testing performed prior to certification. Tests or inspections performed prior to certification may be used to attain a QML listing provided the test vehicles used are representative of the certified technology.

B.3.3.3 Procedure. If existing data is not available to gain QML listing, then the manufacturer must begin production of the qualification test vehicle(s) upon receipt of certification. A test plan will be approved by the qualifying activity at the time of certification.

B.3.3.4 Non-qualification of a certified technology. The TRB shall notify the qualifying activity of any decision not to pursue qualification of any technology previously certified.

B.3.4 Data retention. All records that supports the results of qualification testing (production travellers and test data or results, including failure analysis, if applicable) shall be retained in accordance with 3.9.

B.3.5 Custom technologies qualifications. When an associated specification does not exist for a technology, the TRB can develop a test plan, acceptability requirements, etc., necessary for certification and qualification.

B.3.6 Add-on qualifications. When using add-on qualifications (see 6.4.27.1) the manufacturer may elect not to gain a specific test plan approval prior to qualification testing from the qualifying activity provided the TRB has approved the qualification process procedure plan. After successful completion of the add-on qualification tests and TRB approval of the qualification tests results, the remaining printed boards from the lot will be shippable. The qualifying activity will need to be notified of the results of the add-on qualification so that the added processes, capabilities, or technologies can be listed on the QML.

B.3.7 Qualification failures.

B.3.7.1 Resubmission of failed samples or lots (or both). Unless otherwise specified, resubmission of failed samples or additional samples from the same production lot are not allowed unless such failures are due to equipment or operator errors. Notification of the qualifying activity is required.

B.3.7.2 Corrective actions. If any sample fails a test or inspection, the manufacturer shall perform failure analysis, take necessary corrective action and adjust the process until new samples pass all tests and inspections. Notification of such adjustments or changes must be given to the qualifying activity in a timely manner (see A.5.1).

B.3.8 Qualification test plans. The manufacturer must develop a specific test plan for each qualification. The plan will be made in accordance with the qualification process procedure. The qualification test plan must state what design and manufacturing parameters that the qualification test vehicle represents. The plan must include as a minimum:

- a. Description of the test vehicle (i.e., drawing and traveler).
- b. Test sequence including conditions and sample size (requirement may be met with a test traveler).
- c. Proposed QML listing.
- d. Identification of test facilities.
- e. Milestone chart of event dates.
- f. Statement that the vehicle will be built in accordance with the manufacturer's conversion of customer's requirements and certified flow.

B.3.9 Qualification test data. The TRB should present to the qualifying activity a comprehensive analysis of the qualification data. The aim of this analysis is to show that the manufacturer is capable of producing the technology. Detailed limits and conditions for each verification method used should be clearly identified and recorded. Test vehicles used for destructive tests should be presented to the qualifying activity with the testing results. The following data should be retained by the manufacturer to support the results:

- a. Production and test travelers.
- b. Results from each subgroup test conducted, both initial and any resubmissions.
- c. Number of qualification test vehicles tested and rejected.
- d. Failure mode and mechanism for each rejected qualification test vehicle.
- e. Read and record variable data on all specified dimensional or electrical parameter measurements.

B.3.10 Qualification by similarity. Upon approval of the qualification test report by the qualifying activity, printed boards that are fabricated with the same materials, and processes and within the process parameters and material dimension windows defined in the associated specification shall be considered qualified by similarity.

CONFORMANCE INSPECTION

C.1 SCOPE

C.1.1 Scope. This appendix establishes general requirements applicable to conformance inspection. Conformance inspection covers both lot conformance inspection and periodic conformance inspection. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

C.2. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

C.3 LOT CONFORMANCE INSPECTION.

C.3.1 Lot conformance inspection. Lot conformance inspection testing shall be performed by the manufacturer on each inspection lot to assure that the printed boards meet the requirements of the associated specification and printed board procurement documentation. Printed boards shall not be accepted or approved for delivery until all applicable performance requirements have been verified.

C.3.2 Percent defective allowable (PDA). When the total number of failed/rejected printed boards or panels from an inspection lot for a specific defect exceeds the specified percent defective allowable limit for that particular test routine, subgroup or inspection, then the entire inspection lot shall be rejected.

C.3.2.1 Rejected lots. Once an inspection lot has been rejected the panels or printed boards must be evaluated and corrective action, approved by the TRB, shall be taken. Any panels or printed boards further determined as failures shall not be shipped as compliant printed boards. Traceability history must reflect actions taken to printed boards or justification if any of the printed boards are shipped.

C.3.3 Panel acceptance. The tests to be performed for panel acceptance shall be as specified in the associated specification.

C.3.3.1 Failures. Any test coupon that fails any panel acceptance requirements shall result in the printed boards represented by that test coupons to be removed from the lot.

C.3.4 100 percent inspections. The tests to be performed for 100 percent inspection shall be as specified in the associated specification.

C.3.4.1 Failures. Printed boards or test coupons that fail to meet the requirements of any of the tests listed in the 100 percent inspections of the associated specification, shall be removed from the lot and considered as non-compliant.

C.3.5 Sample test inspections. The tests to be performed for sample inspection shall be as specified in the associated specification.

C.3.5.1 Sampling. Samples must be randomly selected from the entire inspection lot. The number of printed boards or test coupons to be tested or inspected shall in accordance with the applicable requirements of appendix E.

C.3.5.2 Rejected lots. If an inspection lot is rejected, the manufacturer may screen out the defective units and resubmit the lot for reinspection.

C.3.5.3 Resubmission of rejected lots. Resubmitted lots shall be kept separate from new lots and shall be clearly identified as resubmitted lots. When any lot submitted for lot conformance inspection fails any subgroup requirement, it may be resubmitted once for that particular subgroup using tightened inspection criteria as defined in appendix E. A second resubmission using tightened inspection criteria is permitted only if failure analysis is performed to determine the failure mechanism for each failed printed board from the prior submissions and it is determined that the failure is due to:

- a. A defect that can be effectively removed by an additional 100 percent inspection or test of the entire lot.
- b. Random type defects which do not reflect printed board design or processing procedures.

In all instances where failure analysis of the failed printed boards indicates that the failure mechanism is due to processing procedures, a design fault or nonscreenable defects, the lot shall not be resubmitted.

APPENDIX C

C.4 PERIODIC CONFORMANCE INSPECTION.

C.4.1 Periodic conformance inspection. Periodic conformance inspection shall be accomplished by the manufacturer as defined in the associated specification. A manufacturer's normal production tests, environmental tests, and so forth, may be used to fulfill all or part of periodic conformance inspection specified in the associated specification.

C.4.2 Periodic conformance inspection program. Periodic conformance inspection or alternate assessment program shall be implemented by the manufacturer for each technology. The periodic conformance inspection program shall be designed to be used for the purposes of quality monitoring and change control evaluation. The periodic conformance inspection program shall address the following concerns:

- a. General. The periodic conformance inspection program shall indicate what the conformance inspection vehicles are, where they are located and how they are tested and analyzed. The processes or operations to be monitored shall be determined by the manufacturer based on its experience and knowledge of its processes. The criteria for evaluating conformance inspection vehicle(s) shall be determined by the TRB based on the manufacturer's assessment of risk.
- b. Frequency. The TRB shall determine when such periodic conformance inspection should be performed based on the frequencies listed in the associated specification.
- c. Methods. The periodic conformance inspection program can use various test vehicles, methods and measurement techniques listed in the associated specification.
- d. Data and report. Periodic conformance inspection data, including failure analysis results, shall be available for review by the qualifying activity or validation team.
- e. Failures. Periodic conformance inspection failures do not automatically fail or disqualify a lot of printed boards when trends or limits require corrective action, however, failure analysis shall be performed on all failed conformance inspection vehicle(s) and actions taken to correct any problems found.

C.4.3 Conformance inspection vehicle. Conformance inspection vehicle(s), used for the periodic conformance inspection program, are designed for their role as a quality and reliability monitoring vehicle. The conformance inspection vehicle can be incorporated into the panel as a dedicated test coupon, be within a printed board, exist as a separate test vehicle, or any combination thereof. The conformance inspection vehicle(s) shall comply with the following requirements:

- a. Documentation. Documentation procedures for conformance inspection vehicle(s) shall be the same as for production printed boards. Documentation of the conformance inspection vehicle(s) shall also include the design, design rules, test procedures and process rules.
- b. Complexity. The complexity of the conformance inspection vehicle shall reflect, as a minimum, the functionality of the process and technology characteristics.
- c. Design. The conformance inspection vehicle must exercise the worst-case design rules. The conformance inspection vehicle shall be designed to stress the applicable geometric, electrical or mechanical design rules. The electrical and mechanical stress requirements for interconnects shall be worst case conditions. The architecture of the conformance inspection vehicle shall be designed so that failures can be easily diagnosed.
- d. Quantity and location. The number of conformance inspection vehicle(s) required and their locations (panel, printed board, or test vehicle) shall be as specified in the QM plan.

NOTE: Different conformance inspection vehicle(s) may be required whenever the technology, materials, design rules, processes, or the basic functionality of the technology differs.

C.4.4 Disposition of conformance inspection vehicle. Conformance inspection vehicle(s) which have been subjected to periodic conformance inspection shall be retained for the time period specified in the approved QM plan.

C.4.5 Nonproduction. If, at any time, there is a shortage of compliant printed boards available for processing at the QML facility, the TRB shall determine whether the processing of noncompliant printed boards sustains the capability to produce the technology. The TRB shall determine what activities and steps need to be taken to assure that a controlled process is still capable to produce compliant printed boards when required. Failure to maintain or monitor the QM program during compliant printed board production lulls, may be grounds for QML removal.

TEST OPTIMIZATION

D.1 SCOPE

D.1.1 Scope. This appendix provides guidelines on test optimization. Compliance with this appendix is not mandatory. However, manufacturers wanting to use test optimization must be able to demonstrate a assessment system that achieves at least the same level of quality and reliability as could be achieved by complying with the guidelines in this appendix. Process monitoring and controls, statistical tools, and accumulated data may be used to prove the validity of test optimization.

D.2. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

D.3 TEST OPTIMIZATION

D.3.1 Methods of test optimization. Test optimization includes the alternative methods listed below.

- a. Reduction of testing/sampling. This includes reduction in the number of samples or test frequency, whether it is within a lot or periodic sampling.
- b. Modification of tests. This includes using alternate test procedures, equipment, or test vehicles to achieve the same evaluation as the baseline verification method.
- c. Moved tests. This pertains to performing tests in-process instead of after all processing is complete.
- d. Elimination of tests. The tests are no longer performed.

D.3.2 Program requirements. Changes in a manufacturer's baseline test plan to include test optimization are considered major changes. The manufacturer is expected to maintain the established process control and evaluate the effect on quality and reliability of any out-of-control conditions that may exist at critical process parameters. The manufacturer should also evaluate if a relationship exists between any processes used to optimize test and any customer returns, take appropriate corrective actions, and record this information for future reference. As a part of the QML philosophy and conversion of customer requirements provision, the manufacturer should communicate variations in tests with customers, as appropriate or when requested. This information should be accessible via the manufacturer's QM program and should be made available to the qualifying activity.

D.3.3 Conditions of test optimization. Regardless of testing modifications, the manufacturer should supply printed boards capable of passing any test prescribed in the applicable associated specification. Long term quality and reliability of printed boards should remain unaffected or be improved.

D.3.4 Critical process parameters. When deciding whether to eliminate a test, the following should be considered, as a minimum:

- a. Variables critical to test outcome, called critical process parameters, should be identified and are in-control in accordance with the process control plan.
- b. Assignable causes are understood and controlled at critical process parameters.
- c. Critical process parameters have exhibited sufficient capability to assure low printed board defect rates.

D.3.5 Correlation, confirmation, and implementation procedures. The manufacturer should develop and document methods for confirmation and maintenance of process material capability. Test method requirements of the associated specification are intended to address worst case application environments for military grade product. Any test optimization used in lieu of required testing should be approved by the manufacturer's TRB and should document the specific areas of correlation between the alternate method and the associated specification requirement it replaces. The following is a typical flow:

- a. Identify candidate requirements of the associated specification for test optimization.
- b. Using data, identify any correlations between the candidate requirements and the potential alternate method(s).
- c. Where correlation exists, develop and document alternative method(s).

APPENDIX D

- d. Accumulate data off-line to confirm the capability of the test optimization to assure that the requirements are met.
- e. Submit test optimization for TRB approval.
- f. Implement the test optimization as directed by the TRB.

D.3.6 Periodic assessment of test optimization. Test optimization should be periodically assessed, as necessary (determined and documented by the TRB), to assure their continued effectiveness. This periodic assessment is a tool for the TRB to aid in monitoring and maintaining product quality. Methods for periodic assessment may include stress-to-failure tests, failure mode analysis, analytic prediction modeling, etc. If test optimization is determined to no longer meet the initial requirements, the manufacturer should implement the appropriate baseline testing step previously approved by the TRB.

D.3.7 Measurements. Measurements taken for out-of-control conditions along with corrective actions should be recorded and this data should be maintained for a time period consistent with the lot conformance inspection data retention requirements stated in the QM plan.

D.4 NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

D.4.1 Supporting documents. The documents in this section may be used as guidelines for the development of a test optimization program and are not mandatory for this specification.

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA-557 - Statistical Process Control Systems.

(Application for copies should be addressed to the Electronic Industries Association, 2500 Wilson Boulevard, Arlington, VA 22201-3834.)

INSTITUTE FOR INTERCONNECTING AND PACKAGING ELECTRONIC CIRCUITS (IPC)

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

(Application for copies should be addressed to the Institute for Interconnecting and Packaging Electronic Circuits, 2215 Sanders Road, Northbrook, IL 60062-6135.)

D.4.2 Notes. Although IPC-PC-90 and EIA-557 are not directly referenced herein, they may be used as guidelines to assist the manufacturer in the implementation of its test optimization program.

D.4.3 Discussion. The manufacturer may modify, substitute or delete the test and inspections defined in the associated specification. This is accomplished by baselining a flow of test and inspections that will assure that the printed boards are capable of meeting the generic verifications provided in the associated specification. This does not necessarily mean that compliant printed boards have been subjected to the generic performance verifications provided in the associated specification, just that compliant printed boards are capable of meeting them. It is the TRB's responsibility to insure that their printed boards are capable of meeting the performance requirements applicable to each specific printed board technology.

STATISTICAL SAMPLING, TEST AND INSPECTION PROCEDURES

E.1. SCOPE

E.1.1 Scope. This appendix details the statistical sampling, test and inspection procedures to be used with this specification and any associated specification. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

E.2. APPLICABLE DOCUMENTS

E.2.1 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issue of the documents cited in the solicitation (see 6.2).

NATIONAL CONFERENCE OF STANDARDS LABORATORIES

NCSL Z540 - General Requirements for Calibration Laboratories and Measuring and Test Equipment.

(Application for copies should be addressed to the National Conference of Standards Laboratories, 1800 30th Street, Suite 305B, Boulder, CO 80301-1032.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

E.2.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated specification), the text of this document take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

E.3. DEFINITIONS AND SYMBOLS

E.3.1 Definitions. The following definitions shall apply for all statistical sampling procedures:

- a. C = 0 sample plan: The C = 0 sample plans are defined as a combination of a test specimen usage identifier (see b below) and a sample size series (see c below). The resulting C = 0 sample plan will be a two character designator that identifies the sample size series that is to be used with a type of test specimen for a particular verification (see E.4.5).
- b. Test specimen identifier: The following modifiers are used to differentiate when a particular sample size series is to be used for a particular test specimen: (B) shall be used to identify production printed boards, (T) shall be used for test coupons and a asterisk (*) for either printed boards or test coupons.
- c. Sample size series: The sample size series is defined as the following series of letters: B, D, F, H, J, K, and N that are listed in table E-1.
- d. Tightened inspection: Tightened inspection is defined as sampling using an increased sample size (see E.4.3).
- e. Acceptance number (C): The acceptance number is defined as an integral number associated with the selected sample size which determines the maximum number of defectives permitted for that sample size.
- f. Rejection number (R): Rejection number is defined as one plus the acceptance number.

E.3.1 Symbols. The following symbols shall apply for all statistical sampling procedures:

- a. C: Acceptance number.
- b. R: Rejection number.

APPENDIX E

E.4. STATISTICAL SAMPLING PROCEDURES AND SAMPLE SIZE SERIES TABLE

E.4.1 General. Statistical sampling shall be conducted using the $C = 0$ method. The $C = 0$ method as specified herein is a sampling plan that provides a high degree of assurance that a lot having a proportion defective greater than the specified acceptance number ($C = 0$) will not be accepted. For all situations, the acceptance number (C) shall be equal to 0 ($C = 0$) and the rejection number (R) shall be 1 or greater ($R \geq 1$). For reevaluation purposes, tighten inspection shall be used (see E.4.3).

E.4.2 Acceptance and procedure.

E.4.2.1 Acceptance number ($C = 0$). Lot acceptance shall be based on an acceptance number of zero ($C = 0$).

E.4.2.2 Rejection number ($R \geq 1$). Failure of a sample unit for one or more tests of a subgroup shall be charged as a single failure. One or more sample rejects shall be cause for failure of the lot or subplot, as applicable. Any failure on any of the sample units shall constitute a failure of the entire inspection lot or subplot.

E.4.3 Tightened inspection. Tightened inspection shall be performed using one of the following:

- a. Using the sample size series to the left of the specified sample size series (example, if series "J" was specified, then use series "H").
- b. Doubling the sample size in the specified sample series.
- c. One hundred percent inspection with zero failures allowed.

E.4.4 Sample size. The sample size for each subgroup shall be determined from table E-I. If lot size is smaller than sample size, test all of the units. The manufacturer may, at his option, select a sample size greater than that required; however, the number of failures permitted shall not exceed the acceptance number.

E.4.5 $C = 0$ sample plan construction (selection and usage of the sample size series). The sample size series of table E-I to be used will be specified by the associated specification. The associated specification will specify the $C = 0$ sample plan (test specimen identifier and sample size series) or plans (test printed board, test coupons, or either) when different test specimens can be used to perform a verification.

Examples: If an associated specification specified that "Plan BF or TK" be used when verifying test specimens, it is specifying that sample size series "F" of table E-I must be used for selecting printed boards and sample size series "K" must be used for selecting test coupons. If the same associated specification specified that "Plan H" be used, then sample size series "H" of table E-I can be used for either printed boards or test coupons.

TABLE E-I. $C = 0$ (zero defect) sample size series.

Lot size	Sample size (number of test specimens to be inspected) ^{1/}						
	Series B	Series D	Series F	Series H	Series J	Series L	Series N
1 to 8	All	All	All	5	3	2	1
9 to 15	All	All	13	5	3	2	1
16 to 25	All	All	13	5	3	2	1
26 to 50	All	32	13	5	5	3	1
51 to 90	50	32	13	7	6	4	2
91 to 150	50	32	13	11	7	5	2
151 to 280	50	32	20	13	10	6	2
281 to 500	50	48	29	16	11	7	3
501 to 1200	75	73	34	19	15	8	4
1201 to 3200	116	73	42	23	18	9	5

^{1/} If lot size is smaller than sample size test all of the units.

E.5. TEST EQUIPMENT AND INSPECTION FACILITIES

E.5.1 Calibration. All tests and measurements for process control, qualification testing, lot conformance inspection or periodic conformance inspection shall be made with capable instruments whose accuracy has been verified. Calibration of measurement and test equipment and test standards that control the accuracy of inspection and test equipment and facilities shall be in accordance with NCSL Z540.

E.5.2 Inspection facilities. The inspection facility used to perform qualification testing, lot conformance inspection and periodic conformance inspection shall be approved by the qualifying activity for the performance of the tests and inspection requirements of compliant printed boards.

E.5.3 Acquiring activity or manufacturer imposed tests. Acquiring activity or manufacturer imposed tests shall be in accordance with the requirements specified in the printed board procurement documentation or approved QM plan. If any additional imposed tests detect a problem, the manufacturer shall submit all panels/printed boards in the lot to those tests to eliminate rejects and shall take steps to determine and eliminate the cause of failure.

E.5.4 Test method alternatives. Alternate test methods are allowed provided that it is demonstrated to the qualifying activity that such alternatives in no way relax the requirements of the test method referenced by the associated specification (see appendix D).

E.5.5 Procedure in case of test equipment malfunction or operator error. When it has been established that a improper test is due to test equipment malfunction or operator error, the TRB shall document the results of its investigations and corrective actions, if required, and shall make this information available to the acquiring activity and the qualifying activity, as applicable.

E.6 NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

E.6.1 Supporting document. The document in this section may be used as guidelines in understanding how the sample size series of table E-1 were derived and developed.

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA-585 - Zero Acceptance Number Sampling Procedures and Tables for Inspection by Attributes of Isolated Lots.

(Application for copies should be addressed to the Electronic Industries Association, 2500 Wilson Boulevard, Arlington, VA 22201-3834.)

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