INCH-POUND

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SUPERSEDING
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(See 6.14)

MILITARY SPECIFICATION

MODULES, STANDARD ELECTRONIC

GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 Scope. This specification establishes the requirements for Standard Electronic Modules (SEM) as defined in MIL-STD-1378 for the Standard Hardware Acquisition and Reliability Program (SHARP) for use in military systems. The requirements herein serve to verify the design requirements of MIL-STD-1389. Specific requirements for a particular module are listed in the associated detail specifications.

1.2 Classification. Standard electronic modules shall be of the following classes and formats as specified in the associated detail specification.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Naval Sea Systems Command, SEA-55Z3, Department of the Navy, Washington, D.C., 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC FSC 5963

Classes

Class I - For primary utilization in shipboard, subsurface ship, and shore applications.

Class II - For primary utilization in airborne applications and where stringent environmental requirements are imposed.

Class III - For utilization where class I modules may be exposed to radiation.

Class IV - For utilization where class II modules may be exposed to radiation.

Formats

Format A - The basic size has a span of 2.62 inches (66.55 mm), a thickness of 0.290 inches (7.366 mm), and a total height of 1.95 inches (49.53 mm) including keying pins. See appendix A of MIL-STD-1389.

Format B - The basic size has a span of 2.74 inches (69.60 mm), a thickness of 0.290 inches (7.366 mm), and a total height of 1.95 inches (49.53 mm) including keying pins. See appendix B of MIL-STD-1389.

Format C - The basic size has a span of 5.88 inches (149.35 mm), a thickness of 0.280 inches (7.112 mm), and a total height of 4.06 inches (103.12 mm) including keying pins. See appendix C of MIL-STD-1389.

Format D - The basic size has a span of 5.88 inches (149.35 mm), a thickness of 0.280 inches (7.112 mm), and a total height of 4.83 inches (122.68 mm) including keying pins. See appendix D of MIL-STD-1389.

Format E - The basic size has a span of 5.88 inches (149.35 mm), a thickness of 0.380 inches (9.652 mm), and a total height of 6.68 inches (169.67 mm) including keying pins. See appendix E of MIL-STD-1389.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards and handbooks. The following specifications, standards, and handbooks 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

FEDERAL

L-P-378	-	Plastic Sheet and Strip, Thin Gauge, Polyolefin.
NN-P-71	-	Pallets, Material Handling, Wood, Stringer Construction, 2 Way and 4 Way (Partial).
QQ-N-290	-	Nickel Plating (Electrodeposited).
QQ-S-781	-	Strapping, Steel, and Seals.
PPP-B-566	-	Boxes, Folding, Paperboard.
PPP-B-601	-	Boxes, Wood, Cleated Plywood.
PPP-B-621	-	Boxes, Wood, Nailed, and Lock-Corner
PPP-B-636	-	Boxes, Shipping, Fiberboard.
PPP-B-676	-	Boxes Setup.
PPP-C-795	-	Cushioning Material, Packaging (Flexible, Cellular, Plastic Film).
PPP-C-1842	-	Cushioning Material, Plastic, Open Cell (For Packaging Applications).

MILITARY

MIL-P-116	-	Preservation, Methods of.
MIL-B-117	-	Bags, Sleeves and Tubing - Interior Packaging.
MIL-C-5541	-	Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
MIL-A-8625	-	Anodic Coatings, for Aluminum and Aluminum Alloys.
MIL-W-8939	-	Welding, Resistance, Electronic Circuit Modules.
MIL-C-28754	-	Connectors, Electrical, Modular, and Component Parts, General Specification For.
MIL-P-28809	-	Printed-Wiring Assemblies.
MIL-C-28859	-	Connector Component Parts, Electrical Backplane, Printed Wiring, General Specification For.
MIL-A-28870	-	Assemblies, Electrical Backplane, Printed-Wiring, General Specification For.
MIL-G-45204	-	Gold Plating, Electrodeposited.
MIL-P-50884	-	Printed Wiring, Flexible and Rigid Flex.
MIL-P-55110	-	Printed-Wiring Boards, General Specification for.

(See supplement 1 for list of associated detail specifications.)

STANDARDS

MILITARY

MIL-STD-105	-	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-129	-	Marking For Shipment and Storage.
MIL-STD-147	-	Palletized Unit Loads.
MIL-STD-202	-	Test Methods for Electronic and Electrical Component Parts.
MIL-STD-794	-	Parts and Equipment, Procedures for Packaging of.
MIL-STD-810	-	Environmental Test Methods and Engineering Guidelines.
MIL-STD-883	-	Test Methods and Procedures for Microelectronics.
MIL-STD-1331	-	Parameters to be Controlled for the Specification of Microcircuits.

MIL-STD-1378 - Requirements for Employing Standard Electronic Modules.
MIL-STD-1389 - Design Requirements for Standard Electronic Modules.
MIL-STD-1665 - Test Equipment for the Standard Electronic Modules Program.
MIL-STD-1686 - Electrostatic Discharge Control Program For Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (Metric).
MIL-STD-45662 - Calibration Systems Requirements.

HANDBOOKS

MIL-HDBK-217 - Reliability Prediction of Electronic Equipment.
MIL-HDBK-263 - Electrostatic Discharge Control Handbook For Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (Metric).
MIL-HDBK-279 - Total-Dose Hardness Assurance Guidelines for Semiconductor Devices and Microcircuits.
MIL-HDBK-280 - Neutron Hardness Assurance Guidelines for Semiconductor Devices and Microcircuits.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.1.2 Other Government publications. The following other Government publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

PUBLICATIONS

SD-6 - Provisions Governing Qualification.

(Copies of this publication are available from the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for associated detail specifications, specification sheets, or MS standards), 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 Associated detail specifications. The individual item requirements shall be as specified herein and in accordance with the applicable associated detail specification. In the event of any conflict between the requirements of this specification and the detail specification sheet, the latter shall govern. Format A design is required unless otherwise specified in the detail specification.

3.1.1 Definitions. For definitions of terms defined herein see 6.5. Terms not defined herein are defined in MIL-STD-1378, MIL-STD-1389, and MIL-STD-1331.

3.2 Qualification. Modules furnished under this specification shall be products which are authorized by the Quality Assurance Activity for listing on the applicable qualified products list at the time of delivery (see 4.4 and 6.4).

3.3 Materials. Materials used in the manufacture of modules shall be in accordance with the requirements specified in MIL-STD-1389.

3.3.1 Printed-boards and printed-board assemblies. All printed-boards and printed-board assemblies shall conform to the requirements of MIL-STD-1389.

3.3.1.1 Printed-boards. The quality of rigid printed-boards shall be in accordance with the requirements of MIL-P-55110. The quality of flexible printed-boards shall be in accordance with MIL-P-50884, type B. Any processes, inspections, tests, and quality levels which differ from the requirements shall be approved by the Standard Electronic Modules Quality Assurance Activity (SEM-QAA). Equivalent process requests shall be documented and forwarded to the SEM-QAA for review and approval.

3.3.1.2 Printed-board assemblies. The quality of printed-board assemblies shall be in accordance with the requirements of MIL-STD-1389, appendix H. Any processes, inspections, tests, and quality levels which differ from the requirements shall be approved by the SEM-QAA. Equivalent process requests shall be documented and forwarded to the SEM-QAA for review and approval.

3.3.2 Thick film multilayer interconnect boards (MIBs) and assemblies. All thick film MIBs and assemblies shall conform to the requirements of MIL-STD-1389.

3.3.2.1 Thick film multilayer interconnect boards. The quality of thick film MIBs shall be in accordance with the requirements of appendix B of this specification. Any processes, inspections, tests, and quality levels, which differ from the requirements shall be approved by the SEM-QAA. Equivalent process requests shall be documented and forwarded to the SEM-QAA for review and approval.

3.3.2.2 Thick film multilayer interconnect board assemblies. The quality of thick film MIB assemblies shall be in accordance with appendix H of MIL-STD-1389. Any processes, inspections, tests, and quality levels, which differ from the requirements shall be approved by the SEM-QAA. Equivalent process requests shall be documented and forwarded to the SEM-QAA for review and approval.

3.4 Design and construction. Modules shall be in accordance with the design, construction, and physical dimensions specified in MIL-STD-1389.

3.4.1 Electrical requirements. Modules shall be in accordance with the electrical requirements specified in the detail specification and MIL-STD-1389.

3.4.1.1 Preconditioning. Modules shall be subjected to preconditioning in accordance with the following:

(a) Modules shall be subjected to nonoperating temperature cycling for a minimum of ten complete cycles of temperature variation. A cycle shall consist of 15 minutes at temperature extremes of 85 degrees Celsius (°C) plus 10 or minus 0, and minus 55°C, plus 0 or minus 10, with a maximum transfer time between temperature extremes of 5 minutes. A cycle may begin at either temperature.

(b) Upon completion of the temperature cycling, modules shall meet the initial electrical requirements specified in the detail specification.

3.4.2 Mechanical integrity requirements. Modules shall be capable of meeting the requirements specified in 3.4.2.1 through 3.4.2.11 without mechanical or electrical degradation (see 4.7.3).

3.4.2.1 Keying pin torque. Each keying pin shall withstand a torque of 20 inch-ounces (0.14 newton-meter) minimum (see 4.7.3.1).

3.4.2.2 Keying pin pullout. Each keying pin shall withstand a pullout force of 9 pounds (40 newtons) minimum (see 4.7.3.2).

3.4.2.3 Keying pin pushout. Each keying pin shall withstand a pushout force of 40 pounds (178 newtons) minimum (see 4.7.3.3). The force shall be applied in the opposite direction to the force in 3.4.2.2. This test applies only to modules with formats C, D, and E.

3.4.2.4 Keying pin cantilever load. Each keying pin shall withstand a cantilever load of 10 pounds (45 newtons) minimum (see 4.7.3.4).

3.4.2.5 Rib strength. The individual module ribs shall withstand a torque of 10 inch-pounds (1.13 newton-meters) minimum (see 4.7.3.5).

3.4.2.6 Module torque. Format A and B modules shall withstand a 6 inch-pound (0.68 newton-meter) minimum torque and formats C, D and E shall withstand a 25 inch-pound minimum torque (2.83 newton-meters) (see 4.7.3.6).

3.4.2.7 Module header torque. Format A and B modules shall withstand a 6 inch-pound minimum torque and format C, D and E modules shall withstand a 10 inch-pound (1.1 newton-meter) header torque without detrimental effect to the mechanical or electrical properties of the module (see 4.7.3.7).

3.4.2.8 Module cantilever load. Modules shall withstand a force of 2 pounds (9 newtons) minimum for formats A and B, and 5 pounds (22 newtons) for formats C, D and E (see 4.7.3.8).

3.4.2.9 Connector integrity.

3.4.2.9.1 Small formats. Each assembled format A and B module and connector shall withstand a minimum axial force along the contact pin length in either direction equal to the product of 12 ounces (3.3 newtons) minimum multiplied by the number of contacts without any visible separation or bending (see 4.7.3.9). (For example, 12 ounces (3.3 newtons) minimum multiplied by 40 contacts equals 480 ounces (133 newtons). The total computed force shall be applied simultaneously to all module connector contacts simulating module insertion and extraction.)

3.4.2.9.2 Large formats. Each assembled format C, D or E module and connector shall withstand without damage or visible separation a minimum axial force normal to the interface plane equal to 100 pounds (445 newtons) on insertion and 4 ounces (1.1 newtons) per contact on extraction (see 4.7.3.9). The total computed force shall be applied simultaneously to all module connector contacts simulating module insertion and extraction.

(a) On insertion, a 100 plus 5, minus 0 pound (445 plus 22.3, minus 0 newton) force shall be uniformly applied at two locations on the top surface of the header. These two locations are centered on the header width and are located 0.75 inch (19.1 mm) to 1.25 inches (31.8 mm) from both ends of the header. This force shall be uniformly applied by two plates (0.5 inch (12.7 mm) square) forcing the module connector interface plane against a plate with clearance provisions for the rows of contacts.

(b) On extraction, a 4.0 plus 0, minus 0.1 ounce (1.1 plus 0, minus 0.03 newton) force per contact shall be applied at the two extractor holes. A suitable means of clamping the body of the module connector shall be employed to prevent extraction of the module from the test fixture. The force shall be obtained in 2 to 10 seconds and maintained for 10 to 15 seconds.

3.4.2.10 Connector contact integrity. Each contact as mounted in the connector, shall withstand an axial force in either direction of 20 ounces (5.6 newtons) minimum (see 4.7.3.10).

3.4.2.11 Pin shield retention. The pin shield shall withstand, without visible separation from its base, a force of 4 pounds (18 newtons) minimum (see 4.7.3.11). The requirement shall be met after exposure to all manufacturing process temperatures including preconditioning.

3.4.3 Thermal requirements. Modules shall be in accordance with the thermal requirements specified in the detail specification and MIL-STD-1389.

3.4.3.1 Critical component temperature (CCT). Modules shall be capable of operating at their maximum class temperature without exceeding any individual CCT. Component temperature determination shall be in accordance with 4.7.21.

3.4.3.1.1 CCT for formats A and B. For formats A and B, the CCT for semiconductor devices shall be 105°C for classes I and III and 130°C for classes II and IV at the junction. For all other components, the CCT shall be equal to the individual component's maximum specified operating temperature minus 20°C and shall be specified at the component's hottest external area.

3.4.3.1.2 CCT for formats C and E. For formats C and E, the CCT for semiconductor devices dissipating 2.5 watts or less shall be 85°C junction for classes I and III and 110°C at the junction for classes II and IV. For semiconductors dissipating more than 2.5 watts, the CCT may increase 15°C per watt. In no instance may any individual junction CCT exceed 100°C (class I or III) or 125°C (classes II or IV) regardless of the power dissipation of the device. For all other components, the CCT is equal to

the component's maximum specified operating temperature minus 30°C and is measured at the component's hottest external area. Where components do not meet the CCT requirements, but do not exceed 105°C for class I and III, the module shall be considered acceptable if the calculated mean time between failure is greater than 50,000 hours. In no case shall a component have its maximum rated junction temperature exceeded.

3.4.3.1.3 CCT for format D. For format D, the CCT for semiconductor devices dissipating 2.5 watts or less shall be 90°C at the junction. For semiconductors dissipating more than 2.5 watts, the CCT may increase 15°C per watt. In no instance may any individual junction CCT exceed 105°C regardless of the power dissipation of the device. For all other components, the CCT shall be equal to the component's maximum specified operating temperature minus 30°C and is measured at the component's hottest external area. Where components do not meet the CCT requirements, but do not exceed 105°C for class I and III, the module shall be considered acceptable if the calculated mean time between failure is greater than 50,000 hours. In no case shall a component have its maximum rated junction temperature exceeded.

3.4.3.2 Transient critical component temperature (TCCT). Modules shall be capable of operating at their maximum class temperature plus 20°C without exceeding any individual component TCCT. Component temperature determination shall be in accordance with 4.7.21.

3.4.3.2.1 TCCT for formats A and B. For formats A and B, the TCCT for semiconductor devices shall be 125°C for classes I and III, and 150°C for classes II and IV, at the junction. For all other components, the TCCT shall be equal to the maximum specified operating temperature and shall be measured at the component's hottest external area.

3.4.3.2.2 TCCT for formats C, D, and E. For formats C, D, and E, the TCCT for semiconductor devices shall be the CCT temperature plus 20°C. For all other components, the TCCT shall be equal to the maximum specified operating temperature and shall be measured at the component's hottest external area.

3.4.3.3 Thermal prediction and test. All module designs shall have a thermal prediction submitted to the SEM-QAA for approval prior to critical design review or equivalent review. A module thermal test shall be performed when the thermal prediction indicates that one or more component junction temperatures is greater than the maximum allowable CCT less 10°C.

3.4.4 Failure rate. Each module design shall have a failure rate prediction calculated in accordance with appendix G of MIL-STD-1389 and the "Part Stress Analysis" method of MIL-HDBK-217 prior to critical design review or equivalent review. The failure rate shall be verified as specified in 4.4.4.

3.4.5 Parts derating. During module design, all parts shall be derated in accordance with MIL-STD-1389. Parts derating shall be verified as specified in 4.4.4.

3.5 Environmental requirements. Modules shall be in accordance with the following environmental requirements.

3.5.1 Operating environmental requirements. Modules shall withstand, without damage, the following operating environmental requirements. Modules shall pass the electrical test requirements of the detail module specification.

3.5.1.1 Operating temperature. Modules shall be subjected to a series of operating temperature tests as specified in the detail specification. Module types shall be operated during initial qualification. Thereafter, analog modules, modules containing hybrid parts, memory modules, and modules containing unproven technologies shall be operated as deemed necessary by the SEM-QAA. Operating temperature tests shall be performed in accordance with 4.7.4.

(a) Low temperature. Classes I and III modules shall be subjected to a low temperature of 0, plus 0 or minus 5°C. Classes II and IV modules shall be subjected to a low temperature of minus 55, plus 0 or minus 5°C.

(b) High temperature. Classes I and III modules shall be subjected to a high temperature of 60, plus 5 or minus 0°C. Classes II and IV modules shall be subjected to a high temperature of 85, plus 5 or minus 0°C.

(c) Transient temperature. Classes I and III modules shall be subjected to a transient temperature of 80, plus 5 or minus 0°C. Classes II and IV modules shall be subjected to a transient temperature of 105, plus 5 or minus 0°C.

3.5.1.2 Vibration. Classes I and III modules shall withstand simple harmonic motion and random vibration tests (see 4.7.5). Classes II and IV modules shall withstand high frequency and random vibration tests (see 4.7.6). Following vibration, the modules shall pass the electrical tests of 4.7.2 and shall show no physical deterioration or damage.

3.5.1.3 Inclination. Modules shall withstand continuous operation while being inclined at the rated of 5 to 7 cycles per minute in all vertical planes to an angle of 90 degrees from vertical (see 4.7.7).

3.5.1.4 Life. Classes I and III modules shall withstand a life test at 60°C in accordance with 4.7.8. Classes II and IV modules shall withstand a life test at 85°C in accordance with 4.7.8.

3.5.1.5 Barometric pressure (reduced). Classes II and IV modules shall withstand a reduced barometric pressure of 8.00 millimeters (mm) of mercury (see 4.7.9).

3.5.1.6 Radiation hardness assurance. Classes III and IV modules shall withstand an ionizing dose rate of $1X10^{9}$ rad (Silicone (Si)) per s (20 ns pulse width), a total ionizing dose of $3X10^{3}$ rad (Si), and a neutron fluence of $2 X 10^{12}$ neutrons per cm^{2} (see 4.7.10). A failure is defined as a permanent change in any specified electrical reading.

3.5.2 Nonoperating environmental requirements. Modules shall withstand, without damage, the following nonoperating environmental requirements.

3.5.2.1 Durability. Modules shall withstand a minimum of 500 cycles of insertion and extraction into a test fixture that represents a typical card cage rail assembly without loss of mechanical or electrical integrity (see 4.7.11). For formats C, D and E modules shall also withstand a minimum of 500 cycles of lateral displacement to simulate the use of thermal clamping devices. The clamping testing may be included in the insertion and extraction sequences or they may be performed as a separate test. There shall be no exposure of nickel underplating on the module connector contacts when examined under 3X magnification (10X for referee inspection) upon completion of this test.

3.5.2.2 Humidity. Modules shall withstand humid atmosphere cycles of 65°C at 95 percent relative humidity and 30°C and 85 percent relative humidity (see 4.7.12). There shall be no evidence of deterioration or physical damage after this test.

3.5.2.3 Thermal shock. Classes I and III modules shall withstand a thermal shock of minus 55°C to 85°C (see 4.7.13.1). Classes II and IV modules shall withstand a thermal shock of minus 55°C to 125°C (see 4.7.13.2). The minus 55°C is an exception to the standard requirements.

3.5.2.4 Thermal cycle. To evaluate solder joints, modules shall be subjected to thermal cycling at the discretion of SEM-QAA. Classes I and III modules shall be subjected to not more than 125 cycles while class II and IV modules shall be subjected to not more than 400 cycles (see 4.7.14).

3.5.2.5 Shock. Modules shall withstand a shock of 100 gravities (g's) acceleration peak value, normal duration of 6 milliseconds, sawtooth waveform, and a velocity change of 12.3 feet per second (see 4.7.15). The module shall show no deterioration or physical damage.

3.5.2.6 Salt fog. Modules shall withstand a salt fog atmosphere from a 5 percent salt solution at 35°C for 48 hours (see 4.7.16). Failure mechanisms shall include pits, crack formations, and intergranular attack, that produce a concentrated attack that weakens a cross section. Surface corrosion shall not be evidence of failure.

3.5.2.7 Flammability. Modules shall not support flames or an explosive-type fire when subjected to propane torch flames (see 4.7.17).

3.5.2.8 Hydrogen atmosphere. Modules utilizing metal oxide thick film resistors shall withstand a hydrogen atmosphere of 10 percent hydrogen and 90 percent nitrogen at 85°C for 6 hours (see 4.7.18).

3.5.2.9 Storage temperature. Modules shall withstand a storage temperature range of minus 55 to 125°C without evidence of deterioration or physical damage (see 4.7.19). Following this exposure, modules shall meet the electrical tests in accordance with 4.7.2.

3.5.2.10 Fungus. Modules shall support no more than trace amounts of fungal growth (see 4.7.20).

3.5.2.11 Solvents. Modules using adhesive backed labels shall meet the solvents requirement (see 4.7.22) without the label peeling off the module surface.

3.6. Identification marking. Identification marking for each module shall be in accordance with MIL-STD-1389.

3.6.1 Joint Army Navy (JAN) and J marking. The United States Government has adopted, and is exercising legitimate control over the certification marks "JAN" and "J", respectively, to indicate that items so marked or identified are manufactured to, and meet all the requirements of military specifications. Accordingly, items procured to, and meeting all of the criteria specified herein and in applicable associated detail specification shall bear the certification mark "JAN" except that items too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be placed immediately before the part number except that if such location would place a hardship on the manufacturer in connection with such marking, the "JAN" or "J" may be located on the first line above or below the part number. Items furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein or in applicable associated detail specifications shall not

bear "JAN" or "J". In the event an item fails to meet the requirements of this specification and the applicable associated detail specifications, the manufacturer shall remove the "JAN" or the "J" from the sample tested and also from all items represented by the sample. The "JAN" or "J" certification mark shall not be used on products procured to contractor drawings or specifications. The United States Government has obtained Certificate of Registration No 504,860 for the certification mark "JAN".

3.7 Workmanship. Workmanship shall be of such quality that modules will be in accordance with the requirements specified in the detail specification and MIL-STD-1389.

3.7.1 Metallic surfaces. Metallic surfaces shall be free of burrs, cracks, and sharp edges. Voids, blowholes, fissures, racking points, or porosity that are discernible by the unaided eye shall not exceed 10 percent of the total metallic surface area. Connector contacts, keying pins, ribs, and fins shall not be bent or damaged.

3.7.1.1 Scratches. Scratches or modifications on the surface of aluminum parts which have been processed in accordance with MIL-A-8625, class II, type 2, shall be treated with chemical film in accordance with MIL-C-5541 and painted to match the finish color. Racking points only will be allowed on aluminum surfaces which have been treated in accordance with MIL-A-8625, class III, type 2. Scratches or modifications on other metallic surfaces shall be repaired utilizing a protective coating that will guard against corrosion and will match the finish color. The area of repair shall not exceed 5 percent of the total surface of the module.

3.7.2 Nonmetallic surfaces. Nonmetallic surfaces shall be free of cracks, foreign material, and sharp or rough edges. Voids, blisters, pinholes, or mold marks shall not exceed 10 percent of the total nonmetallic surface area.

3.7.2.1 Conformal coatings. The conformal coating shall be in accordance with appendix H of MIL-STD-1389 and shall be a continuous, homogeneous, fully cured material that covers all components, leads (except connector contact leads), and circuitry, except grounding surfaces. The coating thickness may vary with the irregularity of the module surface.

3.7.2.2 Molded or potted surfaces. Molded or potted surfaces shall be continuous, homogeneous, fully cured and cover all components, leads, and circuitry. Pits, pinholes, or voids not exceeding 0.030 inch (0.76 mm) diameter and 0.010 inch (0.25 mm) deep or scratches not exceeding 0.020 inch (0.51 mm) wide by 0.5 inch (13 mm) long and 0.010 inch (0.25 mm) deep are permissible, provided no components or circuitry are exposed. Maximum concentration of defects shall not exceed 5 percent of the total nonmetallic surface area.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.1.2 Government verification. All quality assurance operations performed by the contractor will be subject to SEM-QAA verification at any time. Failure of the contractor to promptly correct deficiencies discovered by him or of which he is notified will be cause for suspension of product acceptance until corrective action has been made or until conformance of product to prescribed criteria has been demonstrated.

4.2 Classification of inspection. Examinations and inspections shall be classified as follows:

(a) Qualification inspection (see 4.4).

(1) Initial qualification (see 4.4.1).
(2) Periodic-check (see 4.4.7).

(b) Quality conformance inspection (see 4.5).

(c) Inspection of packaging (see 4.6).

4.3 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in 4.3.1 through 4.7.2.2.

4.3.1 Standard test conditions. Unless otherwise specified, tests shall be performed in an area having a relative humidity of up to 95 percent and a barometric pressure of between 24 and 32 inches (610 and 813 mm) of mercury. Temperature of the test area shall be maintained at 25, plus or minus 5°C.

4.3.2 Test equipment. Test equipment not specified in MIL-STD-1665 may be utilized for testing SEM, provided accuracy tables for the equipment specified in the test procedure is submitted to the SEM-QAA for approval.

4.4 Qualification inspection. Qualification inspection shall be performed by the SEM-QAA or its designated representative. Qualification inspection shall be conducted in accordance with the following procedures.

4.4.1 Initial qualification. Tests shall be performed to determine the capability of modules to meet the requirements specified herein and in the associated detail specification. Four modules (see table I for class III and class IV requirements) of each military part number shall be subjected to the tests specified in table I and the detail specification as determined by the SEM-QAA. Any deviation in sample size shall be requested in writing by the acquisition activity to the SEM-QAA. The request shall specify the reason for a deviation. These samples shall be electrically and mechanically interchangeable with production modules but need not be necessarily manufactured under production conditions. Materials and processes must be equivalent to those used in production.

4.4.2 Special sample. One of the qualification samples shall be furnished in a configuration allowing ready measurement of CCT and TCCT as agreed upon by the SEM-QAA and the contractor.

4.4.3 Test data. The initial qualification samples shall be accompanied by test data showing compliance with the performance characteristics of the detail specification (25°C, 100 percent and sample tests).

4.4.4 Failure rate and parts derating. The module manufacturer shall submit detailed information to permit evaluation of parts derating and of the failure rate prediction as defined in MIL-STD-1389. This failure rate and parts derating data shall be submitted prior to critical design review or equivalent review.

4.4.5 Thermal performance. The module manufacturer shall submit a detailed thermal prediction, performed in accordance with 3.4.3.3, to the SEM-QAA prior to critical design review or equivalent review. A module thermal test shall be performed when the thermal prediction indicates that one or more component junction temperatures is greater than the maximum allowable CCT less 10°C.

TABLE I. Qualification inspection.

Inspection or test	Requirement paragraph	Test method para	Number of samples classes I and II 5/	Number of samples classes III and IV 3/,4/
Visual	3.4	4.7.1	4/3	8/3
Initial electrical	3.4.1	4.7.2	4/3	8/3
Operating temperature	3.5.1.1	4.7.4	4/3	8/3
Vibration 1/ Shock 1/ Inclination Mechanical Durability Flammability	3.5.1.2 3.5.2.5 3.5.1.3 3.4.2. 3.5.2.1 3.5.2.7	4.7.5 or 4.7.6 4.7.15 4.7.7 4.7.3 4.7.11 4.7.17	1	1
Hydrogen atmosphere Barometric pressure (reduced) CCT-TCCT	3.5.2.8 3.5.1.5 3.4.3.1 or 3.4.3.2	4.7.18 4.7.9 4.7.21	1	1
Life	3.5.1.4	4.7.8	1	1
Thermal shock Humidity Storage temperature Salt fog	3.5.2.3 3.5.2.4 3.5.2.2 3.5.2.9 3.5.2.6	4.7.13 4.7.14 4.7.12 4.7.19 4.7.16	1	1
Fungus	3.5.2.10	4.7.20	1	1
Radiation hardness assurance 2/ 3/	3.5.1.6	4.7.10	N/A	4

TABLE I. Qualification inspection - Continued.

1/ These tests may have their testing order reversed.
2/ These tests may be performed at any point during qualification inspection without respect to prior testing provided that they are immediately preceded by tests that satisfy the initial 100 percent and sample electrical requirements specified in the detail specification.
3/ Required for classes III and IV modules submitted after a design change or for initial qualification.
4/ Eight modules are required for initial qualification tests on modules containing components with unknown radiation hardness design margins (RHDM). This quantity may be reduced by the SEM-QAA upon receipt of proper RHDM documentation. Quantities for periodic-checks shall be as specified in 4.4.7.
5/ The number of samples submitted for testing will vary depending upon whether the submission is for initial qualification or periodic check. Periodic check submissions require only three modules.

4.4.6 Design conformance. The SEM-QAA shall review module designs prior to or during initial qualification tests for conformance to all applicable requirements. This review shall be performed from a scale drawing of the printed-wiring, an assembly drawing, the parts list, the schematic or logic diagrams, programming data for all programmable devices and any other documentation used by the manufacturer to build the module. The manufacturers shall submit this design package prior to the initial qualification samples. Complete design disclosure shall be made for SEM-QAA use only.

4.4.7 Periodic-check. Periodic-checks shall be performed to verify that the contractor is manufacturing modules that meet all the requirements specified herein and in the associated detail specification. Periodic-check tests shall be performed, by the SEM-QAA or its designated representative, every 6 months on a sample of three modules selected at random from modules passing quality conformance inspection during the 6 or 12 month production period (see 4.4.7.1.1 and 4.4.7.1.2). Each sample of modules submitted for periodic-check shall be subjected to those tests listed in table I as deemed necessary by the SEM-QAA. The test sequence shall be the same as that for initial qualification inspection. Any deviation in sample size shall be

requested in writing by the acquisition activity to the SEM-QAA. The request shall specify the reason for a deviation.

4.4.7.1 Submission schedule. The SEM-QAA shall determine the submission schedule of each module supplier by key code. This determination will be based on proven or unproven design and construction technology, and qualification history. Technical concerns and engineering judgement will take precedence in the determination of the submission schedule on submittals that might otherwise meet all of the necessary criteria.

4.4.7.1.1 Proven design and construction technology. The module supplier shall submit periodic check samples at 6 month intervals following successful completion of initial qualification inspection. After the successful completion of two consecutive periodic check submissions at the 6 month intervals, the interval will be extended to 12 months and will remain at 12 months until a periodic check submission is failed or the qualification interval is exceeded without a periodic check submission. After a periodic check failure, four modules will be required for initial qualification testing followed by two consecutive successful periodic check submissions at the 6 month intervals before the 12 month interval may again be attained. If production is interrupted and the 6 or 12 month interval is exceeded, the supplier shall submit the first four modules produced for initial qualification when production resumes.

4.4.7.1.2 Unproven design and construction technology. The module supplier shall submit periodic check samples at 6 month intervals following successful completion of initial qualification inspection. After the successful completion of four consecutive periodic check submissions at the 6 month interval, the interval will be extended to 12 months and will remain at 12 months until a periodic check submission is failed or the qualification interval is exceeded without a periodic check submission. After a successful initial qualification followed by four consecutive successful periodic check submissions, the submission schedule will be the same as for a proven design and construction technology. After a periodic check failure, four modules will be required for initial qualification testing followed by two successful periodic check submissions at the 6 month interval before the 12 month interval may again be attained. If production is interrupted and the 6 or 12 month interval is exceeded, the supplier shall submit the first four modules produced for initial qualification when production resumes.

4.4.7.2 Periodic-check sample submission. Submittal of periodic-check samples and required documentation to the SEM-QAA will be under the cognizance of the Government acquisition activity. Selection of periodic-check samples shall be performed by the Government quality assurance representative. The contractor shall make available to the SEM-QAA upon request, a cross-reference matrix of date code versus serial number versus contract, by military part number, on all modules delivered.

4.4.7.3 Noncontinuous production. When production has been discontinued during a qualification period and periodic-check samples are not submitted on a timely basis, qualification status shall only be maintained upon receipt of a letter of intent that module production will be resumed within a 36 month period. The letter shall list the last production module date code.

4.4.8 Acceptance and rejection criteria. Successful completion of initial qualification inspection or periodic-check shall be based on no major defects. Any defect which may affect function, reliability, or interchangeability (as determined by the SEM-QAA) shall be considered a major defect. The contractor and acquisition activity concerned shall be notified in writing of the test results within 10 days following completion of testing. In case a qualification sample does not successfully pass the tests, the contractor shall be notified at the time of failure (see 6.10).

4.4.9 Correlation samples. The initial developer or contractor of a module type shall submit correlation samples in accordance with appendix A.

4.4.10 Retention of qualification. Upon successful completion of the initial qualification inspection, the contractor retains qualification status on the specific module part number until one of the following occurs:

(a) Change of design (including components, materials, and processes).

(b) Failure of periodic-check.

(c) Failure to submit samples and associated data on a timely basis (maximum interval under no production conditions will be 36 months) (see 4.4.7).

4.4.11 Sequence of testing. Sequence of testing shall be in the order listed in table I.

4.5 Quality conformance inspection. The following quality conformance inspection requirements apply.

4.5.1 Quality conformance criteria. Quality conformance acceptance of modules shall be based on no major defects. Any characteristics failing to conform to the requirements specified herein and in the associated detail specification shall be considered a defect. Electrical tests shall be performed on test equipment which has been correlated by the SEM-QAA in accordance with appendix A.

4.5.2 Sample quality conformance inspection. For sampled inspections, acceptance or rejection of a lot shall be based on the sampling procedures of table II as applicable. If a failure occurs in a sampled electrical quality conformance inspection, the entire inspection lot (see 4.5.7) shall be screened for that parameter before shipment of the lot. All modules failing during the screen shall be rejected.

4.5.3 100-percent inspection. For 100-percent quality conformance inspection parameters, any module not meeting the requirements specified herein shall be rejected.

4.5.4 Failure analysis. Failure analyses shall be conducted by the contractor, on a trend basis, on modules or components that fail tests required by the quality conformance test plan. Selection shall be based on the relative quantity of module failures of the various types manufactured. The results of the failure analyses shall be made available for inspection, if so desired, by the acquisition activity concerned and the SEM-QAA (see 6.3.1).

4.5.5 Test records. Unless otherwise specified by the SEM-QAA, the contractor shall retain module quality conformance test records for a minimum of 1 year after completion of all applicable tests. For read only memory (ROM) and programmable read only memory (PROM) modules, the contractor shall retain a copy of each pattern by key code, control number, revision, and system nomenclature and shall supply test programs upon request by the SEM-QAA.

4.5.6 Test plan. Modules shall be subjected to tests in accordance with table II. These tests shall be performed in the order shown; however, within the subgroup containing visual inspection, the order of testing is optional. Modules subjected to this quality conformance inspection and test plan shall be completed samples requiring no other manufacturing steps.

4.5.7 Inspection lot. An inspection lot shall consist of all modules of a specific part number submitted for quality conformance inspection at any one time.

4.5.8 Test equipment and facilities. The contractor shall provide personnel and furnish and maintain all equipment, gauges, and facilities necessary for the performance of quality assurance provisions.

4.5.8.1 Gauges. The contractor shall provide whatever gauges are necessary and adequate to ensure that each module meets all dimensional requirements. The Government representative shall be permitted to use any of the contractor's manufacturing gauges at no cost to the Government and in addition shall be permitted to check such gauges when it is considered necessary. However, the fact that manufacturing gauges may have been so checked does not relieve the contractor of the responsibility of meeting all dimensional requirements.

4.5.8.2 Test equipment. The ratio of specification tolerances to test equipment precision shall be 10:1 for tolerances of 3 percent or greater and at least 4:1 for tolerances of less than 3 percent. Exceptions, due to precision limitations of available test equipment, shall be specified in the detail specification. Deviations to either of the ratios specified or the specified exceptions shall be recorded and approved in accordance with appendix A. All test equipment shall be accurately calibrated (see 4.5.9.2.4) at specified intervals to ensure valid test results. The calibrations and frequencies shall be subjected to the approval of the cognizant Government representative. The test equipment used for quality conformance testing may be laboratory instruments connected in a breadboard arrangement, a console type of equipment, or an automatic tester. Test setups are provided for laboratory instruments in the detail specifications. Correlation testing shall be performed to ensure measurement adequacy. The test equipment specified on the module drawing is typical of equipment adequate to perform quality conformance and qualification tests and shall be deemed as satisfying all accuracy requirements.

TABLE II. Quality conformance inspections and test plan.

Inspection 1/	Requirement paragraph	Test method paragraph	Sampling	Remarks
Preconditioning	3.4.1.1		100 percent	Preconditioning shall be completed prior to the 25°C electrical inspection.
Electrical requirements at 25°C ambient	3.4.1	4.7.2	Parameters to be tested 100% as specified in the detail specification. Sample per remarks.	For those parameters which are to be sample inspected, two modules or 1% of the inspection lot, whichever is greater, shall be randomly selected from each inspection lot. The electrical parameters marked sample in the detail specification shall be tested at 25°C ambient. 2/
Visual Profile dimension Keying position Marking Workmanship	3.4 3.4 3.4 3.6 3.7	4.7.1 4.7.1 4.7.1 4.7.1 4.7.1	MIL-STD-105, normal inspection level II, single sampling, 0.65% acceptable quality level (AQL), from each inspection lot.	

1/ Order of performance shall be as shown unless otherwise approved by the SEM-QAA.

2/ If failures occur, the entire lot shall be screened for the parameter which failed.

4.5.8.2.1 Correlation. All test equipment used for quality conformance testing shall be correlated by the SEM-QAA or its designated representative in accordance with appendix A.

4.5.9 Quality program requirements. The contractor shall develop and maintain a documented program of quality control for the manufacture of modules. This plan shall be reviewed by the acquisition activity concerned and SEM-QAA prior to manufacture of modules. This program shall consist of a plan of control and quality system that enables adequate control of quality throughout all phases of module manufacture. The requirements herein reflect minimum requirements and are not intended to limit or reduce a contractor's quality assurance program.

4.5.9.1 Procurement source selection. The module contractor shall maintain a documented program for the formal evaluation and approval of his acquisition sources (subcontractors). The contractor's product quality organization shall exercise review authority and provide comments on the adequacy of all acquisition sources. Each selected source shall satisfy at least one of the following conditions:

(a) The selected source shall have a previous record of supplying high quality reliable products of the type being acquired. These records shall be supported by documented quantitative data.

(b) If no previous quality or reliability records are available or product quality cannot be adequately verified by receiving inspection, a review of the selected source's facilities and product quality shall be performed by the module contractor.

4.5.9.1.1 Procurement source control for radiation hardened devices. Semiconductor pieceparts are categorized in MIL-HDBK-279 and MIL-HDBK-280 as being Hardness Critical Category HCC-1, HCC-2, and HNC (hardness non-critical). HCC-1 components have a radiation hardness design margin (RHDM) of less than 10. HCC-1 components shall not be used in classes III and IV modules. HCC-2 components have a RHDM between 10 and 100 and must be documented for source control. Any part dependent on source or process to obtain an increased RHDM shall be HCC-2 at best to maintain component control. HNC components have a RHDM greater than 100 and require no additional documentation controls.

4.5.9.2 Maintenance and calibration of inspection and test equipment. The contractor shall maintain a documented program for the evaluation, approval, maintenance, and control of inspection gauges and other measuring and testing equipment necessary to ensure that modules conform to all requirements specified herein.

4.5.9.2.1 Calibration facilities. The contractor shall have laboratory facilities and standards for the calibration of all dimensional inspection instruments and test equipment. These facilities shall be compatible with contract requirements and shall be such that calibrations are made under adequately stable environmental conditions. In lieu of adequate laboratory facilities, the contractor shall secure the services of a Government certified calibration facility. In either case, the contractor's standards certification shall have a traceable reference to the standards of the National Bureau of Standards.

4.5.9.2.2 Calibration standards. Standards used for calibration of inspection and test equipment shall be of a precision at least four times greater than the precision of the equipment being calibrated.

4.5.9.2.3 Indication of calibration. All test and inspection equipment shall have a sticker or tag denoting the calibration date and the date when due for recalibration. When it is impractical to affix tags or stickers to inspection equipment, it need not be done provided that adequate records, traceable to the equipment, are available and procedures provide for the timely monitoring and removal of equipment from service when the calibration due date is reached. Under no circumstances shall test or inspection equipment be used that is outside the established accuracy limits or has passed the recalibration date. Any measuring equipment that is used for indication purposes only, and where no inspection or test data is recorded while using the equipment, does not require calibration. This equipment shall be marked "For Indication Only".

4.5.9.2.4 Records and procedures. The contractor shall have written procedures for the inspection, maintenance, and recalibration of all measurement equipment used in the manufacture, inspection, and control of modules. The procedures shall include a recalibration schedule for each type of equipment. Frequency of recalibration shall be in accordance with the requirements of MIL-STD-45662. Procedures shall include provisions for ensuring immediate removal from service of equipment that has not been maintained or recalibrated in accordance with established schedules, or has been found to exceed allowable limits. If physical removal is impractical due to weight, service connections, or other characteristics of the equipment, it shall be removed from service and such removal indicated by signs, tags, and so forth. Records of all measurement equipment shall be maintained for Government inspection and shall include identification of each item and indication of the condition of the equipment calibration and recalibration due dates.

4.5.9.3 Change control. After successful initial qualification, the contractor shall forward to the SEM-QAA and the acquisition activity concerned all changes to documents that impact qualification or correlation status. These changes shall be submitted to the SEM-QAA for approval. All changes to test procedures or the manufacturing flow chart shall be approved by the SEM-QAA. The acquisition activity shall be notified of all changes to process, inspection, and procurement documents.

4.5.9.4 Contractor's plan of control. The contractor shall develop and document a plan for the control of module quality throughout all phases of production, material handling, storage, packaging, and shipping. This plan shall be prepared for the acquisition activity concerned and include as a minimum the following:

(a) Manufacturing flow chart.

(b) Inspection and test procedures (incoming, in-process, and final)

(c) Manufacturing instructions.

(d) Process control procedures.

(e) Process certification.

(f) Workmanship samples.

(g) Accumulation and analysis of defect data.

(h) Module assembly drawings.

(i) Electrostatic discharge control program.

4.5.9.4.1 Manufacturing flow chart. A manufacturing flow chart shall be prepared and submitted to the SEM-QAA for approval prior to start of production. This flow chart shall start with the receipt of material and show in graphic form the sequence of manufacturing operations, inspections, and tests performed in producing modules and shall end with the shipment of the complete modules. For read only memory (ROM) and programmable read only memory (PROM) modules; the manufacturing flow chart(s) shall define all processing, burn-in, manufacturing steps, screening, and rework control. The flow chart shall include references to the procedures and instructions to be followed at each operation and shall include the stations at which workmanship samples are located and defect data is recorded. The manufacturing flow chart is subject to review and approval by the SEM-QAA and is subject to change control. Therefore, this chart shall have a title, a document control number, revision status, and approval block for internal and SEM-QAA use.

4.5.9.4.2 Inspection and test procedures. Inspection and test procedures shall be prepared for all inspections and tests performed including inspections and tests of incoming materials, in-process inspections and tests, and final inspection and tests. Final inspection test procedures shall be submitted to the SEM-QAA for approval prior to start of production. These procedures shall include as a minimum the following:

(a) Quantity to be inspected or tested.

(b) Parameters of materials to be inspected and tested.

(c) Limits for acceptance and rejection.

(d) Equipment to be utilized in making inspections and tests.

(e) Detailed instructions on how to perform inspections and tests.

(f) Data to be recorded.

4.5.9.4.3 Manufacturing instructions. Instructions shall be provided for each manufacturing operation. These instructions will be in the form of written procedures and visual aids or formal training for operations prior to actual performance of the operation. These instructions are not required to be submitted to the acquisition activity concerned but shall be submitted to the SEM-QAA for review (for SEM-QAA use only). These instructions shall be retained at the contractor's manufacturing facilities until final acceptance by the Government to insure conformance of all modules manufactured. These instructions shall be available to acquisition activity personnel and Government inspectors to ensure compliance with all quality assurance provisions herein. Use of this information shall be on a proprietary basis.

4.5.9.4.4 Process control procedures. Process control procedures shall be prepared to provide control of quality for the various processes used in the manufacture of modules. These procedures shall include methods for the periodic verification of processing materials, chemical solutions, equipments, and their associated control parameters. Process control procedures shall be prepared for the following processes (as applicable):

(a) Soldering (flow solder, dip solder, hand soldering, and so forth).

(b) Riveting.

(c) Encapsulation, sealing and bonding.

(d) Application of conformal coatings.

(e) Outgassing and baking.

(f) Special technology processes.

Process control procedures are not required to be submitted to the acquisition activity concerned but shall be submitted to the SEM-QAA, before start of production for review and approval. These procedures shall be retained at the manufacturing facilities of the contractor until final acceptance by the Government of all modules manufactured. This information shall be available to acquisition activity personnel and Government inspectors to ensure compliance with all quality assurance provisions herein.

4.5.9.4.5 Process certification. The contractor shall be responsible for obtaining certification prior to start of production, for processes which require special skills and controls. Process certification shall be as follows:

(a) Certification authority. Certification shall be accomplished by either the acquisition activity concerned or an independent laboratory acceptable to the acquisition activity.

(b) Certification requirements. Certification shall consist of an evaluation of the contractor's equipment, facilities, records, and controls over the applicable process in addition to the testing of samples produced. The contractor's capability of meeting all the requirements of the applicable specifications associated with the special process shall also be reviewed.

(c) Processes requiring certification. The following processes (if used in the manufacturing of modules) shall be certified to their applicable specifications in accordance with a and b.

(1) Nickel plating: QQ-N-290.

(2) Gold plating: MIL-G-45204.

(3) Anodizing: MIL-A-8625.

(4) Resistance welding of electronic circuit modules: MIL-W-8939.

(5) Special technological processes.

(d) Certification approval. Process certification shall be approved by the SEM-QAA.

4.5.9.4.6 Workmanship samples. The contractor shall prepare workmanship samples for the evaluation of in-process workmanship prior to the start of production. These samples may be either in the form of drawings, photographs, or hardware and shall be available for review and approval by the acquisition activity concerned. Samples shall be maintained as standards of quality.

4.5.9.4.7 Accumulation and analysis of defect data. Defect data shall be processed as follows:

(a) Accumulation of data. Defect data shall be accumulated from final and in-process test and inspection stations summarizing the types and quantities of defects discovered during test and inspection.

(b) Reporting of data. Defect data shall be analyzed and related to a realistic base (that is, defective unit, defective operation, percent defective, and so forth). Limits shall be established to indicate when a process is out of control. Reports of defect data and analysis shall be prepared and made available to the acquisition activity concerned and the SEM-QAA upon request. These reports shall summarize the defects showing the major processes experiencing problems and their history of performance.

(c) Analysis of data. The contractor shall record defect data and prepare monthly defect data analysis reports for quality control review. If problems are encountered, additional defect data may be required to determine the effectiveness of any corrective action implemented.

4.5.9.4.8 Module assembly drawings. The contractor shall prepare and maintain module assembly drawings. The drawings shall consist of a pictorial view of the module or printed-wiring assembly specifying component location and identification, printed-wiring structure, electrical schematic or logic diagram, parts list, and any other features necessary for module assembly. A note or detail view shall denote orientation of polar diodes, capacitors, and symmetrical multilead components.

4.5.9.4.9 Electrostatic discharge control program. The contractor shall implement and maintain a program for protection of electrical and electronic parts, assemblies, and equipment from electrostatic discharge in accordance with MIL-STD-1686 and MIL-HDBK-263.

4.6 Inspection of packaging. The sampling and inspection of the preservation and interior package marking shall be in accordance with MIL-P-116 groups A and B quality conformance inspection requirements. The sampling and inspection of the packing and marking for shipment and storage shall be in accordance with the quality assurance provisions of the applicable container specification and the marking requirements of MIL-STD-129.

4.7 Test procedures. The following test procedures apply.

4.7.1 Visual examination. Modules shall be examined with no more than ten power to ensure compliance with the detail specification. The following characteristics shall be checked:

(a) Module profile. Dimensions shall be checked to ensure that they are within specified tolerances. Weight shall be checked on initial design and upon any design change.

(b) Keying. Module keying pin positions shall be checked to ensure correct positioning.

(c) Marking. Marking shall be checked to ensure completeness, correct positioning, and legibility.

(d) Workmanship. Modules shall be checked for compliance with the requirements of MIL-STD-1389, appendix H, which specify the workmanship inspection requirements for printed-board assemblies.

4.7.2 Electrical tests. The initial electrical requirements of each module shall be tested to the extent specified in the detail specification. Following each test specified in table I, the electrical quality assurance tests shall be performed as specified herein or in the associated detail specification. When the electrical tests to be performed are not specified, the 100-percent acceptance tests shall be performed.

4.7.3 Mechanical integrity tests. Following the tests specified in 4.7.3.1 through 4.7.3.11, the module shall meet all the configuration requirements specified herein, in the associated detail specification, and the electrical requirements of 4.7.2.

4.7.3.1 Keying pin torque. With the module body supported to prevent rotation of the unit about the longitudinal axis of the keying pin to be tested, the torque specified in 3.4.2.1 shall be applied in a plane perpendicular to the longitudinal axis of the keying pin. The torque shall be applied so that the specified torque is applied in 2 to 10 seconds from the time torque is first applied to the pin and maintained for 10 to 15 seconds. The longitudinal axis of the keying pin is considered the center of the keying pin diameter extending the length of the keying pin.

4.7.3.2 Keying pin pullout. With the module body supported to prevent movement of the unit, the force specified in 3.4.2.2 shall be applied to the keying pin in the longitudinal axis of the keying pin. The force shall be applied at a rate so that the specified force is applied in 2 to 10 seconds from the time the force is first applied to the keying pin and maintained for 10 to 15 seconds.

4.7.3.3 Keying pin pushout. With the module body supported to prevent movement of the unit, the force specified in 3.4.2.3 shall be applied to the keying pin in the longitudinal axis of the keying pin. The force shall be applied at a rate so that the specified force is applied in 2 to 10 seconds from the time the force is first applied to the keying pin and maintained for 10 to 15 seconds. The force shall be applied in the opposite direction to the force in 4.7.3.2. This test shall be applied to format D modules only.

4.7.3.4 Keying pin cantilever load. With the module body supported to prevent movement of the unit, the force specified in 3.4.2.4 shall gradually be applied perpendicular to the longitudinal axis of the keying pin at a minimum distance of 0.200 inch (5.08 mm) from the interface surface. The force shall be applied at a rate so that the specified force is applied in 2 to 10 seconds from the time the force is first applied to the keying pin and maintained for 10 to 15 seconds. The keying pin under test shall have no external support along the keying pin length extending from the interface surface during the test.

4.7.3.5 Rib strength. The individual module ribs shall withstand the torque specified in 3.4.2.5 applied in a direction perpendicular to the plane of the ribs and along the full length of the rib using a method similar to that shown on figure 1. The torque shall be applied at a rate so that the specified torque is applied in 2 to 10 seconds from the time the torque is first applied to the rib and maintained for 10 to 15 seconds.

4.7.3.6 Module torque. The module shall be mounted in a fixture which restrains the movement of the base of the module (see figure 2) and shall have a torque as specified in 3.4.2.6 applied to the module fin or header in each of two opposing directions. The torque shall be applied at a rate so that the specified torque is applied in 2 to 10 seconds from the time the torque is first applied to the module fin or header and maintained for 10 to 15 seconds. During the period of time in which torque is being applied, the module shall be rigidly supported within a zone between the interface plane and 0.50 inch (12.7 mm) above the interface plane for formats A and B, or 1.0 inch (25.4 mm) above the interface plane for formats C, D and E.

4.7.3.7 Module header torque. With the modules restrained as specified in 4.7.3.6, the torque specified in 3.4.2.7 shall be applied in both directions along the header on format C, D and E modules (see figure 3). The torque shall be applied in 2 to 10 seconds and maintained for 10 to 15 seconds.

4.7.3.8 Module cantilever load. The force specified in 3.4.2.8 shall be applied at the center of the fin or header along the centerline between the two extractor holes and perpendicular to the plane of the fin or header in two directions (see figure 4). The module shall be rigidly supported along the module ribs within a zone between the interface plane and 0.50 inch (12.7 mm) above the interface plane. The specified force shall be applied in 2 to 10 seconds from the time the force is first applied and maintained for 10 to 15 seconds.

4.7.3.9 Connector integrity. With the module ribs supported to prevent movement of the unit, the force specified in 3.4.2.9 shall gradually be applied to the connector in both directions of the longitudinal axis of the contact. The force shall be applied at a rate so that the specified force is applied in 2 to 10 seconds from the time the force is applied to the connector and maintained for 10 to 15 seconds.

4.7.3.10 Connector contact integrity. With the body of the connector supported to prevent movement of the connector, the force specified in 3.4.2.10 shall gradually be applied to each contact individually in the connector in both directions of the longitudinal axis of the contact. The force shall be applied at a rate so that the specified force is applied in 2 to 10 seconds from the time the force is first applied to the contacts and maintained for 10 to 15 seconds.

4.7.3.11 Pin shield retention. Each pin shield shall withstand the force specified in 3.4.2.11. The force shall be applied to each end of each pin shield in a direction normal to a plane passing through the centerline of both keying pins in each of two directions 180 degrees apart. The point of application of force shall be midway between the first and second electrical contacts on each end up 0.06, plus 0.00 or minus 0.03 inch (1.5, plus 0.0 or minus 0.8 mm) from the bottom edge of the pin shield (see figure 5). The rate of application of force shall be such that the specified force is applied in 2 to 5 seconds and maintained for 10 to 15 seconds at 25, plus or minus 5°C. For multiple span modules employing connectors having 50 contact rows, the foregoing tests are also required at points opposite the midpoint between contacts 25 and 26 and between 75 and 76.

4.7.4 Operating temperature tests. Modules shall be subjected to the operating temperature requirements specified in 3.5.1.1. Modules with multiple fins or ribs shall have the temperatures measured on the cooling fin or rib most closely approaching the mean temperature of all the cooling fins or ribs. The module shall be set up, operated, temperature cycled and tested according to the detail specification and the temperature cycle specified on figure 6.

(a) Low temperature test. The temperature of the module thermal interface shall be reduced to the low temperature specified for the module class in approximately 5 minutes. This temperature must be maintained for a minimum of 4 hours plus 0.25 hour for each module increment greater than the basic size. The module environment shall be controlled to prevent frost or moisture build-up on the module. The module is then tested and must meet the initial electrical requirements of the detail specification for its class temperature.

(b) High temperature test. With the module operating, the temperature of the module thermal interface shall be increased to the high temperature specified for the module class in approximately 5 minutes. This temperature must be maintained for a minimum of 4 hours plus 0.25 hour for each module increment greater than the basic size. The module is again tested and must meet the initial electrical requirements of the detail specification for its class temperature.

(c) Transient temperature test. With the module operating, the temperature of the module thermal interface shall be increased to 20°C above the high temperature specified for the module class and maintained for 1 hour. Perform electrical tests on the module within the next hour. The electrical tests may be postponed for up to 8 hours if the temperature is maintained and the module is turned off. Once testing is resumed, perform the electrical tests within 1 hour. The module must meet the module class high temperature end-of-life (EOL) requirements for the 100 percent electrical tests. After this portion of the test is complete and with the module nonoperating, the thermal interface temperature is reduced to 25°C in approximately 5 minutes. This temperature is maintained for a minimum of 2 hours plus 0.25 hour for each increment greater than the basic size. The module is again tested to meet the initial electrical requirements of the detail specification for 25°C.

4.7.5 Vibration test (classes I and III). Modules shall be subjected to separate simple harmonic motion and random vibration specified in 3.5.1.2 in accordance with 4.7.5.1 and 4.7.5.2. Module connectors shall be inserted into a backplane utilizing tuning fork type connectors in accordance with MIL-C-28754 or MIL-C-28859. The modules shall be securely clamped along both ribs. Modules shall be operated during these tests when specified in the detail specification. At the completion of each axis of vibration, modules shall be visually examined for damage. Following vibration, the modules shall pass the electrical tests of 4.7.2 plus power supply filter capacitance (if required by the associated detail specification).

4.7.5.1 Simple harmonic motion vibration. Modules shall be subjected to vibration in accordance with MIL-STD-202, method 201 for 3 minutes each axis.

4.7.5.2 Random vibration. Modules shall be subjected to random vibration in accordance with MIL-STD-202, method 214, test condition I, letter D, for 3 minutes each axis.

4.7.6 Vibration test (classes II and IV). Modules shall be subjected to separate high frequency and random vibration as specified in 3.5.1.2 in accordance with 4.7.6.1 and 4.7.6.2. Module connectors shall be inserted into a backplane utilizing tuning fork type connectors in accordance with MIL-C-28754 or MIL-C-28859. The module shall be securely clamped along both ribs. Modules shall be operated during these tests when specified in the detail specification. At the completion of each axis of vibration during the test, modules shall be visually examined for damage. Modules shall pass the electrical tests of 4.7.2 plus power supply filter capacitance (if required by the associated detail specification).

4.7.6.1 High frequency vibration. Modules shall be subjected to high frequency vibration in accordance with MIL-STD-202, method 204, test condition G, two sweeps per axis.

4.7.6.2 Random vibration. Modules shall be subjected to random vibration in accordance with MIL-STD-202, method 214, test condition I, letter E, for 0.5 hour each axis.

4.7.7 Inclination test. When specified in the detail specification, modules shall be subjected to inclination tests as specified in 3.5.1.3 in accordance with the following:

(a) Modules shall be inclined at a rate of 5 to 7 cycles per minute in one plane to angle of 90 degrees on either side of the vertical for a period of 30 minutes minimum. During this period, modules shall be tested and shall satisfy the initial 100 percent electrical requirements specified in the detail specification. At all other times during the inclination test, modules shall be operated as specified on the life test circuit in the detail specification.

(b) Following the cyclic tests specified above, the cyclic motions shall be stopped and the inclination adjusted to any angle within 90 degrees of the vertical. Modules shall then be tested and shall satisfy the initial 100 percent electrical requirements specified in the detail specification. At all other times during the inclination test, modules shall be operated as specified on the life test circuit in the detail specification.

4.7.8 Life test. Modules shall be operated for a period of not less than 500 hours with the module thermal interface held to the maximum class operating temperature as specified in 3.5.1.4. Upon completion of the life test, modules shall meet the end-of-life minimum and maximum limits as specified in the detail specification. Modules shall then be returned nonoperating to an ambient temperature of 25°C with a transfer time of approximately 5 minutes. After a stabilization period of 2 hours plus 0.25 hour for every module increment greater than the basic size, modules shall again meet the end-of-life requirements specified in the detail specification.

4.7.9 Barometric pressure (reduced). Classes II and IV modules shall be subjected to the reduced barometric pressure specified in 3.5.1.5. Modules shall be tested in accordance with MIL-STD-202, method 105, test condition D. Modules shall be mounted such that the module ribs are in contact with the wall of the test chamber. This is the only cooling other than convection. The pressure shall vary at a maximum rate of 0.5 inch (13 mm) of mercury per second. Modules shall be held at the specified pressure for 30 minutes and then, at that pressure, shall meet the electrical tests specified in the detail specification. Upon removal from the chamber, modules shall show no evidence of deterioration or physical damage and shall meet the electrical tests specified in 4.7.2.

4.7.10 Radiation hardness assurance test. Classes III and IV modules shall be subjected to the radiation hardness assurance requirements of 3.5.1.6. The test sample shall consist of a minimum of 5 modules which have been subjected to and passed the module electrical requirements specified in the detail specification for the 100 percent and sample acceptance tests initial limits at 25°C. Post irradiation electrical tests shall be the same electrical requirements using the end-of-life limits at 25°C unless otherwise specified in the detail specification. The test sample shall be subjected to the following sequence and levels of radiation exposure:

(a) Ionizing dose rate: 1×10^9 rad(Si) per s, (20 nS pulse width).
(b) Total ionizing dose: 3×10^3 rad(Si).
(c) Neutron fluence: 2×10^{12} neutrons per cm^2.

Modules are considered to have successfully passed the radiation hardness assurance requirements if the modules pass the end-of-life requirements after each radiation exposure. When the radiation hardness design margin is known to be larger, the SEM-QAA may waive that particular radiation environment. If the radiation hardness design marking is low, or unknown, component change controls as specified in 4.5.9.1.1 shall be implemented. The combination of these radiation exposure environments are considered destructive and, therefore, test sample modules subjected to them shall not be used in, or shipped for use in, any operational system. For the purpose of this specification, all terms used in the following referenced test methods, such as semiconductor device, integrated circuit or part, and so forth, meaning the part under test or irradiation, shall be interpreted as meaning the module.

4.7.10.1 Ionizing dose rate. Modules shall be tested in accordance with MIL-STD-883, method 1023. The radiation pulse width shall be 20-200 nS with 200 rad (Si) maximum absorbed total dose per pulse. All references in method 1023 to linear integrated circuit and linear microcircuit shall be applied to the module under test. Modules shall be operated during irradiation as specified in the detail specification. The measurements shall be taken in the test fixture prior to removal of any bias after the radiation pulse. Modules must pass the 25°C end-of-life electrical tests as specified in 4.7.10.

4.7.10.2 Total ionizing dose. Modules shall be tested in accordance with MIL-STD-883, method 1019. Modules shall be operated during irradiation as specified in the detail specification. Post irradiation electrical tests shall be performed within 2 hours after exposure.

4.7.10.3 Neutron fluence. Modules shall be tested in accordance with MIL-STD-883, method 1017. Modules shall not be operated during irradiation.

4.7.11 Durability. Modules and contacts shall be subjected to 500 cycles of mating as specified in 3.5.2.1 at the rate of not more than 10 cycles per minute. During the test, modules shall be mounted so that the insertion and withdrawal forces are transmitted directly from the fin or header to the connector. Formats C, D and E modules shall be inserted into a backplane meeting the requirements of MIL-A-28870. For modules which exercise the lateral displacement option (floating) the card cage test system shall provide a clearance of 0.006 plus or minus 0.001 inches (0.15 plus or minus 0.03 mm) between the surface of the module guide rib and the interfacing rail surface on the card cage. For modules which do not exercise the lateral displacement option (nonfloat) the clearance above should only be 0.0030 plus 0.0005 or minus 0.0000 inches (0.076 plus 0.013 or minus 0.000 mm) between the surface of the guide rib and the interfacing rail surface on the card cage. The clamping force in both cases shall be 75 pounds to each guide rib. Modules shall be forced against the rail surface on each cycle after modules are seated into the backplane. This clamping force shall be removed prior to extraction of the modules. This clamping force shall be uniformly applied to the module guide ribs on the surface opposite the one in contact with the rail surface. Following this test all formats shall pass the electrical tests specified in 4.7.2.

4.7.12 Humidity. Modules shall be subjected to humid atmosphere cycles as specified in 3.5.2.2. Modules shall be tested in accordance with MIL-STD-810, method 507, procedure III. Modules shall be mounted in the humidity chamber with the module span at a 45 degree angle to a horizontal plane. The modules shall be subjected to 10 cycles. At the conclusion of the exposure to the humid environment, excess water shall be shaken and wiped from the external surfaces of the modules and the mechanical requirements of the modules shall be tested within 1 hour after removal from the test chamber. Modules shall also be tested to the end-of-life (EOL) requirements of the 100 percent electrical acceptance tests and all isolation tests specified in the detail specification after allowing a 4 hour stabilization period at room temperature in a free convection atmosphere.

4.7.13 Thermal shock.

4.7.13.1 Thermal shock (classes I and III). Modules shall be subjected to thermal shock as specified in 3.5.2.3. Modules shall be tested in accordance with MIL-STD-202, method 107, test condition A. Modules shall pass the electrical tests of 4.7.2 with no evidence of physical deterioration or damage.

4.7.13.2 Thermal shock (classes II and IV). Modules shall be subjected to thermal shock as specified in 3.5.2.3. Modules shall be tested in accordance with MIL-STD-202, method 107, test condition B. Modules shall pass the electrical tests of 4.7.2 with no evidence of physical deterioration or damage.

4.7.14 Thermal cycle.

4.7.14.1 Thermal cycle (classes I and III). Modules shall be subjected to thermal cycling as specified in 3.5.2.4. Modules shall be tested in accordance with MIL-STD-883, method 1010, test condition A. The module solder joints shall show no evidence of physical deterioration or damage.

4.7.14.2 Thermal cycle (classes II and IV). Modules shall be subjected to thermal cycling as specified in 3.5.2.4. Modules shall be tested in accordance with MIL-STD-883, method 1010, test condition B. The module solder joints shall show no evidence of physical deterioration or damage.

4.7.15 Shock test. Modules shall be subjected to shock as specified in 3.5.2.5. Modules shall be tested in accordance with MIL-STD-202, method 213, test condition I. Modules shall satisfy the electrical tests of 4.7.2 before and after the shock test.

4.7.16 Salt fog. Modules shall be subjected to salt fog as specified in 3.5.2.6. Modules shall be tested in accordance with MIL-STD-810, method 509, procedure I. At the conclusion of the exposure to the salt fog environment, excess water shall be shaken from the external surfaces of the modules. Modules shall be examined for corrosion with the aid of 10 power

following storage for 48 hours at room ambient conditions to allow for evaporation of excess moisture. Electrical operation of the module shall be used as a criterion for failure only when specified in the associated detail specification or by the acquisition activity concerned.

4.7.17 Flammability. Modules shall be subjected to flammability as specified in 3.5.2.7. Modules shall be tested in accordance with MIL-STD-202, method 111. Modules shall not support violent or explosive type burning and shall be nonburning or shall be self-extinguishing within 5 seconds after removal of flame. Modules shall be mounted securely in a horizontal plane (clamps shall be thermally insulated). The point of flame impingement shall be the center of the module. Modules shall be oriented such that the printed-wiring, or most vulnerable part, is directly within the flame's vertical axis. The heat of the flame at the point of impingement shall be 500 plus or minus 100°C. Electrical tests are not required following the flammability test.

4.7.18 Hydrogen atmosphere. Modules shall be subjected to a hydrogen atmosphere as specified in 3.5.2.8. Modules shall be placed in a chamber wherein the atmosphere consists of 10 percent hydrogen and 90 percent nitrogen and maintained for 6 hours minimum at a temperature of 85, plus 5 or minus 0°C. Following this exposure, modules shall meet the requirements specified in 4.7.2. Due to the hazardous nature of the required environment, caution shall be exercised throughout the conduct of this test.

4.7.19 Storage temperature. Modules shall be subjected to low and high storage temperatures as specified in 3.5.2.9 to ensure that modules can be stored during service use without protective packaging.

4.7.19.1 Low temperature. Modules shall be placed in a chamber and the temperature reduced until minus 55°C is reached with a transfer time between temperature excursions of approximately five minutes. The temperature shall be maintained for a period of 24 hours.

4.7.19.2 High temperature. Modules shall be placed in a chamber and the temperature increased with a transfer time between temperature excursions of approximately five minutes until 125°C is reached. The temperature shall be maintained for a period of 24 hours.

4.7.20 Fungus. Modules shall be subjected to fungus tests specified in 3.5.2.10 in accordance with MIL-STD-810, method 508.3. The module shall support no more than trace amounts of fungal growth following this test. The module shall not support significant growth. Significant growth shall be defined as fungal growth which in time is likely to cause one or more of the following conditions:

(a) A major failure of the module.

(b) Growth which upon extended incubation may develop sufficiently to cause a major failure of the module.

(c) Growth which alters the physical, chemical, or electrical properties of the material supporting fungal growth.

Electrical operation of the module shall be used as a criterion for failure only when specified in the detailed module specification or by the acquisition activity concerned.

4.7.21 Component thermal tests. Modules shall be set up in thermal test fixtures, operated according to the detail specification (if no circuit is specified, the life test circuit shall be used), and tested to the requirements described below. Unless otherwise specified in the detail specification, all power shall be dissipated through each thermal interface individually without any heat loss from the other interfaces. The fin or rib temperatures shall be monitored as near as possible to the thermal interface without disrupting the integrity of the thermal interface.

4.7.21.1 Direct air impingement tests. In addition to the capability to dissipate heat through the rib or fin surfaces, format B, D, and E modules shall be tested for heat dissipation by the direct air impingement test method. Inlet air temperature shall be in accordance with the appropriate module class interface temperature. The inlet air shall be monitored in such a manner that it does not significantly alter the flow of air to the module under test. The direction of air flow across the module shall be from the pin 1 (alpha) end of the module. All modules shall be tested in an air flow duct sized in accordance with the particular design

requirements of MIL-STD-1389, appendix B, D or E, as applicable. Provisions must be incorporated in the ducts to measure component temperature and air flow pressure drop. The ducts shall be provided with adequate transition regions up stream and down stream of the module test location.

4.7.21.2 Critical component temperature (CCT) test. With the module operating at its class high thermal interface temperature, the temperatures of components shall meet the requirements of critical component temperatures in 3.4.3.1.

4.7.21.3 Transient critical component temperature (TCCT) test. With the module operating at its class high thermal interface temperature, the temperature shall be raised to 20°C above the class high temperature in approximately 5 minutes and maintained for 1 hour. The module component temperature shall meet the requirements of the transient critical component temperatures in 3.4.3.2.

4.7.22 Solvents test. Modules which use adhesive backed labels shall meet the requirements of 3.5.2.11 when tested in accordance with MIL-STD-202, method 215.

4.8 Government source inspection. Government acquisition quality assurance actions at source for acceptance of modules furnished under the requirements specified herein are as determined by the acquisition activity unless that activity is the Government, in which case QA activities at source are a requirement. These actions shall include; review of the module contractor's quality program and the means employed to control quality and to comply with contract requirements, review of the supplies, initiation of required corrective action, and the inspection of the modules.

5. PACKAGING

5.1 Preservation. Preservation shall be level A, B, or C, as specified (see 6.2).

5.1.1 Level A.

5.1.1.1 Cleaning. Modules shall be cleaned in accordance with MIL-P-116, process C-I.

5.1.1.2 Drying. Modules shall be dried in accordance with MIL-P-116.

5.1.1.3 Preservation application. Preservatives shall not be used.

5.1.1.4 Unit packs. Each module shall be individually unit packed in accordance with MIL-P-116 submethod IA-8 in a bag or envelope conforming to MIL-B-117, type I, class F, style 1. To avoid capacitor effects, each bag or envelope shall be fabricated from a continuous piece of barrier material. Cushioning shall conform to PPP-C-1842, type III, or PPP-C-795, class 2. Each unit exceeding 30 cubic inches (492 cubic centimeters) shall be placed in a supplementary container conforming to variety 2 of PPP-B-566, PPP-B-676, or PPP-B-636, class weather resistant.

5.1.1.5 Intermediate packs. Unit packs not exceeding 30 cubic inches (492 cubic centimeters) in size shall be placed in intermediate containers conforming to variety 2 of PPP-B-566, PPP-B-676, or PPP-B-636, class weather resistant. Intermediate containers shall be uniform in size shape and quantities, shall be of minimum tare and cube and shall contain multiples of five unit packs, not to exceed 100 unit packs. No intermediate packs are required when the total quantity shipped to a single destination is less than 100 unit packs or when supplementary containers are used.

5.1.2 Level B. The level B preservation for modules shall be as specified for level A except that any variety of the containers conforming to PPP-B-566 or PPP-B-676 or class of the containers conforming to PPP-B-636 may be used to meet the supplementary and intermediate container requirements.

5.1.3 Level C. Except as specified herein, the level C preservation for modules shall conform to the MIL-STD-794 requirements for this level. Wrapping and cushioning materials shall be nonstatic generating and noncorrosive and shall not crumble, flake, powder or shed. Unless otherwise specified in the contract (see 6.2), the quantity per unit pack shall be at the option of the contractor.

5.2 Packing. Packing shall be level A, B, or C, as specified (see 6.2).

5.2.1 Level A. Modules, preserved as specified in 5.1, shall be packed in wood containers conforming to PPP-B-601, overseas type or PPP-B-621, class 2. Closure and strapping shall be in accordance with the applicable container specification except that metal strapping shall conform to QQ-S-781, type I, finish A. The requirements for level B packing shall be used when the total quantity of a stock numbered module for a single destination does not exceed a packed volume of one cubic foot (0.0283 cubic meter).

5.2.2 Level B. Modules, preserved as specified in 5.1, shall be packed in fiberboard containers conforming to PPP-B-636, class weather resistant, style optional, special requirements. The requirements for box closure, waterproofing, and reinforcing shall be in accordance with method V of the PPP-B-636 appendix.

5.2.3 Level C. Modules, preserved as specified in 5.1, shall be packed in fiberboard containers conforming to PPP-B-636, class domestic, style optional, special requirements. Closures shall be in accordance with the PPP-B-636 appendix.

5.3 Marking.

5.3.1 Standard marking. In addition to any special or other identification marking required by the contract (see 6.2), each unit, supplementary, intermediate and exterior container shall be marked in accordance with MIL-STD-129. The complete military or contractor's type or part number, as applicable (including the FSCM), shall be marked on all units, supplementary and intermediate packs in accordance with the identification marking provisions of MIL-STD-129.

5.3.2 Special marking. In addition to the marking requirements of 5.3.1 and regardless of the level or type of packaging specified, all unit, supplementary, intermediate and exterior containers shall be marked as specified for sensitive electronic devices in MIL-STD-129.

5.4 General.

5.4.1 Exterior containers. Exterior containers (see 5.2.1, 5.2.2, and 5.2.3) shall be of a minimum tare and cube consistent with the protection required and shall contain equal quantities of identical stock numbered items to the greatest extent practicable.

5.4.2 Packaging inspection. The inspection of these packaging requirements shall be in accordance with 4.6.

5.4.3 Army acquisitions.

5.4.3.1 Level A and B intermediate packs. Intermediate containers shall not exceed 50 unit packs or exceed a maximum of 40 pounds (13.14 kilograms) net weight or 1.5 cubic feet (0.0425 cubic meter) with at least two dimensions not exceeding 16 inches (41 centimeters). Intermediate containers shall not be required when the total quantity to be shipped will result in only one intermediate pack per shipping container.

5.4.3.2 Level A and B packing. When the gross weight exceeds 200 pounds (90.72 kilograms) or the container length and width is 48 X 24 inches (121 X 61 centimeters) or more and the weight exceeds 100 pounds (45.36 kilograms), 3 X 4 inch (7.6 X 10.2 centimeters) skids (laid flat) shall be applied in accordance with the requirements of the container specification. Palletization shall be required when the containers specified in 5.2.1 and 5.2.2 do not require skids; quantities per destination exceed either a total of 250 pounds (113.4 kilograms), excluding the pallet, or a volume of 20 cubic feet (0.566 cubic meter); and the container size permits use of one of the pallet patterns of MIL-STD-147. A quantity of containers, packed as specified, except that container strapping may be omitted, shall be placed on a pallet, load type I conforming to MIL-STD-147. For level B, unit or intermediate containers which meet these requirements may be palletized without further packing. The pallet shall conform to NN-P-71, type IV, group I or II woods. The load shall be "bonded" to the pallet by strapping conforming to QQ-S-781, type I, finish A, or shrink film conforming to L-P-378, type IV. Stretch wrap in accordance with MIL-STD-147 is authorized for shipments within the continental United States and for containerized shipments.

6. NOTES

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

6.1 Intended use. Standard electronic modules specified herein are intended for use in military systems and subsystems.

6.2 Acquisition requirements. Acquisition documents shall specify the following:

(a) Title, number, and date of this specification.
(b) Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
(c) Title, number, and the military part number.
(d) Levels of preservation and packing required (see 5.1 and 5.2).
(e) If special or other identification marking is required (see 5.3).
(f) JAN certification as required (see 3.6.1).

6.3 Data requirements. The data required by this specification include, but are not restricted to, the following.

6.3.1 Data requirements for qualification. Data items identified in this specification are required to be delivered as applicable to the SEM-QAA for the purpose of facilitating qualification testing. The data will not be disclosed outside the Government nor duplicated, used, or disclosed in whole or in part, for any purpose other than to evaluate the SEM submitted for qualification testing (see 6.4). Generally, these data requirement deliveries coincide with qualification submission/schedules and are not a function of SEM acquisitions. Deliverable data required (but not restricted to those listed) by this specification for qualification are cited below:

Paragraph Number	Data requirement title
3.3.1.1	Printed-board exception
3.3.1.2	Printed-board assembly exception
4.4.3	Test data
4.4.4	Failure rate and parts derating
4.4.5	Thermal performance
4.4.6	Design conformance
4.4.7.2	Periodic-check sample submission
4.4.7.3	Noncontinuous production
4.5.4	Failure analysis
4.5.9	Quality program requirements
4.5.9.3	Change control
4.5.9.4	Contractor's plan of control
4.5.9.4.7	Accumulation and analysis of defect data
10.6, appendix A	Notification
50.3, appendix A	Test procedures documentation
60.4, appendix A	Correlation requirement
70.2, appendix A	Recorrelation criteria

6.3.1.1 Rights in technical data. All data and information provided for use or specified to be delivered for qualification purposes will be furnished for use by the SEM-QAA only. This data shall be delivered to the requirements of SD-6, "Provisions Governing Qualification" and therefore no contractual Data Item Descriptions (DIDs) are required.

6.3.2 Consideration of data requirements. When this specification is used in an acquisition and data are required to be delivered, the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (CDRL) and incorporated into the contract. When the provisions of DoD FAR Supplement, Part 27, Sub-Part 27.410-6 (DD Form 1423) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with contract or purchase order requirements. Deliverable data in this specification are cited below.

Paragraph number	DID number	DID title
4.5.4	DI-E-7045	Report, Failure Analysis for the Standard Electronic Modules Program (SEMP)

6.4 Qualification. With respect to products requiring qualification, awards will be made only to module contractors (1) whose products which are, at the time, set for opening of bids qualified for inclusion in Qualified Products List QPL No. 28787 or (2) who have at least one SEM listed on the QPL-28787, at the time set for opening of bids and deliver with their bid a statement of certification that the procured item(s) will be qualified prior to the required delivery date. The attention of module contractor is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the qualified products list is Naval Sea Systems Command, SEA-55Z3, Department of the Navy, Washington, DC 20362-5101; however, information pertaining to qualification of products may be obtained from the Naval Weapons Support Center, Code 603, Crane, Indiana 47522-5060. Application for qualification tests shall be made in accordance with SD-6, "Provisions Governing Qualification".

6.5 Definitions. The following definitions are applicable to terms used herein.

6.5.1 Acquisition activity concerned. The acquisition activity concerned is the organizational element of the Government which contracts for articles, supplies or services, or it may be a contractor or subcontractor when the organizational element of the Government has given specific written authorization to such a contractor or subcontractor to serve as agent of the acquisition activity concerned. A contractor or subcontractor serving as agent of the acquisition activity concerned shall not have the authority to grant waivers, deviations, or exceptions to this specification unless specific written authorization has been given by the Government.

6.5.2 SEM-QAA. The SEM-QAA performs Standard Electronic Module QPL maintenance and support. These functions are performed by the Naval Weapons Support Center, Code 603, Crane, Indiana 47522-5060.

6.5.3 Failure analysis activity. The failure analysis activity is the SEM-QAA or its designated representative is the activity responsible for performing failure analysis on modules failing qualification inspection.

6.5.4 Module contractor. A module contractor is any person, partnership, company, corporation, or association who owns, operates, or maintains a factory or establishment that produces, on the premises, the modules required under a contract or purchase order with the acquisition activity concerned. If modules are manufactured by an organization within the acquisition activity concerned, that organization should be considered a module contractor.

6.5.5 Material review board (MRB). The MRB will be comprised of three members as follows:

(a) A Government member or his designated representative will be the chairman and should approve the qualifications of all other members and alternates.

(b) A module contractor's representative whose primary responsibility is the quality of the product.

(c) A module contractor's representative whose primary responsibility is the design of the product.

Any concurrence of a disposition by the board must be unanimous. A member may have alternates approved by the chairman.

6.5.6 Initial tolerance. The initial tolerance is the minimum and maximum electrical limit for any particular module characteristic established at an ambient temperature of 25, plus or minus 5°C as well as at the temperature extremes specified for the applicable module class.

6.5.7 End-of-life tolerance. The end-of-life tolerance is the minimum and maximum limit for any particular module characteristic after being subjected to 500 hours operation established at an ambient temperature of 25, plus or minus 5°C as well as at the temperature extremes specified for the applicable module class.

6.5.8 Module thermal interface. The term module thermal interface refers to the fin or rib cooling surface or to the component surface of the module for convective direct air impingement cooling.

6.6 Substitutability. The following order of substitutions is acceptable for all classes.

Class I module ordered	- Suitable replacements include classes II, III and IV.
Class II module ordered	- Suitable replacement is class IV.
Class III module ordered	- Suitable replacement is class IV.

6.7 Request for deviation or waiver. Requests for deviation or waiver from the materials, processes, and requirements specified herein and from any applicable drawings, specifications, publications, and materials or processes referenced herein should be submitted to the acquisition activity concerned for approval.

6.8 Conflicting requirements. Conflicting requirements arising between the requirements specified herein and those in any specification, standard, drawing or publication listed herein, should be referred in writing to the SEM-QAA, for interpretation, clarification, resolution, or correction.

6.9 Nonconforming materials. Any variance of material from this specification and from the associated detail specification will be disposed of in accordance with the decision reached by the MRB (see 6.5.5). The contractor may use in-house established procedures documented in his control plan for such disposition. Records of all such variances and disposition shall be retained on file and available for Government review.

6.9.1 Disposition of nonconforming material. The disposition of nonconforming material, due to improper or faulty manufacturing methods or techniques will generally fall into the following categories:

(a) Use as is -- Material that, in its present condition, can be used without compromising form, fit, function, performance, reliability, safety, and so forth. The disposition will be by the MRB.

(b) Repair -- Material which, after repair, meets the definition of (6.9.1.a) but does not fully meet drawing and specification requirements. This disposition, including approval of the repair procedure, will be by the MRB.

(c) Rework -- Material which can economically be restored to a conforming condition. This disposition does not require MRB approval.

(d) Scrap -- Material not usable in its present condition and which cannot be economically reworked or repaired. This disposition does not require MRB approval.

6.9.2 Shipment of nonconforming material. Modules containing nonconforming material will not be shipped until the applicable waiver or deviation has been approved by the acquisition activity involved or the final MRB disposition has been received. Modules requiring a waiver or deviation will not be marked with JAN or J.

6.10 Corrective action. Upon notification of failure of qualification inspection, the vendor will submit a letter indicating the corrective action. After acceptance of the corrective action, which may or may not require a resubmission, the SEM-QAA will reinstate the qualification status.

6.11 JAN marking. The SEM-QAA will notify in writing each module contractor on a military part number basis when JAN may be marked on a module. Conversely, when a module contractor fails to meet all of the requirements herein, in MIL-STD-1389, and the associated detail specification, the vendor will be notified in writing to stop marking JAN. Such notification will come from the SEM-QAA.

6.12 Conditions for use of level B preservation. When level B preservation is specified (see 5.1), this level of protection should be reserved for the acquisition of modules for resupply worldwide under known favorable handling, transportation, and storage conditions.

6.13 Subject term (key word) listing.

Modules, Standard Electronic
SEM
Standard Electronic Modules
Standard Electronic Modules Program

6.14 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

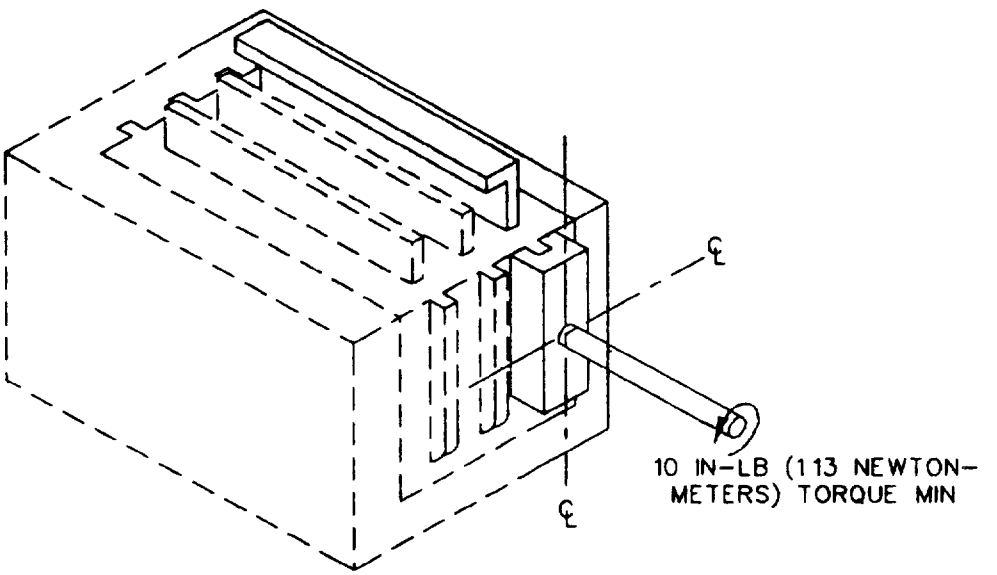
Custodians:
Army - ER
Navy - SH
Air Force - 85

Review activities:
Army - AT, AV
Navy - AS, MC
Air Force - 13, 17, 19
DLA - ES

Preparing activity:
Navy - SH

Agent:
NWSC Crane

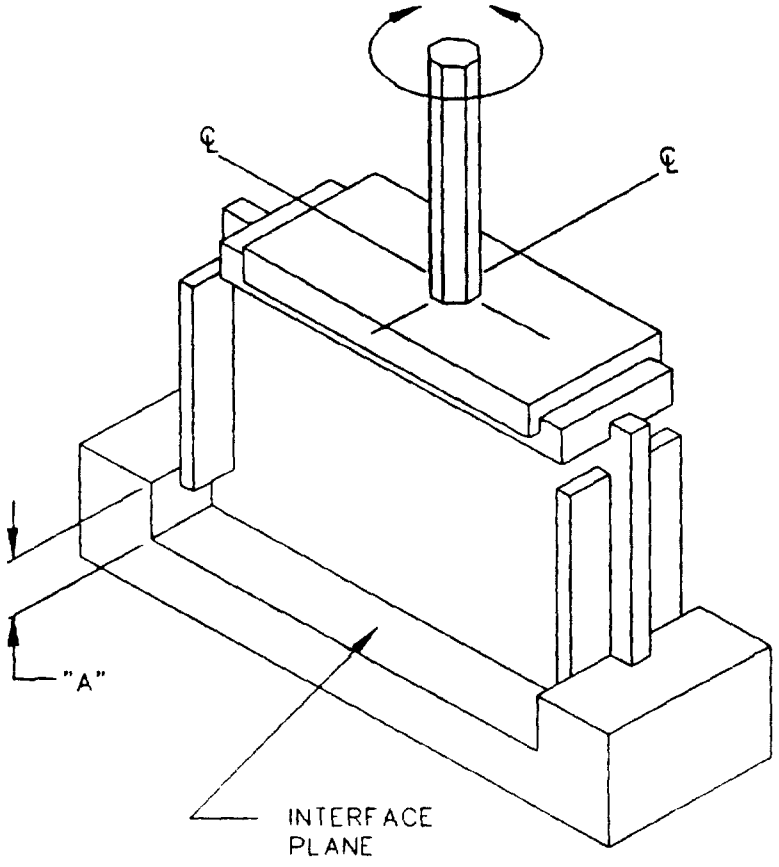
(Project 5963-0039)



NOTES:
1. Required for all formats
2. Metric equivalents are given for general information only.
3. Metric equivalents are in parenthesis.

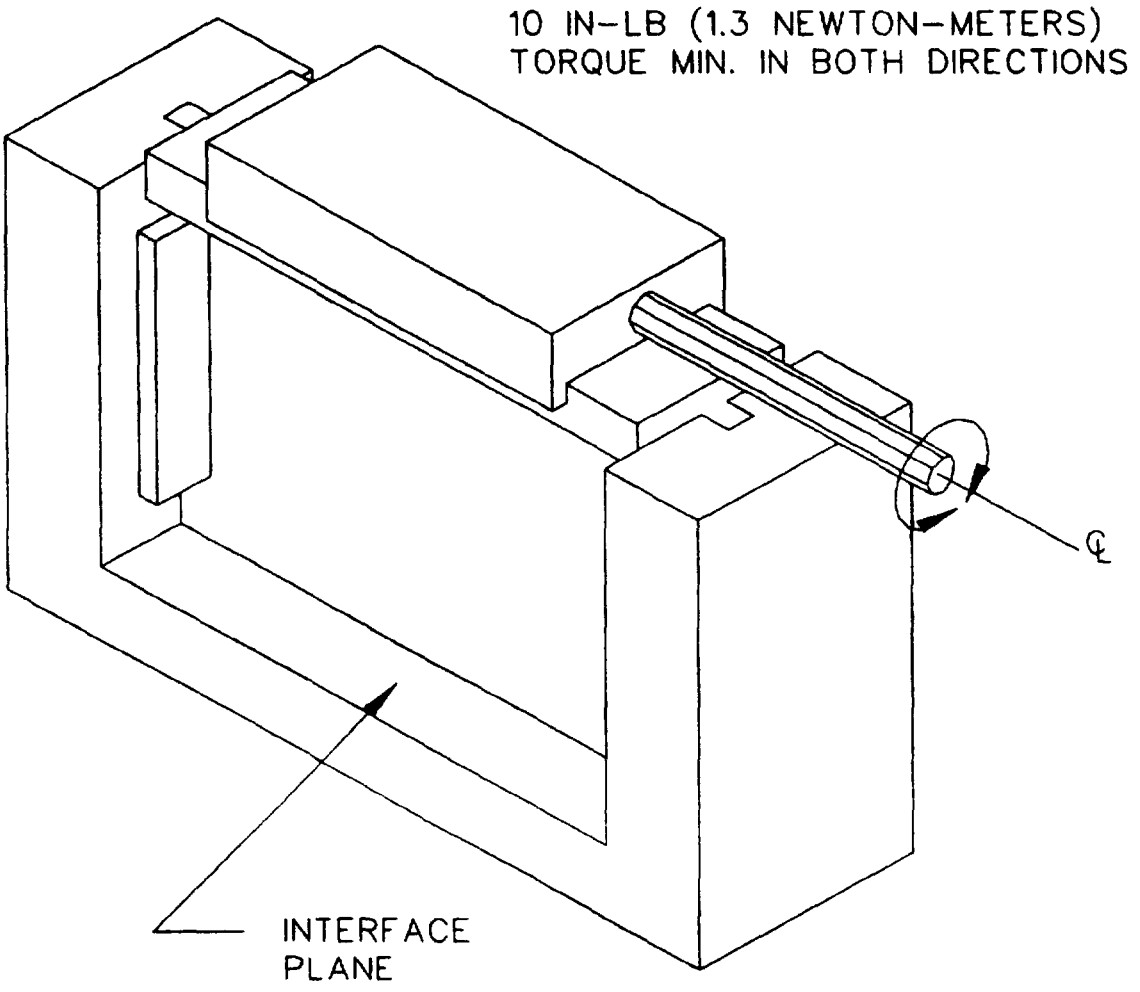
FIGURE 1. Rib strength.

FORMATS A,B 6 IN-LB (Ø 68 NEWTON-METERS) TORQUE MIN IN BOTH DIRECTIONS
FORMATS C,D,E 25 IN-LB (2 82 NEWTON-METERS) TORQUE MIN IN BOTH DIRECTIONS



NOTES:
1. Dimensions are in inches.
2. Metric equivalent are given for general information only.
3. Metric equivalents are in parenthesis.
4. "A" is 0.5 inch (12.7 mm) for formats A and B, and 1.0 inch (25.4 mm) for formats C, D and E.

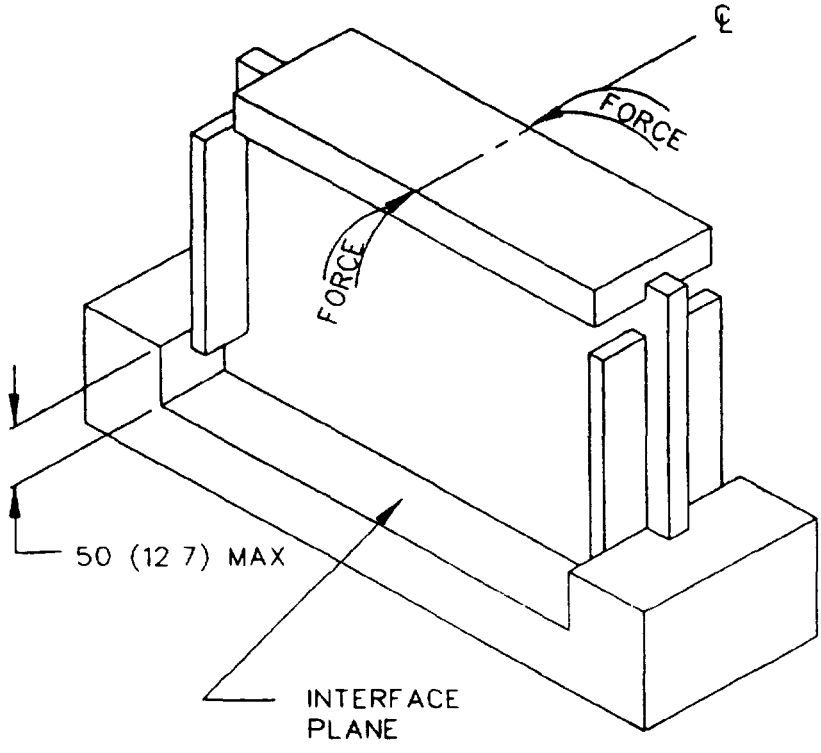
FIGURE 2. Module torque.



NOTES:
1. Metric equivalents are given for general information only.
2. Metric equivalents are in parenthesis.

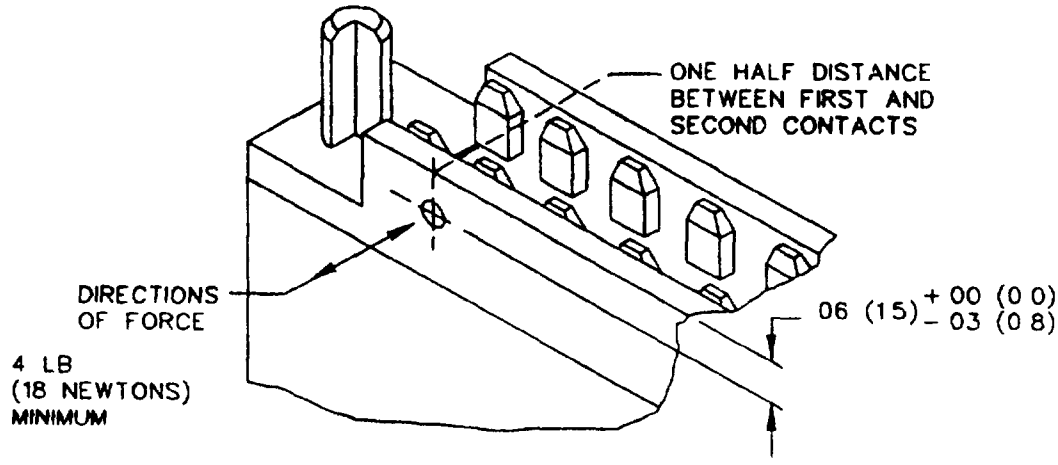
FIGURE 3. Module header torque.

FORMATS A,B. 2 LB (9 NEWTONS)
FORMATS C,D,E. 5 LB (22.3 NEWTONS)
MININUM IN BOTH DIRECTIONS



NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Metric equivalents are in parenthesis.

FIGURE 4. Module cantilever load.



NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Metric equivalents are in parentheses.
4. On modules with 20 contact row connectors, the force is applied at four different points for a total of eight measurements. On modules with 50 contact row connectors, the force is applied at six different points for a total of 12 measurements.
5. Required for all formats.

FIGURE 5. Pin shield retention.

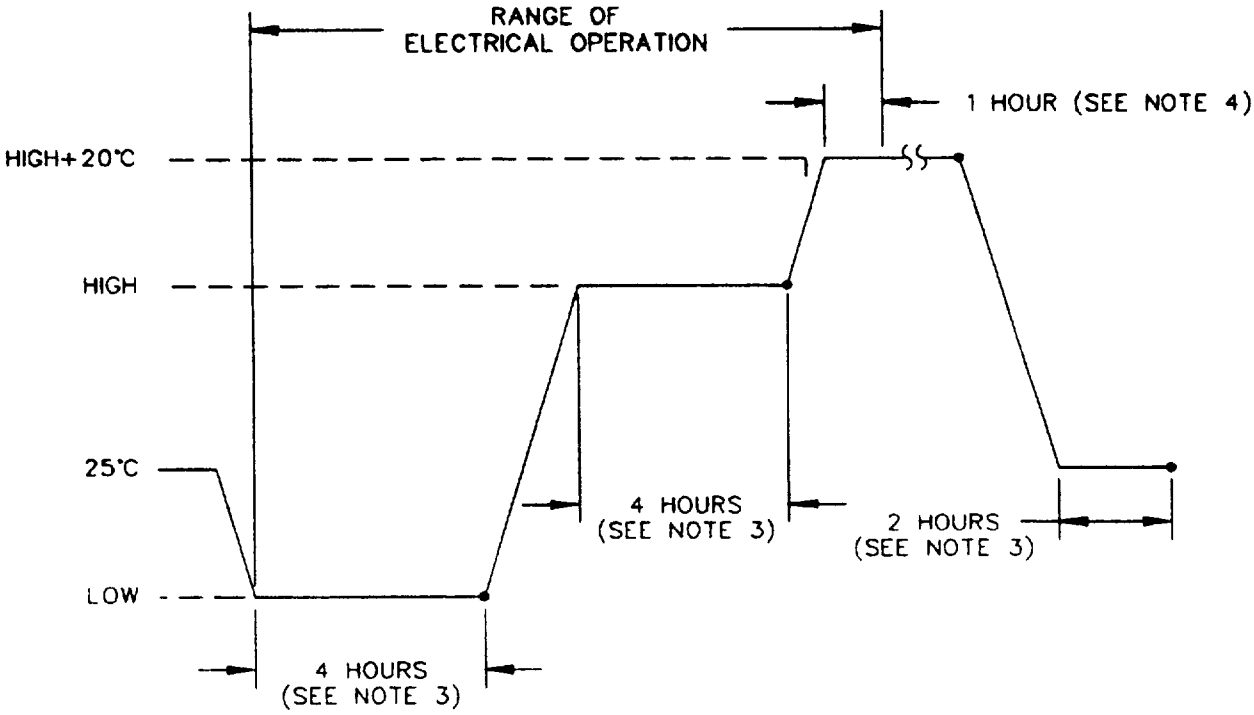


FIGURE 6. Operating temperature cycle.

NOTES:

1. The high, low, room, and transient temperatures shall be:

High	(Classes I and III	60, plus 5 or minus 0°C)
	(Classes II and IV	85, plus 5 or minus 0°C)
Low	(Classes I and III	0, plus 0 or minus 5°C)
	(Classes II and IV	minus 55, plus 0 or minus 5°C)
Room	All classes	25, plus or minus 5°C
Transient	(Classes I and III	80, plus 5 or minus 0°C)
	(Classes II and IV	105, plus 5 or minus 0°C)

2. The transfer time between temperature excursions shall be approximately five minutes.
3. The time at temperature shall be increased by 0.25 hour for each module increment greater than the basic size.
4. The total time allowed for the transient thermal test shall be 1 hour of module operation plus 8 hours of nonoperating storage plus 1 hour for electrical tests.
5. • - Electrical tests shall be performed.

FIGURE 6. Operating temperature cycle - Continued.

APPENDIX A

STANDARD ELECTRONIC MODULE TESTER CORRELATION

10. SCOPE

10.1 Scope. This appendix describes and states criteria for correlation, the method of proving, for a specific military part numbered module, that all production testers shall yield test data which matches the correlation data within close tolerance and determines if the module meets the requirements of the module associated detail specification. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

10.2 Performance. Correlation shall be performed on all production testers used to accept, qualify, or recertify SEM. Successful correlation shall be required to certify the use of a tester and its peripheral equipment (adapter, switching cards).

10.3 Method. Correlation is accomplished by using a common medium between the production tester and the quality assurance provision of the module detail specification. This medium provides a means of comparing the results of a specific module having known recorded parameters with the results of the production testers. This common medium is a module hereafter termed correlation module.

10.4 Responsibility. The SEM-QAA shall be responsible for correlation and shall determine the need for correlation of production testers associated with a given module military part number.

10.5 Notification. The testing facility or acquisition activity should notify the SEM-QAA in writing of a correlation requirement as soon as it becomes known.

20. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

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30. CORRELATION CRITERIA

30.1 Correlation criteria. The following are criteria to be used in determining the need for correlation of a production tester for a specific module part number.

(a) JAN certification. JAN certification for a standard electronic module requires that all test systems be correlated.

(b) Accuracy requirements. The detail specification has critical parameters with close tolerances requiring accurate measurements.

(c) Population. Module types which constitute over 5 percent of a system or are used in more than one system.

(d) Environmental sensitivity. Module types which are sensitive to parasitic resistance, capacitance, or inductance requiring control of module and tester interface.

(e) Test method deviations. A tester with a test method which deviates from procedures specified in the detail module drawing or specification.

(f) Factory field failure. Module types which have experienced excessive factory or field failures.

40. CORRELATION AND PROOF MODULES

40.1 Acquisition. The initial developer or contractor shall provide the SEM-QAA with four production modules of the newly developed military part number for use as correlation and proof modules. Each module shall meet the product design configuration of the drawing or specification. Prior to the availability of production modules, prototype modules meeting the above requirements may be submitted.

40.2 Development. The SEM-QAA shall test the four modules to the requirements of the module drawing or specification. The data shall be recorded and a data file shall be maintained and updated. When the modules are tested by a bench setup, all test equipment and associated information shall be recorded. When the modules are tested by automatic test equipment (ATE), a copy of the program and a drawing of all required interface circuitry shall be maintained. All data shall be referenced to the applicable test conditions of the module drawing or specification. The determination to use bench or ATE shall be made by the correlation activity.

40.2.1 Correlation modules. Two of the modules for which correlation sheets are made shall be designated as correlation modules. The purpose of the correlation modules shall be to obtain comparison data for use in correlating an existing tester. The correlation modules shall display a conspicuous identification sticker marked "CORRELATION MODULE".

40.2.2 Proof modules. The remaining two modules which were tested on a bench test setup or a correlated tester shall be designated as proof modules. The proof modules shall be used to check out new or modified testers in preparation for correlation testing. The proof modules protect the correlation modules from damage and are used for laboratory investigation of requested tester deviations. The proof modules shall display a conspicuous identification sticker marked "PROOF MODULE".

40.3 Repair and retesting of correlation and proof modules. A Government designated facility shall be responsible for repairs or modifications to correlation and proof modules. Correlation and proof modules which have been repaired, modified, or otherwise adjusted shall required retesting in a correlation activity laboratory in order to obtain new correlation module data which shall supersede previous data.

40.4 Storage and control. Correlation and proof modules and their associated data sheets shall be stored by and under control of the SEM-QAA.

APPENDIX A

50. TESTER FACILITY REQUIREMENTS

50.1 Facility requirements. A tester facility shall be considered ready to test a correlation module and to record correlation data when the facility has complied with the following and received approval from the SEM-QAA.

(a) The tester test document has been written to the required revision of the detail module specification.

(b) The tester is compatible with its own documentation which includes a top assembly drawing and shall be made available to the SEM-QAA upon request.

(c) The top assembly drawing number and revision status of the production tester and its peripheral equipment is displayed on the applicable equipment.

(d) The production tester and its associated equipment have been serialized and the serial number displayed on each item along with the current calibration tag.

50.2 Tester documentation. The tester documentation shall contain the following:

(a) Manufacturer and model number of each piece of test equipment used.

(b) Serial number of tester to be correlated.

(c) Tester measurement offsets and parasitic impedance data with an explanation of their derivation.

(d) Test system configuration which includes equipment used, equipment specifications, location of equipment in the test system, and any optional equipment used.

APPENDIX A

50.3 Test procedure documentation. The tester facility shall prepare a test procedure for each module military part number to be correlated. The test procedure shall be submitted to the SEM-QAA for review at least 2 weeks prior to the correlation attempt. The test procedure shall contain the following:

(a) Module drawing or specification number and revision to which tester is testing modules.

(b) Top assembly drawing number and revision of tester and module related peripheral equipment (adapters, switch cards, test tapes, load boards). Drawings of peripheral equipment will be made available to the SEM-QAA on request.

(c) ATE test program documentation which includes:

(1) System software revision.

(2) List of all files and sub-files.

(3) Test measurement routines.

(4) Order of testing.

(5) Flow charts for particular test sequences, that is, algorithms.

(6) Programming constraints.

(7) Data logging and operator routines.

(8) Test pattern documentation including fault coverage, method used (simulator or manual), test plan description, description of timing associated with each pattern file, and list of all tester pattern files.

(d) A definition of each deviation from the detail specification test method which is made in the tester test procedure.

(e) Measurement limits to which tester is testing modules.

(f) Determination of tests as sample, 100 percent, or qualification only.

(g) Proper order of testing per the detail specification.

(h) Comparison of the testers obtained accuracies and required accuracies for each unique test condition of the detail specification (this is not required if the method and test equipment used are the same as in the detail specification).

(i) Schematic drawing of the test fixture(s) for bench test systems.

60. CORRELATION TESTING

60.1 Correlation testing. The SEM-QAA shall require the following items for correlation testing at the location of the applicable tester facility.

(a) The correlation data sheet for each correlation module with the information specified in 40 already recorded.

(b) A copy of the military part number detail specification for which the tester is to be correlated.

(c) Tester documentation as specified in 50.

(d) Two correlation modules and two proof modules of the military part number for which the tester is to be correlated. The SEM-QAA shall supply the necessary correlation and proof modules.

60.2 Using the proof module. Prior to inserting a correlation module into the tester, a proof module of the same military part number shall be inserted into the tester to protect the correlation module. The tester measured parameters of this module shall meet the requirements of the module drawing or specification. When automatic testers are used, a proof module shall be run twice to verify the module has not been damaged. If this

requirement is not met, then the responsible tester facility personnel shall take the necessary corrective action. If the corrective action requires that changes be made in tester documentation, then these changes shall be sent in writing to the SEM-QAA. When the tester test results on the proof modules have met the requirements of this appendix, the tester is ready to have a correlation module inserted. Correlation testing shall be done by tester facility personnel at the tester facility and witnessed by the SEM-QAA.

60.3 Recording information on the correlation data sheet. The correlation personnel shall properly complete the data and information required on the correlation data sheets corresponding to the two correlation modules of the military part number for which the tester is being correlated.

60.4 Correlation requirements. The tester test results shall be considered to have met the correlation requirements when they agree with the requirements of 90.3 through 90.4.

60.4.1 Discrepancies. Tester facility personnel shall be responsible for taking corrective action on each discrepancy found. Before correlation data is retaken on the tester, tester facility personnel shall explain to the SEM-QAA in writing the reason for and action taken on each discrepancy. All changes and revisions to either tester documentation or tester test documentation shall be submitted in writing to the SEM-QAA. Upon approval of these changes by the SEM-QAA, correlation data shall be taken on those test conditions deemed necessary by the SEM-QAA.

60.4.2 Failure on one correlation module. If a tester measurement fails the correlation criterion on one correlation module only, this measurement shall be repeated on both correlation modules. If the same results are obtained, the measurement will not be considered to have failed correlation until the data of the failed module has been verified on the SEM-QAA laboratory bench test setup.

60.5 Correlation not successful. When correlation is not successful, the reason and correction action planned shall be entered in the tester correlation report (see figure 7) and forwarded to the acquisition activity.

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60.6 Correlation successful. When correlation is successfully completed, the SEM-QAA shall issue a correlation report (see figure 7) which is the tester's official certification for use in testing the specific module military part number.

60.7 Report. The SEM-QAA shall send copies of the completed correlation report to the cognizant Government activity at the tester facility and to the acquisition activity.

70. RECORRELATION

70.1 Responsibility. The responsibility for recorrelation of a tester or any part thereof shall be assumed by the SEM-QAA.

70.2 Recorrelation criteria. The following criteria shall be used to determine the necessity for recorrelation.

(a) The tester or any part thereof has undergone modification which directly influences the electrical testing of modules.

(b) Repeated failures of a specific module military part number are indicated by tester measurements.

(c) Repeated failures of a specific module military part number are indicated by system usage.

(d) A module of a specific military part number has undergone modification which effects a change in the test procedure, the test results, or the tester, or any part thereof.

(e) Elapse of qualification status criteria as specified in this specification.

The SEM-QAA shall be notified when recorrelation is required.

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80. CORRELATION CONTROL DOCUMENTATION

80.1 Information required. For every SEM module military part number, the following information shall be documented and maintained by the SEM-QAA.

(a) Tester correlation data.

(b) Tester test equipment data.

(c) Tester test procedure (see 50.3).

(d) Tester documentation (see 50.2).

(e) Tester correlation report (see figure 7).

90. CALCULATION AND APPLICATION OF TESTER OFFSETS AND CORRELATION TOLERANCES

90.1 General. The tester test results shall be compared to the correlation module bench test data plus known tester offsets. The tester results will be considered correlated if they agree with the correlation module bench test data plus known tester offsets within the correlation tolerances.

90.2 Tester offsets. A tester measurement offset is a constant quantity associated with that tester's measurement of a particular electrical parameter. An offset may be caused by parasitic loading of the SEM by the tester or by a deviation in test method.

(a) Example 1.

A module transition time is found to be equal to 125 nS as measured in the laboratory with an oscilloscope. On a production tester, the transition time measurement on the same module is found to be equal to 145 nS due to 95 pF of parasitic capacitance associated with the tester adapter output pins into which the module is plugged. The resultant offset is therefore 145 minus 125 equals 20 nS.

(b) Example 2.

A module test specification states that a voltage is to be measured at a test point. At the test point, this voltage is found to be 9.8 volts as measured in the laboratory. The production tester cannot make measurements at the test point. It must make the voltage measurement at a module contact on the other side of a conducting diode. The diode voltage drop is found to be equal to 0.6 volt. The output measured by the tester is therefore equal to 9.8 volts minus 0.6, equaling 9.2 volts. The tester offset is then minus 0.6 volt.

(c) Offset.

The offset is used for two purposes. First, it serves in the correlation between the bench test data and the tester data on the correlation modules. Second, the final programmed tester pass or fail limits are calculated using the offset. This is shown as follows:

Final minimum limit equals minimum test specification limit plus offset.

Final maximum limit equals maximum test specification limit plus offset.

90.3 Correlation tolerance. The tester results from the correlation module are compared to the results obtained by adding the appropriate tester offsets to the bench test data (taken to module test specification) on this same module. These results should be identical within a tolerance called the correlation tolerance. One of the two methods is used to calculate the correlation tolerance depending upon the module specification parameter requirement. These methods are as follows.

90.3.1 Parameter tolerance equal to or greater than 3 percent. In cases where the parameter tolerance is greater than or equal to 3 percent of the parameter, 22 percent of the parameter tolerance shall determine the correlation tolerance. This can be expressed as follows:

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$$\text{Correlation tolerance} = \pm 0.22 \left[\frac{\text{Max test specification limit} - \text{min test specification limit}}{2} \right].$$

Correlation tolerance = ±0.11 [Maximum test specification limit - minimum test specification limit].

(a) Example.

A test specification states that the requirements for a parameter are t_r equals 125 nS, plus or minus 15 percent. The maximum limit would be 125 plus 0.15 (125) equaling 143.8 nS. The minimum limit would be 125 minus 0.15 (125) equaling 106.2 nS. The correlation tolerance is 0.11 times the quantity, 143.8 minus 106.2, equaling plus or minus 4.14 nS. This means that the tester measured t_r should agree with the bench test measured t_r plus tester offset (if applicable) within 4.14 nS. If only a maximum or only a minimum limit is specified in the test specification, a study of the circuit involved or a consultation with the design engineer is required to determine the unspecified limit. If the upper or lower limit is infinity, minus infinity, or undefined, then the parameter will not be correlated.

90.3.2 Parameter tolerance less than 3 percent. In cases where the parameter tolerance is less than 3 percent of the parameter, 25 percent of the parameter tolerance plus the bench test equipment accuracy will determine the correlation tolerance. This can be expressed as follows:

$$\text{Correlation tolerance} = \pm \left\{ 0.25 \left[\frac{\text{Max test spec limit} - \text{min test spec limit}}{2} \right] + \left[\text{bench test eqpt accuracy} \right] \right\}.$$

(a) Example.

A test specification states that the requirements for a module parameter are V_p equals 10 volts, plus or minus 1 percent. The maximum limit is 10 plus the quantity 0.01 times 10. equaling 10.1 volts. The minimum

limit is 10 minus the quantity, 0.01 times 10, equaling 9.9 volts. In addition, the voltmeter used to measure V_p in the laboratory during the recording of correlation data has an accuracy of plus or minus 0.1 percent of full scale as specified by the manufacturer. The accuracy of a 10 volt reading is, therefore, plus or minus 0.1 percent times 10 volts, equals plus or minus 0.01 volt.

$$\text{Correlation tolerance} = \pm \left\{ 0.25 \left[\frac{(10.1 - 9.9)}{2} \right] + [.01] \right\}.$$

Correlation tolerance = ± 0.035 volt.

90.4 Parameter tolerance undefined in terms of percent. In cases where the parameter tolerance cannot be defined in terms of percent due to the parameter requirement being centered about zero, 22 percent of the parameter tolerance shall determine the correlation tolerance. In case where the parameter tolerance cannot be defined in terms of percent due to the reading being taken in decibel (dB), 1.1 times the sum of the bench test equipment accuracy and the tester test equipment accuracy shall determine the correlation tolerance.

(a) Example.

A test specification states that the requirements for a module parameter are V_{offset} equals 0, plus or minus 10 mV. The maximum limit is 0 plus 10, equals 10 mV. The minimum limit is 0 minus 10, equals minus 10 mV.

$$\text{Correlation tolerance} = \pm 0.22 \left[\frac{10 - (-10)}{2} \right].$$

Correlation tolerance = ± 2.2 mV.

(b) Example.

A test specification states that the requirements for a module parameter are Gain equals 20 dB, plus or minus 2 dB (in the electrical

requirements table and in the test table). The test equipment used in the laboratory and the tested test equipment has an accuracy of plus or minus 0.2 dB.

Correlation tolerance = ± 1.1 (0.2 + 0.2).

Correlation tolerance = ± 0.44 dB.

For those test conditions where the electrical requirements table limits are specified in dB and in the test table limits specified in volts, the correlation limits shall be determined in volts.

90.5 Test equipment accuracy deviation. In the case where a deviation from the test equipment accuracy requirements specified herein and MIL-STD-1665 has been granted either through the module specification or through waiver acceptance, 1.1 times the sum of the bench test equipment accuracy and the tester test equipment accuracy shall determine the correlation tolerance. This can be expressed as follows:

Correlation tolerance = ±1.1 (bench test equipment accuracy + tester test equipment accuracy).

(a) Example.

A test specification states that the requirements for a module parameter are 8 nA, plus or minus 25 percent. The required test accuracy is plus or minus 25 divided by 10, equals plus or minus 2.5 percent. The module specification states that the test accuracy may be as great as plus or minus 5 percent. The test equipment used in the laboratory has an accuracy of plus or minus 3 percent on the 10 nA scale. The accuracy of this reading is therefore plus or minus 0.03 times 10, equaling 0.3 nA. The test equipment used at the tester facility has an accuracy of plus or minus 4 percent on the 10 nA scale. The accuracy of this reading is therefore plus or minus 0.04 times 10, equaling plus or minus 0.4 nA.

Correlation tolerance = ±1.1 (0.3 + 0.4).

Correlation tolerance = ±0.77 nA.

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TESTER CORRELATION REPORT
STANDARD ELECTRONIC MODULE
SND-NWSCC 10410/2 (REV. 2/89)

MODULE KEY CODE	MIL M-28787				☐ YES X & S TESTS (& Q TESTS FOR NWSCC) ☐ NO ☐ OTHER
	MIL-M-28787	/SHEET NO	REV LTR	AMENDMENT NO.	
	EQUIVALENT OR SPECIFICATION CONTROL				
	DWG NO		REV LTR		

VENDOR AND LOCATION	CORRELATION
	☐ INITIAL ☐ RECORRELATION (DATA RETAKEN) ☐ RECORRELATION (PAPER UPDATE)
TEST PROCEDURE	
NUMBER / REVISION	DATE (DATA TAKEN)

TEST EQUIPMENT CORRELATED

VENDOR TESTER PERSONNEL

CORRELATION STANDARDS AND SERIAL NOS.

COMMENTS

AUTHORIZED DEVIATIONS

SEM-QAA APPROVAL	DATE
CORRELATION ENGINEER	
SEM-QAA APPROVAL	

Data sheets available from Commanding Officer Naval Weapons Support Center (Code 6021) Crane IN 47522

FIGURE 7. Tester correlation report format.

APPENDIX B

THICK FILM MULTILAYER INTERCONNECT BOARD PERFORMANCE SPECIFICATION

10. SCOPE

10.1 Scope. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance. This appendix will cover performance requirements for ceramic circuit boards containing two or more layers of interconnection separated by dielectric, intended for surface mount components.

10.2 Classifications.

Type I: Inert fired systems
Type II: Air fired systems

20. APPLICABLE DOCUMENTS

20.1 Government documents.

20.1.1 Specifications. The following specifications form a part of this appendix to the extent specified herein. Unless otherwise specified, the issue of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

QQ-S-571	-	Solder, Tin Alloy, Tin-Lead Alloy, and Lead Alloy

MILITARY

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

(Unless otherwise indicated, copies of federal and military specifications are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

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20.1.2 Other Government publications. The following other Government publications form a part of this appendix to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

PUBLICATIONS

Materials Research Report No 3-72	-	Printed-Wiring Assemblies; Detection of Ionic Contaminants On.
Materials Research Report No 3-78	-	Printed-Wiring Assemblies; Review of Data Generated with Instrument Used to Detect and Measure Ionic Contaminants On.

(Applications for copies of these reports should be addressed to the Commanding Officer, Naval Avionics Center, Code 814, Indianapolis, IN 46219.)

20.2 Other publications. The following documents form a part of this appendix to the extent specified herein. Unless otherwise specified, the issues of documents which are DOD adopted are those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issue of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM F44-68	-	Standard Specification for Metallized Surfaces on Ceramic

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

B 46.1	-	Surface Roughness

APPENDIX B

(Applications for copies should be addressed to the American National Standard Institute, 1430 Broadway, New York, NY 10018.)

INSTITUTE FOR INTERCONNECTING AND PACKAGING ELECTRONIC CIRCUITS (IPC)

S-804 - Solderability Test Methods for Printed Wiring Boards

(Applications for copies should be addressed to the Institute for Interconnecting and Packaging Electronic Circuits, 7380 N. Lincoln Avenue, Lincolnwood, IL 60646.)

(Nongovernment standards and other publications are normally available from the organization which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

30. REQUIREMENTS

30.1 Materials. The procurement specification for ceramic and thick film materials shall contain as a minimum all requirements listed in 30.1.1 through 30.1.4.5.

30.1.1 Ceramic blank.

30.1.1.1 Material. Composition of the ceramic blank shall be as specified in the master drawing. A certificate of compliance, attesting to the material's composition, shall be obtained from the ceramic supplier and shall be available for review by the Multilayer Interconnect Board (MIB) procuring activity.

30.1.1.2 Thickness. Thickness, of the ceramic blank shall meet the dimensional requirements specified in the master drawing (see 40.8.3.2).

30.1.1.3 Workmanship. Workmanship shall meet the requirements of 30.2.3.

30.1.1.4 Surface finish. Surface finish shall meet the requirements of the procurement specification (see 40.8.3.3).

30.1.2 Conductor paste.

30.1.2.1 Paste viscosity. When specified as a requirement in maintaining process control, the required value or limit shall be documented in the materials receiving and inspection (R&I) procedure(s). Measurement of this parameter shall be performed upon receipt of the material and adjustment made, if necessary, to the specified value prior to fabrication of a test coupon or release for production use (see 40.8.3.1).

30.1.2.2 Paste solids content. When specified as a requirement in maintaining process control, the required value or limits shall be documented in the materials R&I procedure(s). Measurements of this parameter shall be performed upon receipt of the material and adjustment made, if necessary, to the specified value prior to fabrication of a test coupon or release for production use (see 40.8.3.4).

30.1.2.3 Quality of fired print, resistivity. Conductor paste shall be in accordance with the requirements and test methods listed in table III.

TABLE III. Conductor paste requirements.

Tests	Requirement paragraph		Methods paragraph
	Solderable	Non-solderable	
Quality of fired print	30.2.3	30.2.3	40.8.1
Solderability	30.1.2.5	N/A	40.8.4.3
Resistivity	Requirement in procurement specification	Requirement in procurement specification	40.8.3.5
Metallization adhesion	30.1.2.4	N/A	40.8.3.6

30.1.2.4 Metallization adhesion. Conductor paste used for component mounting lands shall be tested in accordance with 40.8.3.6. Each land shall exhibit a minimum adhesion of 4.0 pounds (17.8 newtons) initially and 3.0 pounds (13.4 newtons) after aging.

30.1.2.5 Solderability. Conductor material intended for component and connector lands shall exhibit a minimum of 95 percent solder wetting per land (see 40.8.4.3).

30.1.3 Dielectric.

30.1.3.1 Dielectric viscosity. When specified as a requirement in maintaining process control, the required value or limits shall be documented in the materials R&I procedure(s). Measurements of this parameter shall be performed upon receipt of the material and adjustment made, if necessary, to the specified value prior to fabrication of a test coupon or release for production use (see 40.8.3.1).

30.1.3.2 Dielectric solids content. When specified as a requirement in maintaining process control, the required value or limits shall be documented in the materials R&I procedure(s). Measurements of this parameter shall be performed upon receipt of the material and adjustment made, if necessary, to the specified value prior to fabrication of a test coupon or release for production use (see 40.8.3.4).

30.1.3.3 Dielectric current leakage. Current leakage shall meet the requirements of the procurement specification (see 40.8.3.7). Current leakage measurement not required for type II.

30.1.3.4 Dielectric constant, quality of fired print, insulation resistance. Dielectric paste shall meet the requirements listed in table IV.

30.1.4 Overglaze.

30.1.4.1 Overglaze viscosity. When specified as a requirement in maintaining process control, the required value or limits shall be documented in the materials R&I procedure(s). Measurement of this parameter

shall be performed upon receipt of the material and adjustment made, if necessary, to the specified value prior to fabrication of a test coupon or release for production use (see 40.8.3.1).

TABLE IV. Dielectric requirements.

Tests	Requirement paragraph	Methods paragraph
Dielectric constant	Requirements of procurement spec.	40.8.4.11
Quality of fired print	30.2.3	40.8.1
Insulation resistance	30.2.2.6	40.8.4.12

30.1.4.2 Overglaze solids content. When specified as a requirement in maintaining process control, the required value or limits shall be documented in the materials R&I procedure(s). Measurements of this parameter shall be performed upon receipt of the material and adjustment made, if necessary, to the specified value prior to fabrication of a test coupon or release for production use (see 40.8.3.4).

30.1.4.3 Bias and humidity. The insulation resistance shall be equal to or exceed 10 megohms (see 40.8.4.10).

30.1.4.4 Overglaze current leakage. The maximum current leakage shall be less than or equal to 20 microamps per cm^2 (see 40.8.3.7).

30.1.4.5 Quality of fired print. Quality of fired print must meet the requirements of 30.2.3 (see 40.8.1).

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30.2 Completed multilayer interconnect board requirements.

30.2.1 Mechanical characteristics.

30.2.1.1 Dimensions.

30.2.1.1.1 Size. Thickness, length, and width shall meet the dimensional requirements specified in the master drawing (see 40.8.4.1.1).

30.2.1.1.2 Flatness. The MIB shall be flat within 0.003 inch (0.08 mm) per inch 0.010 inch (0.25 mm) overall or as defined in the master drawing (see 40.8.4.1.2).

30.2.1.2 Land adhesion. Each land shall exhibit a minimum separation strength of 625 pounds per square inch (p.s.i.) (see 40.8.4.2). Alternate methods of testing land adhesion may be used when approved by the SEM-QAA.

30.2.1.3 Solderability. Conductor land areas intended for attachment of surface mount components or leads shall exhibit 95 percent solder wetting per land (see 40.8.4.3).

30.2.1.4 Thermal shock. Thermal shock test shall be performed on untinned MIBs (see 40.8.4.4). The MIB test specimen shall then meet the following requirements in sequence (a) through (d). This is a destructive test.

	Requirement	Test method paragraph
(a)	Shall exhibit no cracking or delamination	40.8.1
(b)	Shall exhibit no separation or fracture of conductors and no delamination.	40.8.2
(c)	30.2.2.1 (continuity) 30.2.2.2 (isolation)	40.8.4.7 40.8.4.8
(d)	30.2.1.2 (pad adhesion)	40.8.4.2

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30.2.1.5 Pre-tinned MIBs. (Pre-tinning is optional.) The solder shall be in accordance with composition Sn60, Sn62, or Sn63 of QQ-S-571. The soldering flux shall be a flux conforming to MIL-F-14256 type R or RMA.

30.2.2 Electrical characteristics.

30.2.2.1 Continuity. Conductors of MIBs shall be electrically tested (see 40.8.4.7) to ensure continuity of all nets, and shall meet maximum line resistance requirement as specified in the master drawing. During continuity testing, the maximum limit, unless otherwise specified on the master drawing, shall be 10 ohms.

30.2.2.2 Isolation. All MIBs shall be tested for electrical isolation, 100 percent net to net. Minimum line-to-line resistance shall be as specified in the master drawing (see 40.8.4.8). During isolation testing the minimum limit, unless otherwise specified on the master drawing, shall be 1 megohm.

30.2.2.2.1 Shorts. Any MIB which at any time during its manufacture or testing has had a short removed by the application of electrical power in excess of 50 milliwatts, shall be considered not in compliance with this specification.

30.2.2.3 Thermal cycle. All MIBs shall be subjected to 100 percent thermal cycling and shall be tested for continuity both before and after ten cycles of thermal cycling. If the initial ten thermal cycles are error free, no further testing is required and the lot is accepted. If continuity failure occurs during the initial exposure, a second group of temperature cycles may be performed on the remainder of the lot with continuity tests at ten cycle completion. If this second group of ten thermal cycles is error free, no further testing is required and the lot is accepted. If continuity failure occurs after the second exposure, a third group of temperature cycles may be performed on the remainder of the lot with continuity tests at the ten cycle completion. The third group of temperature cycles must be error free or the lot is rejected (see 40.8.4.5).

30.2.2.4 Dielectric withstanding voltage. There shall be no flashover, sparkover, or breakdown at a minimum of 500 volts direct current, between ground and voltage plane (see 40.8.4.9).

30.2.2.5 Bias and humidity. The insulation resistance shall be equal to or exceed 10 megohms (see 40.8.4.10).

30.2.2.6 Insulation resistance. The resistance between two specified nets shall be greater than or equal to 1000 megohms (see 40.8.4.12). One of the nets shall be a power or ground plane and the other shall contain conductor traces on an immediately adjacent layer.

30.2.3 MIB workmanship and quality of fired print.

30.2.3.1 Defects. Reject criteria for defects occurring in a completed MIB, test coupon, or MIB test specimen shall be as listed in table V (see 40.8.1).

30.2.3.1.1 Reduced spacing. The presence of any metallization which reduces the spacing between conductive elements to less than 50 percent of that specified on the master drawing or of the spacing designed into the master pattern shall be cause for rejection.

30.2.3.1.2 Foreign material. Foreign material which bridges or reduces the spacing between conductive elements to less than 50 percent of that specified on the master drawing or of the spacing designed into master pattern shall be cause for rejection. Such material attached to the component mounting surface shall be permitted provided it does not interfere with component mounting. Corrosive foreign material shall not be permitted.

30.2.3.1.3 Reduced metallization. The absence of any metallization or presence of foreign material which reduces the width of the conductive element to less than 50 percent of that specified on the master drawing or of the width designed into the master drawing shall be cause for rejection.

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TABLE V. Visual reject criteria for defects.

Defects	Ceramic blank	Completed MIB/test coupon or specimen		
		Dielectric	Metallization	Overglaze
	Reject if:	Reject if:	Reject if:	Reject if:
Pit or indentation	>0.002 inch (0.051 mm) deep	N/A	N/A	N/A
Chip out (ceramic blank)	>0.010 inch (0.254 mm) into area to be screened or >50% thickness	Chip out extends under the thick film so as to reduce the supporting ceramic beneath the thick film to <75% remaining (see figure 8b)		
Scratch	>0.0007 inch (0.0178 mm) maximum depth	Exposes underlying metallization	Exposes underlying dielectric	Exposes underlying dielectric
Crack	Any visible cracks	Any visible crack	Any visible crack	Any visible crack
		Ceramic blank of completed MIB: (1) Extends into perimeter of designed thick film (2) Visible on top and bottom of ceramic blank		

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TABLE V. Visual reject criteria for defects - Continued.

Defects	Ceramic blank	Completed MIB/test coupon or specimen		
		Dielectric	Metallization	Overglaze
	Reject if:	Reject if:	Reject if:	Reject if:
Blister	N/A	Results in delamination	Blister exceeds >5% of solder. Max height 0.001 inch (0.025 mm). Must not intersect via.	Any peeling, lifting, or blistering of overglaze. Bubbles are acceptable provided they occur entirely within the glassy film or films.
Chip out (dielectric)	N/A	Type I: Any chip out which exposes underlying metallization. Any chip out which exposes underlying dielectric not covered with overglaze. Type II: Any chip out which exposes underlying metallization. (See figure 8a.)		
Foreign material (corrosive)	N/A	None permitted	None permitted	None permitted
Excessive metallization	Extends into the perimeter of the designed thick film.	Reduces spacing between any two conductive elements by 50% or more of the designed width.	Reduces spacing between any two conductive elements by 50% or more of the designed width.	Present

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TABLE V. Visual reject criteria for defects - Continued.

Defects	Ceramic blank	Completed MIB/test coupon or specimen		
		Dielectric	Metallization	Overglaze
	Reject if:	Reject if:	Reject if:	Reject if:
Delamination	N/A	Any visible delamination	Any visible delamination	Any overglaze separation from underlying material
Pin holes	N/A	Underlying metallization is exposed	See void	Underlying dielectric or metallization is exposed
Void	Chip out (see figure 8b)	Underlying metallization is exposed	Voids exceed 5% of solder attachment area. Voids must not intersect via. Voids must not reduce the effective conductor width by more than 50%.	Underlying dielectric or metallization is exposed

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TABLE V. Visual reject criteria for defects - Continued.

Defects	Ceramic blank	Completed MIB/test coupon or specimen		
		Dielectric	Metallization	Overglaze
	Reject if:	Reject if:	Reject if:	Reject if:
Foreign material	N/A	Reduces spacing between any two conductive elements by 50% or more of the designed width.	Reduces the designed conductor width by more than 50%.	Reduces spacing between any two conductive elements by 50% or more of the designed width, interferes with component mounting, greater than 2 mils without overglaze covering greater than 10 mils.
Glass over copper	N/A	N/A	N/A	Overglaze covers greater than 25% of the design land area. Overglaze must be confined to perifery of land.

30.2.3.1.4 Via closure. The linear dimensions of any via which is less than 50 percent of that specified on the master drawing or of the linear dimension designed into the master pattern shall be cause for rejection.

30.2.3.2 Construction integrity. When cross sectioned in accordance with 40.8.2, the conductor, dielectric, and overglaze (if applicable) dimensional characteristics shall meet the requirements listed on the master drawing. Misregistration between via printings or via to conductor shall not exceed 25 percent of the via linear dimensions. Overall composite misregistration shall not exceed that specified on the master drawing. If not specified, maximum composite misregistration shall not exceed 0.005 inches (0.127 mm). The cross section shall also be examined for the presence of any foreign material, (see 30.2.3.1.2), delamination, and separation or fracture of conductors.

30.2.3.3 Cleanliness. When tinned MIBs are tested, the resistivity shall be not less than 2 X 10^6 ohms per centimeter (cm) or equivalent (see 40.8.4.6).

30.2.4 Marking. The MIB shall be permanently marked on the thick film surface in an area which will not be obscured by subsequent manufacturing operations. This marking shall provide, as a minimum, traceability information needed to determine processing parameters at the time of the MIB build for determination of possible cause of failure. For example, the following information may be used:

Vendor identification
Revision of board design
Lot number of the board type
Serial number of the board

On the back surface of the MIB, as a minimum, the vendor assigned part number shall be permanently marked.

30.2.4.1 Marking of non-compliant MIBs. Any MIB which is not in compliance with this specification shall be permanently marked "non-compliant", "scrap", or an equivalent on the thick film surface of the MIB.

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40. QUALITY ASSURANCE PROVISIONS

40.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may utilize his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this appendix where such inspections are deemed necessary to assure supplies and services conform to the prescribed requirements.

40.1.1 Government verification. All quality assurance operations performed by the contractor will be subject to Government verification at any time. Verification will consist of:

(a) Surveillance of the operations to determine that practices, methods, and procedures of the written inspection system are being properly applied.

(b) Inspection to measure quality of product to be offered for acceptance.

(c) Inspection of delivered products to assure compliance with all inspection requirements of this appendix.

Failure of the contractor to promptly correct deficiencies discovered by contractor or of which contractor is notified shall be cause for suspension of acceptance until corrective action has been made or until conformance of product to prescribed criteria has been demonstrated.

40.1.2 Classification of inspection. Examinations and inspections of the MIB and constituent materials shall be classified as follows:

(a) Material inspection (see 40.6).

(1) Material qualification (see 40.6.1).

(2) Material conformance (see 40.6.2).

(b) MIB inspection (see 40.7).

(1) MIB qualification (see 40.7.1).

(2) MIB conformance (see 40.7.2).

40.2 Manufacturing process flow. A manufacturing process flow chart shall be prepared by the MIB manufacturer and approved by the procuring activity. The process flow chart shall define the process sequence and show all operations and inspections. Procedures and instructions shall be defined for each operation as depicted on the process flow chart and approved by the SEM-QAA.

40.3 Traceability. A traceability system shall be maintained, on a current basis, by the MIB manufacturer. The procuring activity shall be able to trace and determine that each MIB lot passed the applicable screening, qualification, and conformance inspections.

40.4 Rework. All rework permitted on MIBs shall be accomplished in accordance with the documented procedures, which were approved by the procuring activity.

40.5 Test coupon. The MIB manufacturer shall fabricate test coupons to be used for bias and humidity testing and material qualification and conformance testing in accordance with the following requirements:

40.5.1 Coupon pattern. The test coupon pattern shall be furnished by the SEM-QAA.

40.5.1.1 Level A pattern. The coupon pattern occupies a 2 inch by 2 inch ceramic blank. The level A pattern is comprised of a base dielectric followed by a conductor pattern. The conductor pattern is comprised of conductor adhesion test lands, a 225 square resistivity line (terminals 2 and 3), and a large electrode pattern (see figures 9 and 10).

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40.5.1.2 Level B pattern. The level B pattern adds dielectric or overglaze depending on test (see figures 9 and 10).

40.5.1.3 Level C pattern. The level C pattern adds a second electrode pattern followed by dielectric or overglaze (see figures 9 and 10).

40.5.2 Representation. Test coupons shall be representative of the product being offered under this appendix with regard to conductor, dielectric and overglaze thickness and lay-up.

40.5.2.1 Representation of dielectric. The base dielectric should be omitted from the coupon if the actual product has connector or solder lands which are screened directly onto the ceramic blank.

40.5.3 Coupon firing. The coupons shall be fired under normal furnace loading conditions.

40.5.4 Coupon processing. Coupons shall be processed utilizing the same production equipment and procedures used in regular production.

40.5.5 Traceability. Traceability shall be maintained on coupon fabrication with respect to the requirements in this appendix.

40.6 Material inspection. Inspection of all materials for fabrication of MIBs shall be in accordance with the requirements listed in the procurement specifications.

40.6.1 Material qualification. Materials shall be qualified initially and requalified after any material change. Materials shall be qualified individually or jointly in accordance with 40.6.1.1. Material qualification shall consist of examinations and tests listed in tables VI through IX. Coupons and documented test data shall be retained by the manufacturer for three years.

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TABLE VI. Conductor material inspection.

Order	Requirement item	Requirement paragraph	Method paragraph	Material qualification sample plan	Material conformance sample plan
	Viscosity	30.1.2.1	40.8.3.1	1 container	1 container per lot
	Solids content	30.1.2.2	40.8.3.4	1 container	1 container per lot
1	Quality of fired print	30.2.3	40.8.1	4 A coupons	4 A coupons
2	Resistivity	30.1.2.3	40.8.3.5	4 A coupons	4 A coupons
3	Solderability	30.1.2.5	40.8.4.3	4 A coupons	4 A coupons
4	Adhesion	30.1.2.4	40.8.3.6	4 A coupons	4 A coupons

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TABLE VII. Dielectric material inspection.

Order	Requirement item	Requirement paragraph	Method paragraph	Material qualification sample plan	Material conformance sample plan
	Viscosity	30.1.3.1	40.8.3.1	1 container per lot	1 container per lot
	Solids content	30.1.3.2	40.8.3.4	1 container per lot	1 container per lot
1	Quality of fired print	30.2.3	40.8.1	5 B coupons	5 B coupons
2	Current leak	30.1.3.3	40.8.3.7	5 B coupons	5 B coupons
1	Dielectric constant	30.1.3.4	40.8.4.11	5 C coupons	5 C coupons
2	Insulation resistance	30.2.2.6	40.8.4.12	5 C coupons	5 C coupons

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TABLE VIII. Overglaze material inspection.

Requirement item	Requirement paragraph	Method paragraph	Material qualification sample plan	Material conformance sample plan
Viscosity	30.1.4.1	40.8.3.1	1 container per lot	1 container per lot
Solids content	30.1.4.2	40.8.3.4	1 container per lot	1 container per lot
Quality of fired print	30.2.3	40.8.1	5 B coupons	5 B coupons
Current leakage	30.1.4.4	40.8.3.7	5 B coupons	5 B coupons
Bias and humidity	30.1.4.3	40.8.4.10	5 C coupons	5 C coupons

TABLE IX. Ceramic blank material inspection.

Requirement item	Requirement paragraph	Method paragraph	Material qualification sample plan	Material conformance sample plan 1/
Thickness	30.1.1.2	40.8.3.2	20	4% AQL
Workmanship	30.1.1.3	40.8.1	20	4% AQL
Surface finish	30.1.1.4	40.8.3.3	20	4% AQL

1/ MIL-STD-105, normal inspection level II, single sampling, 4% AQL, from each material lot.

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40.6.1.1 Qualification of materials. Sample plans in accordance with 40.6.1.1.1 and 40.6.1.1.2 shall be utilized when qualifying materials on an individual basis. All other materials needed to manufacture test coupons, with material being qualified individually must previously have been qualified.

40.6.1.1.1 Conductor paste, dielectric paste or overglaze sample plan. One container of each material is required. Viscosity and solids content shall be measured in accordance with the applicable material requirements of this appendix. The number and type of test coupons shall be manufactured in accordance with 40.5 and table X for each paste being qualified. All test coupons shall be examined for quality of fired print as specified in 30.2.3 prior to being tested, stored, or sent to the procuring activity.

When materials are to be qualified jointly, they shall be qualified in the following order: conductor paste, dielectric paste, and then overglaze. The number and type of test coupons shall be manufactured in accordance with 40.5 and table X for each material being qualified. All test coupons shall be examined for quality of fired print (see 30.2.3) prior to being tested, stored, or sent to the procuring activity.

40.6.1.1.2 Ceramic blank sample plan. Twenty ceramic blanks shall be tested in accordance with table IX in the order listed.

40.6.2 Material conformance. Material conformance shall be conducted on a lot by lot basis individually or jointly, in accordance with 40.6.2.1 and consist of examinations and tests listed in tables VI through IX. Retesting of material is required to extend the shelf life beyond that period specified by the manufacturer and for any subsequent extended shelf life periods. Each shelf life extension is limited to 50 percent of the manufacturer's specified period. Coupon and documented test data shall be retained by the manufacturer for three years.

40.6.2.1 Conformance of materials. Sample plans in accordance with 40.6.2.1.1 and 40.6.2.1.2 shall be utilized when conducting material conformance tests.

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TABLE X. Sample plan.

Material	Coupon number and type required	Test performed	Distribution of coupons		
			Test sample	Send to procuring activity	Manufacturer store for 3 years
Conductor material	12-A	Quality of fired print resistivity solderability adhesion	4	5	3
Dielectric material	13-B	Quality of fired print current leakage	5	5	3
	13-C	Quality of fired print dielectric constant insulation resistance	5	5	3
Overglaze material	13-B	Quality of fired print current leakage	5	5	3
	13-C	Quality of fired print bias and humidity	5	5	3

40.6.2.1.1 Conductor paste, dielectric paste or overglaze sample plan. Viscosity and solids content shall be measured on a sample drawn from container per material lot. All remaining tests shall be conducted in accordance with 40.6.1.1.1.

40.6.2.1.2 Ceramic blank sample plan. Ceramic blanks shall be tested in accordance with the requirements of table IX in the order listed.

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40.7 MIB inspection. Inspection of MIBs shall be based on the requirements as specified in 30.2.1 through 30.2.3.

40.7.1 MIB qualification. MIBs shall be qualified initially and after any material or process change which impacts reliability, function or interchangeability or if no product has been qualified under this appendix for a twelve month period. MIBs shall be qualified in accordance with 40.7.1.1 and table XI. If a sample fails qualification or requalification, corrective actions shall be taken with double the sample size to be submitted for testing with zero failures allowed. Complete documentation is required.

40.7.1.1 MIB qualification sample plan. MIB test specimens shall be used for qualification testing. The MIB test specimen shall be based on the most complex design (such as the number of layers, via size, criticality and so forth), materials and processes. Eighteen MIB test specimens shall be manufactured and allocated as follows:

(a) 4 test specimens - Manufacturer store for 3 years.

(b) 3 test specimens - Subject to the tests in table XI in the order listed (1 through 11). Continuity and isolation failures may be utilized as test specimens for solderability and metallization adhesion.

(c) 7 test specimens - Send to procuring activity.

(d) 2 test specimens - Bias and humidity test (see table XI).

(e) 2 test specimens - Thermal shock test (see table XI).

All test specimens shall be inspected for workmanship prior to being stored or sent to the procuring activity.

40.7.2 MIB conformance. MIB conformance shall be in accordance with table XI, utilizing MIBs from the production lot.

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TABLE XI. Multilayer interconnect board inspection.

Order	Requirement item	Requirement paragraph	Method paragraph	MIB qualification sample plan	MIB conformance sample plan
1	Workmanship	30.2.3	40.8.1	3	100%
2	Cleanliness	30.2.3.3	40.8.4.6	3	2 per lot
3	Dimensions	30.2.1.1	40.8.4.1	3	2 per lot
4	Continuity	30.2.2.1	40.8.4.7	3	100%
5	Isolation	30.2.2.2	40.8.4.8	3	100%
6	Thermal cycle	30.2.2.3	40.8.4.5	3	100%
7	Dielectric withstanding voltage	30.2.2.4	40.8.4.9	3	2 per lot
8	Insulation resistance	30.2.2.6	40.8.4.12	3	2 per lot
9	Solderability	30.2.1.3	40.8.4.3	3	2 per lot
10	Land adhesion	30.2.1.2	40.8.4.2	3	2 per lot
11	Destructive analysis	30.2.3	40.8.2	3	2 per AMTI
	Bias and humidity	30.2.2.5	40.8.4.10	2	2 per AMTI
	Thermal shock	30.2.1.4	40.8.4.4	2	N/A

40.7.2.1 MIB conformance sample plan. MIB conformance tests shall be in accordance with the sample plan in table XI in the order listed. Bias and humidity testing shall be conducted in accordance with 40.8.4.10 on a minimum of two MIB test specimen samples selected from a production lot.

40.7.2.1.1 Bias and humidity test interval. MIB conformance testing, shall be performed at a maximum interval not to exceed the average manufacturer throughput interval (AMTI) or two months, whichever is less.

40.7.2.1.2 Bias and humidity sampling. Two MIB samples shall be selected from each production lot completed within the test interval. From this group of samples, two (which represent the test lot) shall be subjected to bias and humidity tests in accordance with 40.8.4.10. The remaining two lot samples shall be held until completion of bias and humidity testing. If the two samples subjected to bias and humidity pass, all but four of the remaining samples, (two from each of two lots) may be returned to the appropriate production lots. Artwork patterns and electrical hook-up for bias and humidity testing shall be available for the four samples retained. If requested, two of these samples shall be forwarded to the procuring activity. The remaining samples shall be retained by the manufacturer for a minimum of three years. If either sample fails bias and humidity testing, then all lot samples shall be subjected to bias and humidity testing, and each lot shall be accepted or rejected based upon the test results. In addition, possible suspect lots (those lots not completed within the test period interval, but on which some processing was performed) shall be readily identifiable from production lot travelers for possible disposition. Lot traveler information shall be retained for a minimum of three years.

40.8 Test methods. Test methods not defined in this appendix shall be documented by the manufacturer and submitted to the procuring activity for approval. Alternative methods shall be used only with prior agreement by the procuring activity.

40.8.1 Visual examination. Visual examination shall be accomplished utilizing an optical apparatus or aid which provides a minimum magnification to 10X, unless otherwise specified. Maximum magnification shall not exceed 15X. Referee inspections may be performed using magnifications up to 30X.

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40.8.2 Destructive analysis.

40.8.2.1 Test specimen. For MIB qualification, the MIB test specimen defined in 40.7.1.1 shall be utilized for this evaluation. Sample production MIBs shall be utilized for conformance testing.

40.8.2.2 Specimen preparation. Cross sectioning shall be performed at a minimum of two locations on each test specimen. Sections shall be made parallel to length and width of the specimen and locations shall be chosen to provide cross sections of at least two vias and (collectively) all conductor levels. Cross sectioning and polishing shall be performed as described in the appendix of ASTM F44-68, or by other methods approved by the procuring activity.

40.8.2.3 Microscopic examination. General examination or determination of conformance to the visual requirements as specified in 30.2.3 or 30.2.1.4(d) shall be performed using a magnification of 100X with referee examination at 200X.

40.8.2.4 Measurements. Using a magnification of 200X, with a filar eyepiece measure and record the conductor thickness and width, the dielectric thickness between conductor levels and the layer-to-layer misregistration at vias. Values shall be as specified in 30.2.3.

40.8.3 Material test method.

40.8.3.1 Viscosity. Viscosity shall be measured in accordance with a documented test procedure and shall be as specified in 30.1.2.1, 30.1.3.1 and 30.1.4.1.

40.8.3.2 Thickness. Thickness measurement shall be made using a measuring gauge with resolution sufficient to measure the requirements specified in 30.1.1.2.

40.8.3.3 Surface finish. Surface finish shall be measured in accordance with ANSI B 46.1 and meet the requirements specified in 30.1.1.4.

40.8.3.4 Solids content. A ceramic blank is weighed. A sample of paste is screened on a ceramic blank and then weighed. The sample is weighed again subsequent to drying and firing. The solids content is to be calculated by the following method.

$$\% \text{ solids} = \frac{\text{Mass of ceramic blank with fired paste-Mass of ceramic blank}}{\text{Mass of ceramic blank with wet paste-Mass of ceramic blank}} \times 100$$

This test shall meet the requirements specified in 30.1.2.2, 30.1.3.2 and 30.1.4.2.

40.8.3.5 Resistivity. Resistivity shall be measured in accordance with a documented test procedure approved by the procuring activity and shall meet the requirements of table III and 30.1.2.3.

40.8.3.5.1 Test sample. The test sample shall be the type A test coupon described in 40.5. Resistivity shall be measured between terminals 2 and 3.

40.8.3.6 Metallization adhesion. Conductor adhesion shall be measured utilizing the 90 degree wire pull test. The test shall meet the requirements specified in 30.1.2.4.

40.8.3.6.1 Test sample. The test sample shall be the type A test coupon described in 40.5.

40.8.3.6.2 90 degree wire pull test. Peel strength testing shall be accomplished by the soldering of a 20 gauge, tinned solid copper wire to each of 10, 0.080 inch (2.03 mm) by 0.080 inch (2.03 mm) lands, on each test sample per 40.8.3.6.1. Each wire shall be bent 90 degrees to the land at a distance of 0.050, plus or minus 0.025 inch (1.270, plus or minus 0.635 mm) from the land edge to the angle, as shown on figure 11. The wire shall be pulled normal to the land surface at a maximum rate of 5.0 inches (127 mm) per minute. Initially 5 wires shall be pulled from each test coupon. These test coupons shall then be conditioned for 48 hours at a temperature of 150°C and then the remaining wires pulled.

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40.8.3.7 Current leakage.

40.8.3.7.1 Test specimen. The test specimen shall be the type B test coupon described in 40.5.

40.8.3.7.2 Specimen preparation. Attach a test lead to test terminal 1 on the specimen, using solder or an appropriate clamp (see figure 11).

40.8.3.7.3 Test procedure.

(a) Setup. A sufficient amount of one normal NaCl solution is placed in a standard glass beaker or similar glass container. The solution shall be continuously gently stirred (magnetic stirbar recommended) throughout the test.

(b) Counterelectrode. A platinum foil or gauze electrode, 1 cm X 5.5 cm, minimum, is immersed vertically in the NaCl solution to a depth of 4 cm. A test lead attached to the unimmersed portion of the electrode is connected to the positive terminal of a 10 volt direct current source via a current meter having a sensitivity of one microamp or better and a range of 1000 microamps.

(c) Immersion. With the specimen test lead connected to the negative terminal of the voltage source, vertically immerse the porosity test end of the specimen into the solution to the necked down region of the electrode pattern. The specimen shall be parallel to the counterelectrode and within 1 to 5 cm distant from it.

(d) Measurement. The current indicated by the meter 5 minutes after immersion shall be recorded. The measured value shall be as specified in 30.1.3.3 or 30.1.4.4, as applicable.

40.8.4 MIB test methods.

40.8.4.1 Dimensions.

40.8.4.1.1 Size. Thickness, length and width measurements shall be made using a measuring gauge with resolution sufficient to measure the requirements specified in 30.2.1.1.1.

40.8.4.1.2 Flatness. The total indicator reading perpendicular to the horizontal shall be measured when the ceramic blank MIB is placed unrestrained on a flat horizontal surface with the convex surface upward. Flatness shall meet requirements of 30.2.1.1.2.

40.8.4.2 Land adhesion. Lands shall be subjected to a tensile pull test from the approximate land center (see figure 12). Wire size and type shall be compatible with land size and soldering method. Rate of pull shall be a maximum of 5.0 inches (127 mm) per minute. Alternate methods of testing land adhesion may be used when approved by the SEM-QAA. Adhesion shall meet the requirements of 30.2.1.2.

40.8.4.3 Solderability. Either of the following methods may be used for solderability testing.

(a) In accordance with IPC-S-804, method 1, dated January 1982, after having deleted 3.2.2, 3.3.2, 3.4.2, 3.4.3, 3.4.4, 3.7.1.2, 3.7.2 and 4.1.2.1.

(b) Testing may be performed by utilizing screened on solder paste and reflow soldering equipment normally used in the attachment of surface mount devices (SMD).

40.8.4.3.1 Test sample. The test sample shall be the type A test coupon described in 40.5 or production MIBs as applicable.

40.8.4.3.2 Flux. Either nonactivated or mildly activated rosin flux, in accordance with MIL-F-14256, shall be used.

40.8.4.3.3 Land preparation. Abrading of MIB lands in preparation for solderability testing is permitted if such procedure is employed in the assembly of components to the MIB. The procuring activity shall provide such information.

40.8.4.3.4 Test terminations. Terminations to be tested shall be identified in the master drawing.

40.8.4.3.5 Dwell time. Specimen dwell time within the solder, per IPC-S-804, method 1, shall be in accordance with the specification unless otherwise stated in the master drawing.

40.8.4.4 Thermal shock. Sample MIBs shall be tested in accordance with MIL-STD-202, method 107 (400 cycles, minus 55 to 125°C). Test specimens shall meet the requirements specified in 30.2.1.4.

40.8.4.5 Thermal cycle. Thermal cycle test shall consist of 10 complete thermal cycles from minus 55, plus or minus 3°C to 100°C minimum. A cycle shall consist of 15 minutes minimum dwell time at the stabilized temperature extreme of each part, plus the transfer time between extremes. Cycling may be performed in either a dual or single chamber machine with the following transfer conditions. All parts in each lot shall be electrically tested both before and after each thermal cycle in accordance with tests 40.8.4.7 and 40.8.4.8, and shall meet the requirements specified in 30.2.2.1 and 30.2.2.2.

40.8.4.5.1 Single chamber. Chamber temperature between extremes shall be changed at a minimum rate of 5°C per minute.

40.8.4.5.2 Dual chamber. Maximum transfer time between temperature extremes shall be 5 minutes.

40.8.4.6 Cleanliness.

40.8.4.6.1 Ionic or resistivity of solvent extract. A convenient sized funnel shall be positioned over an electrolytic beaker. The MIB shall be suspended within the funnel. A wash solution of 75 percent by volume of ACS reagent grade isopropyl alcohol and 25 percent by volume of distilled water shall be prepared. This wash solution must have resistivity equal to or greater than 6 X 10^6 ohms per centimeter. The wash solution shall be directed in a fine stream from a wash bottle onto both sides of the MIB until 100 milliliters of the wash solution is collected for each 10 square inches of surface (including both sides of the MIB). The time required for

the wash activity shall be a minimum of 1 minute. It is imperative that the initial washings be included in the sample to be measured for resistivity. The resistivity of the collected wash solution shall be measured with a conductivity bridge or other instrument of equivalent range and accuracy. All laboratory equipment and facilities must be meticulously clean. The alternate test methods given in 40.8.4.6.3 may be used to perform the cleanliness test. Other test methods shall have prior approval of the acquiring activity.

40.8.4.6.2 Resistivity of solvent extract. This test procedure, including solution preparation and laboratory equipment and facilities cleaning procedures, is documented in Materials Research Report No. 3-72.

40.8.4.6.3 Alternate methods. The following methods of determining cleanliness have been shown to be equivalent to the resistivity of solvent extract method:

(a) Omega Meter™ Model 200 by Kenco Alloy and Chemical Company, Incorporated.

(b) Ionograph™ by Alpha Metals Incorporated.

(c) Ion Chaser™ by E. I. DuPont Company, Incorporated.

Test procedures and calibration techniques for these methods are documented in Materials Research Report No. 3-78. Table XII lists the equivalence factors for these methods in terms of microgram equivalents of sodium chloride per unit area.

40.8.4.7 Continuity. Continuity shall be measured using equipment and documented test procedures approved by the procuring activity and which meet the requirements specified in 30.2.2.1.

40.8.4.8 Isolation. Isolation shall be measured using equipment and documented test procedures approved by the procuring activity and which meet the requirements specified in 30.2.2.2. The maximum power applied to the board shall be 50 milliwatts.

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TABLE XII. Equivalent factors.

Method	Ohm-cm ($X10^6$)	Equivalence factors	Equivalents of sodium chloride	
			Micrograms per sq in	Micrograms per sq cm
Resistivity of solvent extract	2	1	10.06	1.56
Omega Meter™ 1/	2	1.39	14.00	2.20
Ion Chaser™	2	2.01	20.00	3.10
Ionograph™	2	3.25	33.00	5.10

1/ Model 200, 300, 400, 500 or 600.

40.8.4.9 Dielectric withstanding voltage. Dielectric withstanding voltage shall be performed in accordance with MIL-STD-202, method 301, and shall meet the requirements specified in 30.2.2.4.

40.8.4.10 Bias and humidity.

40.8.4.10.1 Test sample. The test sample shall be the type C thick film multilayer test coupon described in 40.5 or production MIBs as applicable. The manufacturer shall review the artwork pattern of the MIB test sample to determine electrical connection to achieve the maximum number of crossovers, which can be biased on the top two buried layers. Artwork patterns of the MIB selected for testing and identification of crossover points shall be forwarded to the procuring activity for review and approval prior to testing. For test coupons, bias shall be applied between terminals 1 and 4.

40.8.4.10.2 Sample preparation. Attach test leads of 24 or 26 gauge polytetrafluoroethylene insulated wire to the sample at the designated locations using solder and flux specified in 30.2.1.5. Remove flux residue by immersing sample in isopropyl alcohol or a suitable solvent and scrubbing with a soft bristle brush. Rinse thoroughly by immersion in a second alcohol bath and finally by spraying with fresh alcohol using a chemical wash bottle.

40.8.4.10.3 Test procedure.

(a) Setup. Attach the test leads to a voltage-regulated power supply of 30 volts direct current plus or minus 1 percent. The positive lead(s) shall be connected to the supply only through a current-limiting resistance of 600 Kilohms plus or minus 5 percent.

Measure and record the voltage across the resistor(s) using a digital voltmeter having a readout of at least 3 1/2 digits, a sensitivity of 100 microvolts and an input impedance of 10 megohms.

Place the test specimen in a humidity chamber in a vertical position and under a condensation drip shield.

(b) Exposure. Perform the environmental exposure in accordance with MIL-STD-810, method 507.2, procedure III.

(c) Measurement. At the end of the 10 day exposure, measure and record the voltage across the current limit resistance. Calculate the insulation resistance as follows:

$$I.R. = \frac{(30-V_R)\ 5.66 \times 10^5}{V_R}$$

Where V_R = Voltage across limit resistor

I.R. = Insulation resistance

APPENDIX B

If the calculated value is less than the minimum allowed by 30.1.4.3, the specimen may be removed from the chamber, dried of excess surface moisture and the measurement repeated after one hour at ambient laboratory conditions. The polarizing voltage shall be maintained on the specimen during this interval. Calculated values shall meet requirements of 30.1.4.3 and 30.2.2.5.

40.8.4.11 Dielectric constant. Dielectric constant shall be measured in accordance with a documented test procedure approved by the procuring activity and shall meet the requirements of the procurement specifications.

40.8.4.11.1 Test sample. The test sample shall be the type C test coupon described in 40.5 or production MIBs, as applicable.

40.8.4.12 Insulation resistance. Insulation resistance shall be measured in accordance with MIL-STD-202, method 302, test condition A. The measured value shall meet the requirements of 30.2.2.6.

40.8.4.12.1 Test sample. The test sample shall be the type C test coupon described in 40.5 or production MIBs, as applicable.

50. PREPARATION FOR DELIVERY.

50.1 MIB packaging. MIBs shall be wrapped for shipment in chemically neutral material. Containers utilized for shipping shall provide maximum protection and support for the MIBs.

60. NOTES.

60.1 Terms and definitions.

60.1.1 MIB. A MIB is a ceramic circuit board containing two or more layers of interconnection, separated by dielectric.

60.1.2 Ceramic blank. The ceramic blank is the supporting material upon which the elements of a ceramic multilayer interconnect board are deposited.

60.1.3 Via. The via is an opening in the dielectric.

60.1.4 Via fill. The via fill is the conductor material within the dielectric vias which form the interconnect between the metal layers.

60.1.5 Layer. A layer is an individual deposition of conductive material comprised of conductors and terminations.

60.1.6 Test specimen. The test specimen is a MIB manufactured to design specifications, using production techniques, equipment, and processes for the purpose of MIB qualification or conformance.

60.1.7 Test coupon. The test coupon is a specially designed MIB containing test patterns, manufactured with the same material, equipment, and processes as the production MIBs, used to determine material qualification or conformance.

60.1.8 Material lot. The material lot is the material manufactured as one batch and identified as one manufacturer's lot.

60.1.9 MIB lot. The MIB lot is a group of MIBs manufactured as one batch and identified as one manufacturer's lot.

60.1.10 Viscosity. Viscosity is the resistance of a fluid to flow.

60.1.11 Touch-up. Touch-up is an in-process correction which does not deviate from the manufacturing flow.

60.1.12 Rework. A rework is a documented in-process correction which deviates from the manufacturing flow and restores the MIB to conformance.

60.1.13 Average manufacturer throughput interval (AMTI). The AMTI is the average length of time required to process a given MIB lot.

60.1.14 Pit and indentation. Pit and indentation are depressions in the surface of a ceramic blank.

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60.1.15 Chip out. A chip out is a void in dielectric or ceramic blank caused by physical or thermal damage.

60.1.16 Scratch. A scratch is a relatively long, narrow, shallow groove or cut in the surface.

60.1.17 Crack. A crack is a line of fracture.

60.1.18 Blister. A blister is a gas filled spheroidal or globular pocket within or between thick film materials.

60.1.19 Delamination. Delamination is a major separation between layers.

60.1.20 Pin hole. A pin hole is a small hole occurring as an imperfection which penetrates entirely through conductor, dielectric, or encapsulant films.

60.1.21 Void. A void is an absence of material.

60.1.22 Paste flow. Paste flow is the yielding to gravity resulting in a dimensional widening of the screen printed thick film material.

60.1.23 Foreign material. Foreign material is any material unintended to be on the MIB or any material displaced from its original or intended position within the MIB.

60.2 Master drawing information. The following information is to be provided on the master drawing.

(a) Dimensions of completed MIB.

(b) Ceramic blank material.

(c) Ceramic blank thickness.

(d) Overglaze thickness (if required).

APPENDIX B

(e) Surface finish of ceramic blank.

(f) Conductor thickness, width and spacing.

(g) Dielectric thickness.

(h) Identification of terminations and number, to be used for solderability testing.

(i) Maximum line resistance.

(j) Minimum line to line resistance.

(k) If abrading of the component mounting pads is permissible for solderability testing.

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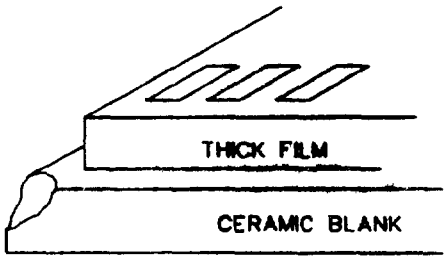
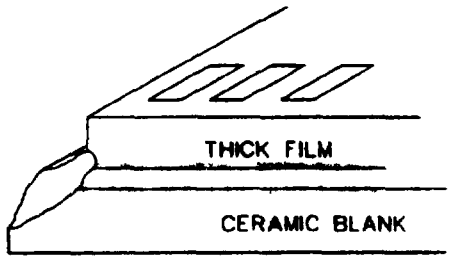


ACCEPT

TYPE I · CHIP OUT WHICH EXPOSES UNDERLYING DIELECTRIC, COVERED WITH OVERGLAZE

TYPE II CHIP OUT DOES NOT EXPOSE UNDERLYING METALLIZATION

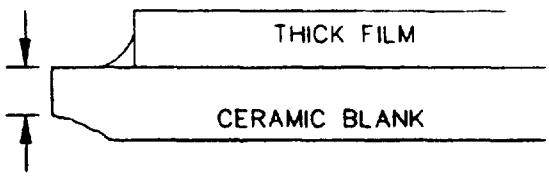


REJECT

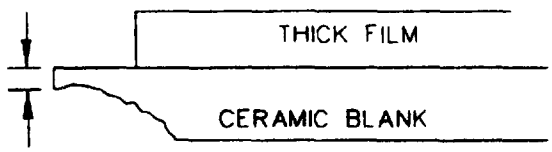
TYPE I · ANY CHIP OUT WHICH EXPOSES UNDERLYING METALLIZATION. CHIP OUT WHICH EXPOSES UNDERLYING DIELECTRIC NOT COVERED WITH OVERGLAZE

TYPE II ANY CHIP OUT WHICH EXPOSES UNDERLYING METALLIZATION

FIGURE 8a. Chip out criteria (dielectric).



ACCEPT – > 75% CERAMIC SUPPORT OF THICK FILM REMAINING



REJECT – < 75% CERAMIC SUPPORT OF THICK FILM REMAINING

FIGURE 8b. Chip out criteria (ceramic blank).

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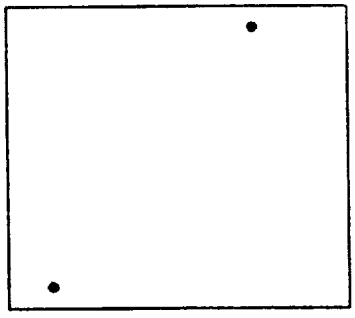
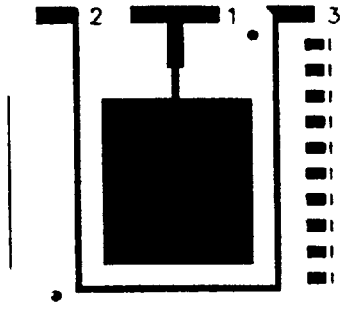
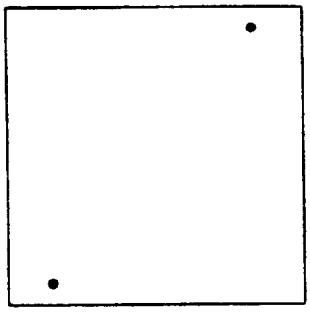


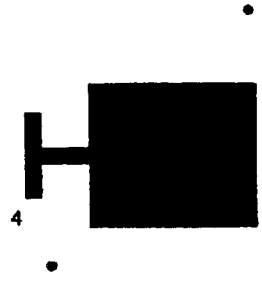
BASE DIELECTRIC



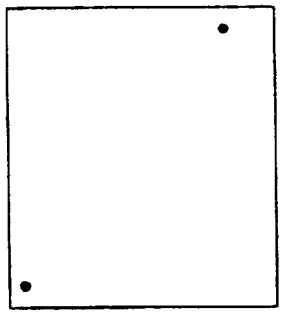
FIRST METAL



INNER DIELECTRIC



TOP METAL



TOP DIELECTRIC

FIGURE 9. Test coupon levels.

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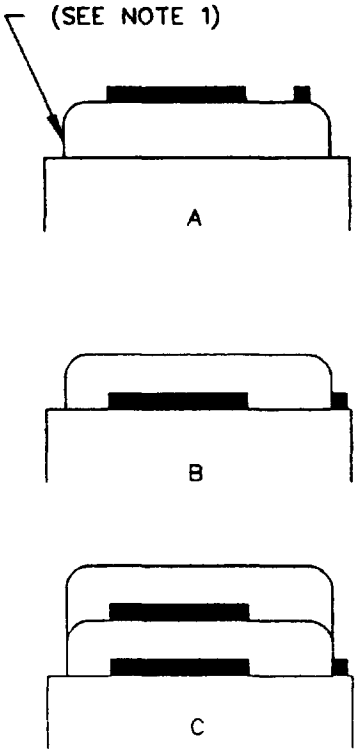

	APPLICATIONS		
	CONDUCTOR MATERIAL	DIELECTRIC MATERIAL	OVERGLAZE MATERIAL
A	QUALITY OF FIRED PRINT ADHESION RESISTIVITY SOLDERABILITY	N/A	N/A
B	N/A	QUALITY OF FIRED PRINT CURRENT LEAKAGE	QUALITY OF FIRED PRINT CURRENT LEAKAGE
C	N/A	QUALITY OF FIRED PRINT DIELECTRIC CONSTANT INSULATION RESISTANCE	QUALITY OF FIRED PRINT BIAS/HUMIDITY

NOTE:

1. Optional dielectric (see 40.5.2.1).

FIGURE 10. Applications of coupon levels.

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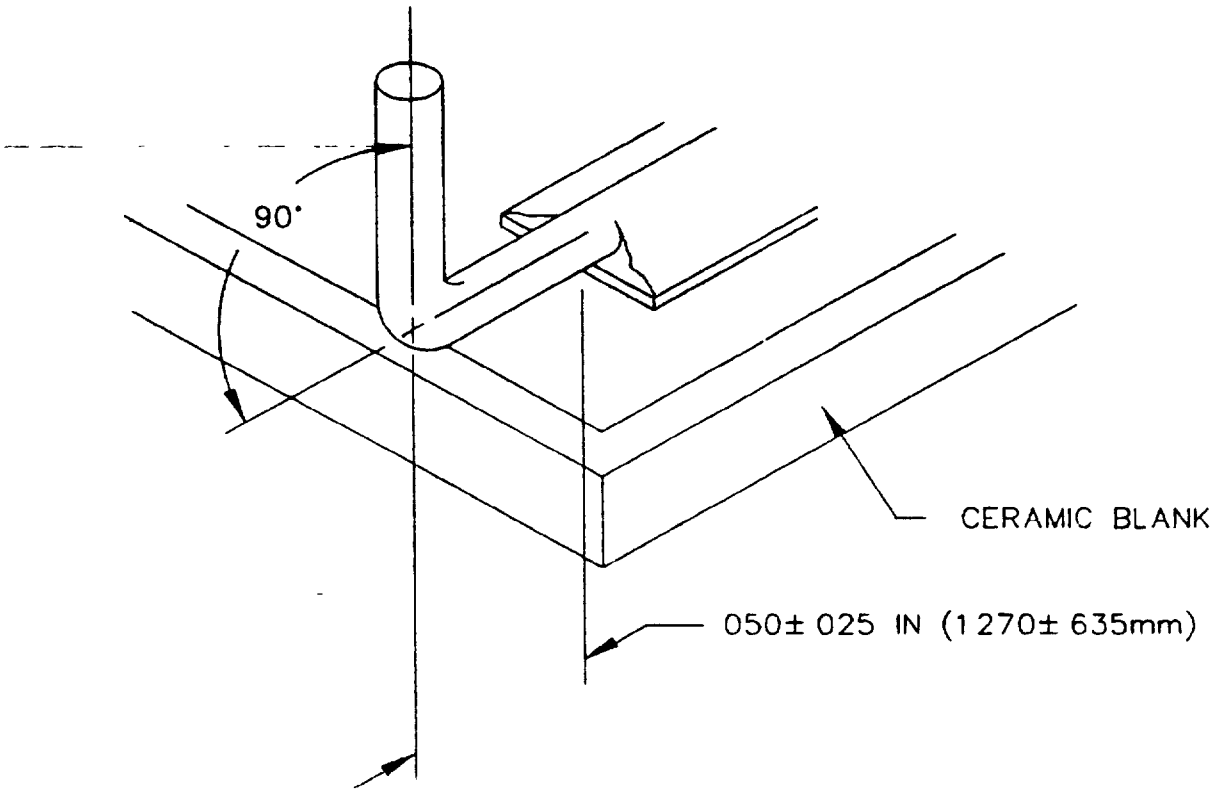

NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.

FIGURE 11. 90 degree wire pull test.

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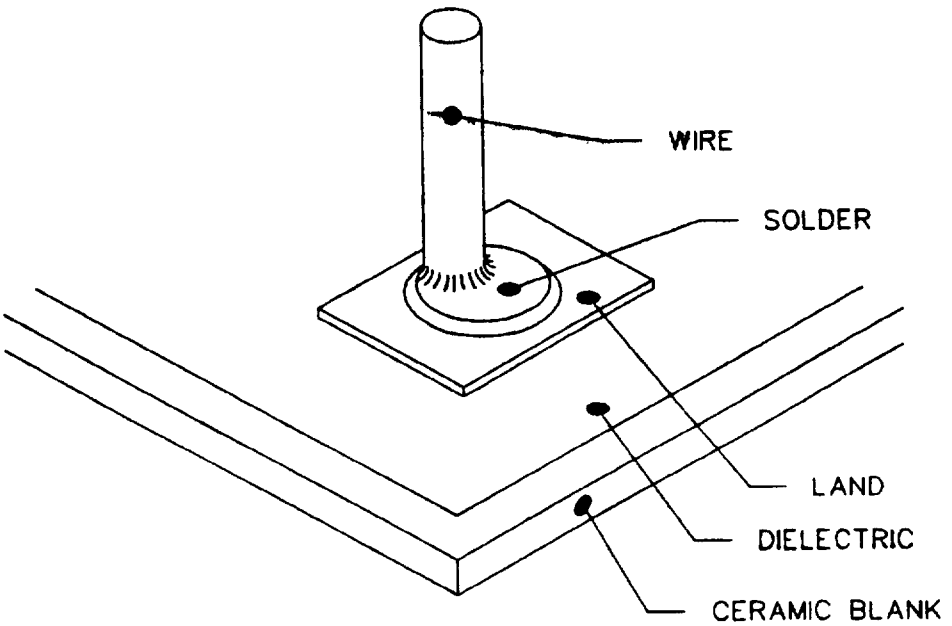

FIGURE 12. Tensile Test.

INDEX

INCH-POUND

MIL-M-28787D
SUPPLEMENT 1
30 MARCH 1989
SUPERSEDING
SUPPLEMENT 1F
25 April 1985

MILITARY SPECIFICATION

MODULES, STANDARD ELECTRONIC

GENERAL SPECIFICATION FOR

This supplement forms a part of MIL-M-28787D, dated 30 March 1989.

ASSOCIATED DETAIL SPECIFICATIONS

MIL-M-28787/No.	Amendment	Key code	Class	Name
1C(EC)	3	GDJ	I, II	Latch
4B(EC)	1	GDK	I, II	Gate, exclusive -OR
5B(EC)	1	BDL	I, II	Multiplexer
6C(EC)	1	FDA	I	Counter, binary, synchronous
7C(EC)	3	GDN	I, II	Decoder, binary
9B(EC)	1	LDP	I	Gate, NAND
11A(EC)	2	KDL	I	Adder
12B(EC)	-	KDJ	I	Arithmetic logic unit
14B(EC)	-	JBD	I	Terminator, resistor-capacitor
16A(EC)	1	JDK	I, II	Receiver, interface
17A(EC)	2	LDJ	I, II	Gate, AND-OR-INVERT
18B(EC)	-	LDQ	I, II	Gate, NAND
19B(EC)	1	LDN	I, II	Gate, NAND

AMSC N/A FSC 5963

DISTRIBUTION STATEMENT A. Approved for public release, distribution is unlimited.

ASSOCIATED DETAIL SPECIFICATIONS - Continued.

MIL-M-28787/No.	Amendment	Key code	Class	Name
20A(EC)	2	LDC	I, II	Inverter
22C(EC)	1	ABE	I, II	Diode, programmable
23B(EC)	1	SBT	I, II	Receiver, interface
24A(EC)	2	GPR	I	Rectifier, low current
27A(EC)	2	GDM	I	Counter, up and down, binary
30B(EC)	-	BBA	I	Counter, up/down, binary
31B(EC)	1	JDD	I	Counter, up/down, BCD, presettable
33B(EC)	2	JDJ	I	Shift register
34B(EC)	1	JBN	I, II	Multivibrator, monostable
38B(EC)	1	NPM	I	Relay, DPDT
39B(EC)	-	KBC	I	Adder
41B(EC)	1	EBL	I, II	Flip-flop, JK
47B(EC)	1	BBB	I	Buffer, three-state
48A(EC)	1	MDP	I	Driver, translate
49A(EC)	2	KDF	I	Diode, pairs
51B(EC)	-	MDQ	I	Receiver, translate
53B(EC)	2	KDN	I, II	Receiver, differential line
54B(EC)	-	QDH	I	Receiver, interface
55B(EC)	2	KDM	I, II	Driver, differential line
57A(EC)	3	TTY	I	Switch, analog
58C(EC)	-	ADK	I, II	Counter, binary coded decimal
59B(EC)	1	KDP	I	Shift register
60B(EC)	1	KDQ	I	Multiplexer
61B(EC)	1	KDR	I	Flip-flop, D type
62C(EC)	3	CFA	I	Comparator
64A(EC)	2	LHJ	I	Gate, AND-OR-INVERT
65A(EC)	1	AHA	I	Decoder
66B(EC)	1	BHL	I	Multiplexer
67B(EC)	-	JHD	I	Multiplexer
68A(EC)	-	LHH	I	Gate, NAND
69A(EC)	1	KHR	I	Flip-flop, D type
70B(EC)	-	FHA	I, II	Counter, binary

SUPPLEMENT 1

ASSOCIATED DETAIL SPECIFICATIONS - Continued.

MIL-M-28787/No.	Amendment	Key code	Class	Name
71C(EC)	3	CHF	I	Shift register
72B(EC)	1	KHQ	I	Multiplexer
73A(EC)	-	JHK	I	Receiver, interface
74 (EC)	4	No key code	I	Memory, read only
75A(EC)	-	LHP	I	Gate, NAND
76A(EC)	-	MHL	I	Encoder, priority
77A(EC)	1	MHK	I	Encoder, parity
78A(EC)	1	AHD	I	Multiplexer
79A(EC)	2	RDH	I	Logic, unit, arithmetic
80A(EC)	-	BYF	I	Memory, random access
81A(EC)	1	KHL	I	Multiplexer
82A(EC)	1	RBG	I	Inverter
83B(EC)	-	RBF	I	Gate, NAND
84A(EC)	-	CBF	I	Shift register
86A(EC)	3	ERN	I	Relay
87B(EC)	2	ARM	I	Regulator, positive
88A(EC)	2	SEX	I	Multiplexer
109B(EC)	-	MDL	I	Driver, interface
110A(EC)	3	MDM	I	Receiver, interface
111A(EC)	2	MDN	I	Terminator, interface
112C(EC)	-	PDL	I, II	Shift register, serial and parallel
113A(EC)	2	FAG	I	Switch
126A(EC)	1	FLB	I	Load, resistor, standard
128B(EC)	1	CTR	I	Transformer
129A(EC)	1	EMF	I	Isolation module
130A(EC)	1	QPL	I	Network, miscellaneous
133B(EC)	2	NRN	I	Relay, 4PDT
135A(EC)	1	QPM	I	Inductor, 1. 5 ampere
136A(EC)	1	RPN	I	Transformer
137A(EC)	-	VPX	I	Inductor
140B(EC)	-	AGD	I	Multiplexer
141B(EC)	1	GYB	I	Memory, random access
142B(EC)	-	JDB	I	Comparator, magnitude
143B(EC)	-	GBB	I	Flip-flop, JK

ASSOCIATED DETAIL SPECIFICATIONS - Continued.

MIL-M-28787/No.	Amendment	Key code	Class	Name
147A(EC)	-	HVA	I	Oscillator
152A(EC)	1	ABF	I	Driver, lamp/relay
153B(EC)	1	HRF	I	Relay
154A(EC)	1	DBA	I	Logic converter, analog to digital
161A(EC)	-	AKE	I	Terminator, network
162 (EC)	2	EKB	I	Driver, interface
163A(EC)	-	EKC	I	Driver, interface
168A(EC)	2	GYC	I	Memory, read only, programmable
169B(EC)	1	GYF	I	Memory, read only, programmable
175A(EC)	-	FBG	I	Adder, discrete sum
177C(EC)	-	FGC	I	Amplifier, operational
178B(EC)	1	GDP	I	Driver, FET, switch
179B(EC)	-	GGD	I	Capacitor, programmable
180A(EC)	1	GGG	I	Network, resistor, programmable
182A(EC)	-	VGS	I	Demultiplexer
183A(EC)	1	ZSW	I	Switch, analog
184B(EC)	-	SES	I	Amplifier, power
185B(EC)	1	STT	I	Transformer, Scott-T
186B(EC)	1	SHY	I	Generator, function, MSB
187B(EC)	1	SHU	I	Generator, function, LSB
188B(EC)	-	SHV	I	Octant/quadrant
189C(EC)	-	SHX	I	Processor, error, S/D
190A(EC)	-	BAC	I	Buffer-limiter
191B(EC)	-	PEE	I	Sample and hold
192B(EC)	2	ARN	I	Regulator, negative
193A(EC)	4	SYT	I	Memory, random access
194A(EC)	1	UHX	I	Generator, function
196A(EC)	1	BDM	I	Receiver, line
197A(EC)	2	EBD	I	Inverter
202B(EC)	-	MAD	I	Driver
204A(EC)	-	RUM	I	Network, resistor

ASSOCIATED DETAIL SPECIFICATIONS - Continued.

MIL-M-28787/No.	Amendment	Key code	Class	Name
205A(EC)	2	BED	I	Amplifier, summing
206A(EC)	-	FQB	I	Driver, lamp/relay
208 (EC)	3	HQE	I	Programmable timer
209B(EC)	-	GZC	I	Fuse
210A(EC)	-	CZH	I	Test point
211A(EC)	1	FZJ	I	Test point, isolated
212A(EC)	-	DQD	I	Standard serial output
213A(EC)	-	EQG	I	Converter, parallel/serial
214 (EC)	2	EQF	I	Converter, serial/parallel
215A(EC)	-	EQJ	I	Standard serial input
216B(EC)	-	ADL	I, II	Resistor, pullup
218A(EC)	-	EEE	I	Filter, low pass, active
219B(EC)	-	HEE	I, II	Amplifier, power
220A(EC)	-	KAD	I	Modulator, synchronous
221A(EC)	-	LEE	I	Amplifier, phase shift
222A(EC)	-	JQM	I	NAND/Schmitt
223A(EC)	2	KDC	I, II	Multiplexer
225B(EC)	-	HUH	I	Switch, S/D, multispeed
226A(EC)	1	PTE	I	Transformer, Scott-T
227A(EC)	2	PTF	I	Transformer, resolver
229A(EC)	-	BEE	I	Amplifier, summing
231A(EC)	-	GEE	I	Comparator
232A(EC)	2	QQQ	I	Converter, analog/digital
233B(EC)	-	FBE	I	Amplifier, clipper
234A(EC)	1	GVQ	I, II	Oscillator, crystal
235A(EC)	-	QVG	I	Oscillator, crystal
236A(EC)	-	QVQ	I	Oscillator, crystal
237A(EC)	1	HRH	I, II	Microprocessor
238A(EC)	1	GHM	I, II	Gate, NAND
239A(EC)	1	QBQ	I	Driver, NTDS slow
240A(EC)	2	CGR	I	Transformer, signal
241 (EC)	-	QDR	I	Driver, interface, NTDS (ANEW)

ASSOCIATED DETAIL SPECIFICATIONS - Continued.

MIL-M-28787/No.	Amendment	Key code	Class	Name
242A(EC)	-	QDF	I	Receiver, interface, NTDS (ANEW)
243A(EC)	1	DQK	I, II	Gate, AND
244A(EC)	-	DQJ	I, II	Gate, AND
245A(EC)	-	DPA	I	Amplifier, AGC
246B(EC)	-	MUM	I	Optical isolator
248A(EC)	1	AMC	I, II	Buffer, non-inverting
249A(EC)	-	AME	I, II	Gate, NOR
250 (EC)	1	AMF	I, II	Counter, binary
251 (EC)	2	AMG	I, II	Latch
252 (EC)	1	AMH	I, II	Gate, AND-OR-INVERT
253 (EC)	1	BMA	I, II	Gate, NAND
254 (EC)	1	BMB	I, II	Gate, NAND
255 (EC)	1	BMC	I, II	Gate, exclusive OR
256 (EC)	1	BMD	I, II	Flip-flop, D-type
257 (EC)	1	BME	I, II	Multivibrator, monostable
258A(EC)	1	BMH	I, II	Decoder, BCD to decimal
259 (EC)	2	EMJ	I, II	Gate, NOR
260 (EC)	1	EMK	I, II	Gate, NAND
261 (EC)	1	EMM	I, II	Gate, inverter
262 (EC)	2	EMN	I, II	Inverter, buffer
263 (EC)	1	EMP	I, II	Gate, NOR
264A(EC)	-	EMQ	I, II	Flip-flop, JK
265A(EC)	2	No key code	I	Memory, read only
266B(EC)	1	GQB	I, II	Driver, bus
267B(EC)	-	YBZ	I, II	Buffer, three-state
268A(EC)	-	AGA	I	Multiplier
269A(EC)	-	FGH	I, II	Amplifier, differential
270 (EC)	2	ZRX	I, II	Relay
271A(EC)	-	RQB	I, II	Converter, binary/BCD
272A(EC)	1	ZEZ	I, II	Converter, BCD/binary
273A(EC)	1	SJS	I, II	Shift register
274B(EC)	-	YKV	I, II	Timer
275A(EC)	-	BMG	I, II	Counter, binary/BCD

ASSOCIATED DETAIL SPECIFICATIONS - Continued.

MIL-M-28787/No.	Amendment	Key code	Class	Name
277 (EC)	1	EML	I, II	Shift register
278A(EC)	-	FQD	I, II	Driver, lamp/relay
279 (EC)	1	RRF	I, II	Relay
286 (EC)	2	KYF	I	Memory, random access
287A(EC)	2	HRL	I, II	Buffer, bidirectional
288A(EC)	3	JRH	I, II	Clock, microprocessor
291A(EC)	-	AFA	I, II	Decoder
292A(EC)	2	BHA	I, II	Counter, up/down, binary
293 (EC)	1	CHH	I, II	Gate, NAND
294A(EC)	-	CHP	I, II	Gate, NAND
295A(EC)	1	FEA	I, II	Counter, binary
296A(EC)	3	GHK	I, II	Flip-flop, JK
297A(EC)	1	RHF	I, II	Gate, NAND
298A(EC)	1	RHG	I, II	Inverter
300A(EC)	-	HFB	I, II	Comparator, magnitude
301A(EC)	2	ERD	I, II	Microprocessor
302A(EC)	3	ZJS	I	Memory, random access
303A(EC)	1	ZJT	I, II	Memory, random access
304A(EC)	3	ZJU	I, II	Microprogram controller
305A(EC)	1	ZJX	I, II	Controller, interrupt
307A(EC)	-	MJB	I, II	Regulator, current, programmable
308A(EC)	2	MJC	I, II	Program control unit
309A(EC)	-	DAA	I, II	Amplifier, operational
310B(EC)	1	FMD	I, II	Components, miscellaneous
311A(EC)	-	HRQ	I, II	Relay, signal
312 (EC)	1	DLB	I	Driver, translator
313A(EC)	-	DLC	I	Receiver, translator
314 (EC)	-	FRC	I, II	Multiplexer
315 (EC)	-	FRE	I, II	Flip-flop, JK
316A(EC)	-	No key code	I, II	Memory, read only
317A(EC)	-	PJB	I, II	Register
318A(EC)	1	GRB	I, II	Resistor
319A(EC)	1	NZC	I, II	Counter, binary

ASSOCIATED DETAIL SPECIFICATIONS - Continued.

MIL-M-28787/No.	Amendment	Key code	Class	Name
320B(EC)	1	LZN	I, II	Switch, crosspoint
321A(EC)	-	RRB	I, II	Multiplexer
322A(EC)	1	DBK	I, II	Converter, D/A
325 (EC)	-	NQD	I, II	Multiplexer
327 (EC)	-	JHB	I, II	Comparator, magnitude
328 (EC)	1	NGK	I, II	Interface, microprocessor
331A(EC)	-	YBS	I, II	Oscillator, crystal
332 (EC)	-	MFP	I, II	Decoder
333 (EC)	1	MKR	I, II	Converter, D/A
335	-	NBP	I	Direct memory access
336 (EC)	-	NBQ	I, II	Interface, microprocessor
337A(EC)	-	JWP	I, II	Converter, S/D
338 (EC)	1	NTA	I, II	Encoder, priority
339	-	NTD	I	Multiplexer, three-state
340 (EC)	-	EAP	I, II	Amplifier
343 (EC)	2	MFD	I	Relay, latching
344 (EC)	1	MFG	I	Encoder, fault isolation
345 (EC)	-	JAP	I, II	Converter, S/D
394	-	MHA	I, II	Microprocessor

SUPPLEMENT 1

INACTIVE FOR DESIGN 1/

MIL-M-28787/No.	Amendment	Key code	Class	Name
2B(EC)	-	GDE	I	Flip-flop, JK
3B(EC)	1	GDA	I	Gate, NAND
8B(EC)	-	GDC	I	Gate, NAND
10B(EC)	-	GDB	I	Gate, NAND
21B(EC)	1	WDU	I	Gate, NAND
28A(EC)	1	PDM	I	Shift register
29B(EC)	-	FDH	I	Inverter
32B(EC)	-	KBR	I	Flip-flop, D type
40B(EC)	-	KBL	I	Multiplexer
42B(EC)	1	JBK	I	Comparator, magnitude
44B(EC)	1	GBL	I	Latch
45B(EC)	1	ZBZ	I	Counter, binary coded decimal
46C(EC)	1	ZBY	I, II	Counter, binary
85A(EC)	-	BDN	I	Multiplexer
114A(EC)	2	BDA	I	Gate, NAND
115A(EC)	1	BDB	I	Gate, NAND
116A(EC)	1	BDC	I	Gate, NAND
117A(EC)	-	BDD	I	Multivibrator, monostable
118B(EC)	-	BDE	I	Multivibrator, monostable
119A(EC)	2	BDH	I	Gate, NAND, power
120B(EC)	1	CDB	I	Gate, NAND, power
121B(EC)	-	CDD	I	Multivibrator, monostable
122B(EC)	1	CDE	I	Multivibrator, monostable
123A(EC)	1	ADH	I	Flip-flop, JK
124A(EC)	1	CMH	I	Test point
125A(EC)	1	FLA	I	Extender, test point, and resistor
127D(EC)	1	FLE	I	Capacitor
132A(EC)	1	MVJ	I	Oscillator, square wave

1/ Inactive for design detail specifications are not listed in the cross reference by key code or cross reference by name.

INACTIVE FOR DESIGN - Continued. 1/

MIL-M-28787/No.	Amendment	Key code	Class	Name
155A(EC)	-	DBC	I	Logic converter, digital to analog
156A(EC)	-	DBE	I	Gate, inverter
157A(EC)	-	DBF	I	Gate, NAND
158A(EC)	1	DBG	I	Gate, NAND
159A(EC)	-	DBH	I	Gate, NAND
160A(EC)	1	EBH	I	Register, shift
166B(EC)	1	BBJ	I	Counter, up/down, binary
170A(EC)	-	EBA	I	Gate, AND-OR-INVERT
171A(EC)	-	EBB	I	Gate, exclusive OR
172A(EC)	-	EBC	I	Flip-flop, JK
173A(EC)	-	EBE	I	Multiplexer
174A(EC)	2	FBA	I	Arithmetic logic unit
176B(EC)	-	FBH	I	Register, programmable
200	-	QQA	I, II	Register, multiport
224A(EC)	3	JDF	I	Flip-flop, JK
228A(EC)	3	PEG	I	Integrator, S/D
306A	2	MJA	I, II	Microprocessor

1/ Inactive for design detail specifications are not listed in the cross reference by key code or cross reference by name.

SUPPLEMENT 1

CROSS REFERENCE BY KEY CODE

Key code	MIL-M-28787/No.	Key code	MIL-M-28787/No.
ABE	22	CFA	62
ABF	152	CGR	240
ADK	58	CHF	71
ADL	216	CHH	293
AFA	291	CHP	294
AGA	268	CTR	128
AGD	140	CZH	210
AHA	65	DAA	309
AHD	78	DBA	154
AKE	161	DBK	322
AMC	248	DLB	312
AME	249	DLC	313
AMF	250	DPA	245
AMG	251	DQD	212
AMH	252	DQJ	244
ARM	87	DQK	243
ARN	192	EAP	340
BAC	190	EBA	170
BBA	30	EBD	197
BBB	47	EBL	41
BDL	5	EEE	218
BDM	196	EKB	162
BED	205	EKC	163
BEE	229	EMF	129
BHA	292	EMJ	259
BHL	66	EMK	260
BMA	253	EML	277
BMB	254	EMM	261
BMC	255	EMN	262
BMD	256	EMP	263
BME	257	EMQ	264
BMG	275	EQF	214
BMH	258	EQG	213
BYF	80	EQJ	215
CBF	84	ERD	301

CROSS REFERENCE BY KEY CODE - Continued.

Key code	MIL-M-28787/No.	Key code	MIL-M-28787/No.
ERN	86	HEE	219
FAG	113	HFB	300
FBE	233	HQE	208
FBG	175	HRF	153
FDA	6	HRH	237
FEA	295	HRL	287
FGC	177	HRQ	311
FGH	269	HUH	225
FHA	70	HVA	147
FLB	126	JAP	345
FMD	310	JBD	14
FQB	206	JBK	42
FQD	278	JBN	34
FRC	314	JDB	142
FRE	315	JDD	31
FZJ	211	JDJ	33
GBB	143	JDK	16
GDJ	1	JHB	327
GDK	4	JHD	67
GDM	27	JHK	73
GDN	7	JQM	222
GDP	178	JRH	288
GEE	231	JWP	337
GGD	179	KAD	220
GGG	180	KBC	39
GHK	296	KDC	223
GHM	238	KDF	49
GPR	24	KDJ	12
GQB	266	KDL	11
GRB	318	KDM	55
GVQ	234	KDN	53
GYB	141	KDP	59
GYC	168	KDQ	60
GYF	169	KDR	61
GZC	209	KHL	81

CROSS REFERENCE BY KEY CODE - Continued.

Key code	MIL-M-28787/No.	Key code	MIL-M-28787/No.
KHQ	72	NRN	133
KHR	69	NTA	338
KYF	286	NTD	339
LDC	20	NZC	319
LDJ	17	PDL	112
LDN	19	PEE	191
LDP	9	PJB	317
LDQ	18	PTE	226
LEE	221	PTF	227
LHH	68	QBQ	239
LHJ	64	QDF	242
LHP	75	QDH	54
LZN	320	QDR	241
MAD	202	QPL	130
MDL	109	QPM	135
MDM	110	QQA	200
MDN	111	QQQ	232
MDP	48	QVG	235
MDQ	51	QVQ	236
MFD	343	RBF	83
MFG	344	RBG	82
MFP	332	RDH	79
MHA	394	RHF	297
MHK	77	RHG	298
MHL	76	RPN	136
MJA	306	RQB	271
MJB	307	RRB	321
MJC	308	RRF	279
MKR	333	RUM	204
MUM	246	SBT	23
NBP	335	SES	184
NBQ	336	SEX	88
NGK	328	SHU	187
NPM	38	SHV	188
NQD	325	SHX	189

CROSS REFERENCE BY KEY CODE - Continued.

Key code	MIL-M-28787/No.
SHY	186
SJS	273
STT	185
SYT	193
TTY	57
UHX	194
VGS	182
VPX	137
YBS	331
YBZ	267
YKV	274
ZEZ	272
ZJS	302
ZJT	303
ZJU	304
ZJX	305
ZRX	270
ZSW	183
---	74
---	265
---	316

SUPPLEMENT 1

CROSS REFERENCE BY NAME

Name	MIL-M-28787/No.	Key code
Adder	11	KDL
Adder	39	KBC
Adder, discrete sum	175	FBG
Amplifier	340	EAP
Amplifier, AGC	245	DPA
Amplifier, clipper	233	FBE
Amplifier, differential	269	FGH
Amplifier, operational	177	FGC
Amplifier, operational	309	DAA
Amplifier, phase shift	221	LEE
Amplifier, power	184	SES
Amplifier, power	219	HEE
Amplifier, summing	205	BED
Amplifier, summing	229	BEE
Arithmetic logic unit	12	KDJ
Buffer, bidirectional	287	HRL
Buffer, non-inverting	248	AMC
Buffer, three-state	47	BBB
Buffer, three-state	267	YBZ
Buffer-limiter	190	BAC
Capacitor, programmable	179	GGD
Clock, microprocessor	288	JRH
Comparator	62	CFA
Comparator	231	GEE
Comparator, magnitude	142	JDB
Comparator, magnitude	300	HFB
Comparator, magnitude	327	JHB
Components, miscellaneous	310	FMD
Controller, interrupt	305	ZJX
Converter, analog/digital	232	QQQ
Converter, binary/BCD	271	RQB
Converter, BCD/binary	272	ZEZ

CROSS REFERENCE BY NAME - Continued.

Name	MIL-M-28787/No.	Key code
Converter, D/A	322	DBK
Converter, D/A	333	MKR
Converter, parallel/serial	213	EQG
Converter, serial/parallel	214	EQF
Converter, S/D	337	JWP
Converter, S/D	345	JAP
Counter, binary	70	FHA
Counter, binary	250	AMF
Counter, binary	295	FEA
Counter, binary	319	NZC
Counter, binary/BCD	275	BMG
Counter, binary, synchronous	6	FDA
Counter, binary coded decimal	58	ADK
Counter, up and down, binary	27	GDM
Counter, up/down, binary	30	BBA
Counter, up/down, binary	292	BHA
Counter, up/down, BCD, presettable	31	JDD
Decoder	65	AHA
Decoder	291	AFA
Decoder	332	MFP
Decoder, binary	7	GDN
Decoder, BCD to decimal	258	BMH
Demultiplexer	182	VGS
Diode, pairs	49	KDF
Diode, programmable	22	ABE
Driver	202	MAD
Driver, bus	266	GQB
Driver, differential line	55	KDM
Driver, FET, switch	178	GDP
Driver, interface	109	MDL
Driver, interface	162	EKB

CROSS REFERENCE BY NAME - Continued.

Name	MIL-M-28787/No.	Key code
Driver, interface	163	EKC
Driver, interface, NTDS (ANEW)	241	QDR
Driver, lamp/relay	152	ABF
Driver, lamp/relay	206	FQB
Driver, lamp/relay	278	FQD
Driver, NTDS slow	239	QBQ
Driver, translate	48	MDP
Driver, translator	312	DLB
Encoder, fault isolation	344	MFG
Encoder, parity	77	MHK
Encoder, priority	76	MHL
Encoder, priority	338	NTA
Filter, low pass, active	218	EEE
Flip-flop, D type	61	KDR
Flip-flop, D type	69	KHR
Flip-flop, D-type	256	BMD
Flip-flop, JK	41	EBL
Flip-flop, JK	264	EMQ
Flip-flop, JK	315	FRE
Flip-flop, JK	143	GBB
Flip-flop, JK	296	GHK
Fuse	209	GZC
Gate, AND	243	DQK
Gate, AND	244	DQJ
Gate, AND-OR-INVERT	17	LDJ
Gate, AND-OR-INVERT	64	LHJ
Gate, AND-OR-INVERT	252	AMH
Gate, exclusive OR	255	BMC
Gate, exclusive -OR	4	GDK
Gate, inverter	261	EMM
Gate, NAND	9	LDP

CROSS REFERENCE BY NAME - Continued.

Name	MIL-M-28787/No.	Key code
Gate, NAND	18	LDQ
Gate, NAND	19	LDN
Gate, NAND	68	LHH
Gate, NAND	75	LHP
Gate, NAND	83	RBF
Gate, NAND	238	GHM
Gate, NAND	253	BMA
Gate, NAND	254	BMB
Gate, NAND	260	EMK
Gate, NAND	293	CHH
Gate, NAND	294	CHP
Gate, NAND	297	RHF
Gate, NOR	249	AME
Gate, NOR	259	EMJ
Gate, NOR	263	EMP
Generator, function	194	UHX
Generator, function, LSB	187	SHU
Generator, function, MSB	186	SHY
Inductor	137	VPX
Inductor, 1.5 ampere	135	QPM
Interface, microprocessor	328	NGK
Interface, microprocessor	336	NGQ
Inverter	20	LDC
Inverter	82	RBG
Inverter	197	EBD
Inverter	298	RHG
Inverter, buffer	262	EMN
Isolation module	129	EMF
Latch	1	GDJ
Latch	251	AMG

SUPPLEMENT 1

CROSS REFERENCE BY NAME - Continued.

Name	MIL-M-28787/No.	Key code
Load, resistor, standard	126	FLB
Logic converter, analog to digital	154	DBA
Logic unit, arithmetic	79	RDH
Memory, direct access	335	NBP
Memory, random access	80	BYF
Memory, random access	141	GYB
Memory, random access	193	SYT
Memory, random access	286	KYF
Memory, random access	302	ZJS
Memory, random access	303	ZJT
Memory, read only	74	---
Memory, read only	265	---
Memory, read only	316	---
Memory, read only, programmable	168	GYC
Memory, read only, programmable	169	GYF
Microprocessor	237	HRH
Microprocessor	301	ERD
Microprocessor	306	MJA
Microprocessor	394	MHA
Microprogram controller	304	ZJU
Modulator, synchronous	220	KAD
Multiplexer	5	BDL
Multiplexer	60	KDQ
Multiplexer	66	BHL
Multiplexer	67	JHD
Multiplexer	72	KHQ
Multiplexer	78	AHD
Multiplexer	81	KHL
Multiplexer	88	SEX
Multiplexer	140	AGD
Multiplexer	223	KDC

CROSS REFERENCE BY NAME - Continued.

Name	MIL-M-28787/No.	Key code
Multiplexer	314	FRC
Multiplexer	321	RRB
Multiplexer	325	NQD
Multiplier	268	AGA
Multiplexer, three-state	339	NTD
Multivibrator, monostable	34	JBN
Multivibrator, monostable	257	BME
NAND/Schmitt	222	JQM
Network, miscellaneous	130	QPL
Network, resistor	204	RUM
Network, resistor, programmable	180	GGG
Octant/quadrant	188	SHV
Optical isolator	246	MUM
Oscillator	147	HVA
Oscillator, crystal	234	GVQ
Oscillator, crystal	235	QVG
Oscillator, crystal	236	QVQ
Oscillator, crystal	331	YBS
Processor, error, S/D	189	SHX
Program control unit	308	MJC
Programmable timer	208	HQE
Receiver, differential line	53	KDN
Receiver, interface	16	JDK
Receiver, interface	23	SBT
Receiver, interface	54	QDH
Receiver, interface	73	JHK
Receiver, interface	110	MDM
Receiver, interface, NTDS (ANEW)	242	QDF
Receiver, line	196	BDM
Receiver, translate	51	MDQ
Receiver, translator	313	DLC

CROSS REFERENCE BY NAME - Continued.

Name	MIL-M-28787/No.	Key code
Rectifier, low current	24	GPR
Register	317	PJB
Register, multiport	200	QQA
Regulator, current, programmable	307	MJB
Regulator, negative	192	ARN
Regulator, positive	87	ARM
Relay	86	ERN
Relay	153	HRF
Relay	270	ZRX
Relay	279	RRF
Relay, DPDT	38	NPM
Relay, 4PDT	133	NRN
Relay, latching	343	MFD
Relay, signal	311	HRQ
Resistor	318	GRB
Resistor, pullup	216	ADL
Sample and hold	191	PEE
Shift register	33	JDJ
Shift register	59	KDP
Shift register	71	CHF
Shift register	84	CBF
Shift register	273	SJS
Shift register	277	EML
Shift register, serial and parallel	112	PDL
Standard serial input	215	EQJ
Standard serial output	212	DQD
Switch	113	FAG
Switch, analog	57	TTY
Switch, analog	183	ZSW
Switch, crosspoint	320	LZN
Switch, S/D, multispeed	225	HUH