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SUPERSEDING
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MILITARY SPECIFICATION

CIRCUIT CARD ASSEMBLIES, RIGID, FLEXIBLE, AND RIGID-FLEX

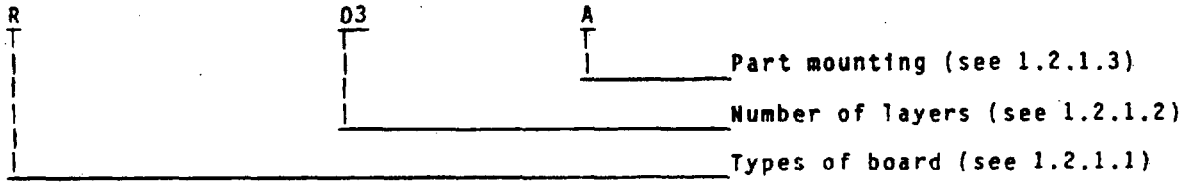
This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification establishes the requirements for circuit card assemblies, consisting of printed wiring boards on which separately manufactured parts have been added. The term "assemblies" is used herein when referring to circuit card assemblies. The term "board" is used herein when referring to printed wiring board or printed circuit boards.

1.2 Classification.

1.2.1 Types. Assemblies shall be of the following types shown.



1.2.1.1 Type of board. The type of board shall be identified as follows.

R - Rigid (types 1, 2, and 3 in accordance with MIL-P-55110).

F - Flexible (types 1, 2, and 3 in accordance with MIL-P-50884).

C - Rigid and flexible combination (types 4 and 5 in accordance with MIL-P-50884).

1.2.1.2 Number of layers. The number of layers shall be identified by a two digit number as follows.

01 - Single sided board.

02 - Double sided board.

03 - Thirteen layer board.

0* - Mixture of number of layers.

1.2.1.3 Part mounting. The part mounting shall be identified as follows.

A - Plated through-hole mount only.

B - Surface mount only.

C - Mixed mount (combinations of A and B).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Space and Naval Warfare Systems Command, ATTN: SPAWAR 003-1212, Washington, DC 20363-5100 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 5999

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 specification to the extent specified herein. Unless otherwise specified, the issues 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.
QQ-S-781	-	Strapping, Steel, and Seals.
QQ-W-343	-	Wire, Electrical, Copper (Uninsulated).
PPP-B-566	-	Box, Folding, Paperboard.
PPP-B-601	-	Boxes, Wood, Cleated Plywood.
PPP-B-621	-	Box, Wood, Nailed and Lock-Corner.
PPP-B-636	-	Box, Shipping, Fiberboard.
PPP-B-676	-	Boxes, Setup.
PPP-C-795	-	Cushioning Material, Packaging (Flexible Cellular Plastic Film) For Packaging Applications.
PPP-C-1752	-	Cushioning Material, Packaging, Unicellular.
PPP-C-1797	-	Cushioning Material, Resilient, Low Density, Unicellular, Polypropylene Foam.
PPP-C-1842	-	Cushioning Material, Plastic, Open Cell (For Packaging Applications).

MILITARY

MIL-P-116	-	Preservation, Methods Of.
MIL-B-117	-	Bag, Sleeve and Tubing Interior Packaging.
MIL-F-14256	-	Flux, Soldering, Liquid (Rosin Base).
MIL-I-46058	-	Insulating Compound, Electrical (For Coating Printed Circuit Assemblies).
MIL-P-50884	-	Printed Wiring, Flexible General Specification For.
MIL-P-55110	-	Printed Wiring Boards.

STANDARDS

MIL-STD-105	-	Sampling Procedures and Tables For Inspection By Attributes.
MIL-STD-129	-	Marking For Shipment And Storage.
MIL-STD-130	-	Identification Marking Of U.S. Military Property.
MIL-STD-147	-	Palletized Unit Loads.
MIL-STD-202	-	Test Methods For Electronic And Electrical Component Parts.
MIL-STD-275	-	Printed Wiring For Electronic Equipment.
MIL-STD-454	-	Standard General Requirements for Electronic Equipment.
MIL-STD-794	-	Part and Equipment, Procedures for Packaging and Packing of.
MIL-STD-810	-	Environmental Test Methods and Engineering Guidelines.
DOD-STD-1686	-	Electrostatic Discharge Control Program For Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices (Metric)).
DOD-STD-2000/1	-	Soldering Technology, High Quality/High Reliability.
DOD-STD-2000/2	-	Part and Component Mounting for High Quality/High Reliability Soldered Electrical and Electronic Assemblies.
DOD-STD-2000/3	-	Criteria for High Quality/High Reliability Soldering Technology.
DOD-STD-2000/4	-	General Purpose Soldering Requirements for Electrical and Electronic Equipment.

MIL-STD-2118 - Flexible and Rigid Flex Printed Wiring For Electronic Equipment Design Requirements For.
MIL-STD-45662 - Calibration Systems Requirements.

HANDBOOKS

FEDERAL

H-6 - Federal Item Name Directory for Supply Cataloging.

(Copies of specifications, standards, and handbooks required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the non-Government documents which is current on the date of the solicitation.

INSTITUTE FOR INTERCONNECTING AND PACKAGING ELECTRONIC CIRCUITS

IPC-S-805 - Solderability Tests for Component Leads and Terminations.
IPC-S-815 - General Requirements for Soldering Electrical Connections.
IPC-T-50 - Circuit, Interconnecting and Packaging Electronic, Terms and Definitions.
IPC-CC-830 - Insulating Compound, Electrical (For Coating Printed Circuit Assemblies).
IPC-TM-650 - Test Methods Manual.

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

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

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General requirements. Assemblies furnished under this specification shall be a product which meets the requirements of this specification and the applicable assembly drawing (see 6.1 and 6.2). The design features of the assemblies shall be in accordance with MIL-STD-275 or MIL-STD-2118 and the approved assembly drawing (see 30.1.1).

3.1.1 Conflict. In the event of any conflict between the approved assembly drawing and the requirements of this specification, the provisions of the assembly drawing(s) shall govern. Changes to the approved assembly drawing(s) shall be processed in accordance with the requirements of MIL-STD-275.

3.2 First article. Assemblies furnished under this specification shall be products which have passed the first article inspection specified in 4.4. Alternatives provided in this specification do not constitute authority to produce production units using different materials or processes other than those used on the first article sample, unless it can be demonstrated that the change is equivalent to or superior to the current procedure and is approved by the acquiring activity.

3.3 Terms and definitions. Terms and definitions shall be in accordance with Federal Cataloging Handbook H-6, IPC-T-50, and the appendix (see 30.). In case of conflict, H-6 shall take precedence over IPC-T-50, and IPC-T-50 shall take precedence over the appendix (see 30.).

3.4 Materials and parts. Materials and parts furnished for the assembly shall be as specified herein and in the applicable assembly drawing. The responsibility for inspection of material quality shall be as specified in 4.1.

3.4.1 Materials and processes compatibility. It shall be the responsibility of the manufacturer to select those processes, materials, and components which are compatible with one another and which best suit the end product desired by the contract.

3.4.2 Rigid boards. Rigid assemblies shall use rigid boards built and inspected in accordance with MIL-P-55110 and designed in accordance with MIL-STD-275.

3.4.3 Flexible and rigid-flex boards. Flexible and rigid-flex assemblies shall use flexible and rigid-flex boards built and inspected in accordance with MIL-P-50884 and designed in accordance with MIL-STD-2118.

3.4.4 Incoming inspection. Incoming inspection should be performed on all incoming parts, boards, and materials.

3.4.5 Storage. Parts, board, and materials shall be appropriately stored prior to assembly.

3.4.6 Solderability. Terminations, boards, component leads, and wires shall be tested for solderability in accordance with 4.3.1 within 3 months prior to assembly.

3.4.7 Marking. Parts shall be capable of being processed and cleaned as required by this specification and the assembly drawing and retain marking legibility.

3.4.8 Gold-plated leads and wires. All gold-plated leads and wires which are to be soldered shall have the gold removed before soldering by single or double dipping into a flowing or nonflowing hot solder, respectively, of sufficient volume to assure gold removal.

3.4.9 Solder. The solder used shall be in accordance with composition Sn 60, Sn 62, Sn 63 of QQ-S-571.

3.4.9.1 Solder paste for surface mounting. The board shall be visually inspected after solder paste application, prior to component placement, for sufficient solder paste on all lands, complete coverage, registration, and excess solder paste.

3.4.10 Fluxes. Fluxes used on the assembly shall produce no detrimental effects. Subsequent to their use and removal, the board shall meet all cleanliness requirements of this specification (see 4.7.2). The soldering flux used to make an electrical solder connection or mechanical attachment shall be a liquid flux conforming to MIL-F-14256, type R or RMA, or a solid flux contained in a cored solder wire conforming to type R or RMA of QQ-S-571. (The use of RA flux requires prior approval to be used on contracts.) Water soluble fluxes shall not be allowed for soldering.

3.4.11 Conformal coating. Conformal coating material shall be as specified on the approved assembly drawing and shall be in accordance with IPC-CC-830 or MIL-I-46058. Solder mask shall not be considered as conformal coating. The type of conformal coating shall be as listed on the assembly drawing. The conformal coating shall be compatible with the solder mask.

3.4.12 Buffer material (see 3.6.8). The buffer material, when required, shall be a thin, pliant material such as polyvinylidene fluoride, polyethylene terephthalate, or silicon rubber, and be nonreactive with the conformal coating, solder mask, all materials, and all components to which it comes in contact. The buffer material shall be fungus and flame resistant, and clear or transparent so markings on the components are visible (see 3.8.9 and 3.9).

3.5 Design principles and production criteria. Component mounting and attachment shall be in accordance with this specification, and the approved assembly drawing (see 3.1), or other documents of the assembly manufacturer referenced on the approved assembly drawing. The requirements of 3.5.3 through 3.5.4.3.2 shall apply to the mounting of components on the assembly.

3.5.1 Two-part connectors (plug and receptacle). Two-part connectors containing male or female quick disconnect electrical contacts and integral aligning hardware to assure proper mating of the contacts shall be specified as the only means to integrate plug-in assemblies. Board connectors may be uniquely keyed in such a manner as to prevent improper mating. Connectors may be surface or through-hole mounted.

3.5.2 Wires. Use of hard wiring directly to plug in connector mounted assemblies shall not be permitted. Plug in assemblies shall have all external electrical connections accomplished through the use of two-part connectors.

3.5.3 Component mounting. Each component shall be mounted, located, oriented, and attached as specified on the approved assembly drawing. All components shall be correctly soldered (see 3.5.4 and 3.5.5). The leads of components should be preformed by automatic equipment. In unique specific applications, components intended for mounting by plated through-holes may be formed by utilizing hand tools that will not induce component or lead damage.

3.5.3.1 Location. Components shall be mounted on printed wiring boards in a configuration which will facilitate cleaning and solder flow. Creation of potential moisture and contamination traps shall be avoided.

3.5.3.2 Conductive areas. Each component shall be mounted so that subsequent conformal coating will cover the conductive area under the part body except where thermal dissipation or electrical conduction is required. When conformal coating will not cover conductive areas under the component, the conductive areas shall be insulated and protected against moisture entrapment by applying an insulating material (thermoset resin or film, dielectric material, solder mask coating, etc.) over the area prior to mounting of components as specified by the assembly drawing.

3.5.3.3 Spacing. Lands and terminals shall be located and spaced so that the terminations of each component are not obscured by any other component, or by any other permanently installed parts. Each component shall be capable of being removed from the assembly without having to remove any other component, except for chip carriers and plug-in sockets.

3.5.3.3.1 Design envelope. Unless otherwise detailed on the assembly drawing, the board edge is regarded as the extreme perimeter of the assembly, beyond which no portion of a component is allowed to extend. Exceptions, for parts such as connectors, will be depicted explicitly in assembly views.

3.5.3.3.2 Clearance. The part body shall be mounted to provide a minimum of 0.010 inch clearance between the part body and the board surface (dielectric surface) to facilitate subsequent soldering, cleaning, and coating operations.

3.5.3.3.3 Electrical spacing. Assemblies shall be conformally coated (see 3.6). The minimum spacing between component terminations, leads, wires, conductor patterns, and other conductive material (such as conductive markings or mounted hardware) shall be in accordance with table I.

TABLE I. Electrical spacing for conformally coated assemblies.

Voltage between conductors (dc or ac peak)	Minimum spacing
Volts	Inches (mm)
0-100	0.005 (0.13)
101-300	0.015 (0.76)
301-500	0.030 (1.52)
Greater than 500 1/	0.00012 (.00305) per volt

1/ For reference only; voltages greater than 500 volts should be evaluated for the specific design application.

3.5.3.4 Alignment of component leads. Axial component leads shall coincide to the centerline through their respective land areas whenever possible. The component lead may overhang the land area only if the resultant electrical spacing between adjacent conductors meets the requirements specified in table I and if there is sufficient contact area to provide a proper solder fillet or bond.

3.5.3.5 Stress relief bends. Components shall be mounted or provided with stress relief bends in such a manner that the leads cannot overstress the component-lead interface when subjected to the conditions of 3.8.3 through 3.8.6. The straight lead length adjacent to the component body shall be in accordance with figure 1.

3.5.3.6 Lead bend radius. Minimum bend radius for leads shall be in accordance with figure 1.

3.5.3.7 Axial-leaded components. Axial-leaded components shall be mounted as specified on the approved assembly drawing.

3.5.3.7.1 Perpendicular mounting. When specified on the approved assembly drawing, axial-leaded components weighing less than 0.50 ounce (14 g) may be mounted perpendicular to the board. The end of the component is defined to include any coating meniscus, solder seal, solder or weld bead, or any other extension. The maximum allowed vertical height of the component from the board mounting surface shall be 0.55 inch (14 mm) (see figure 2). Perpendicular mounted components shall not be surface mounted.

3.5.3.8 Multiple-leaded components. Multiple-leaded components (components with three or more leads), except multiple leaded components mounted to thermal planes or heat sinks, shall be mounted in such a manner that components are spaced off the board to facilitate cleaning, provide electrical isolation, and to prevent moisture traps. The necessary gap may be prescribed as an exceptional fabrication requirement by identifying the subject component and prescribing the required underbody clearance dimension or the gap may be achieved by virtue of the component's own standoff features.

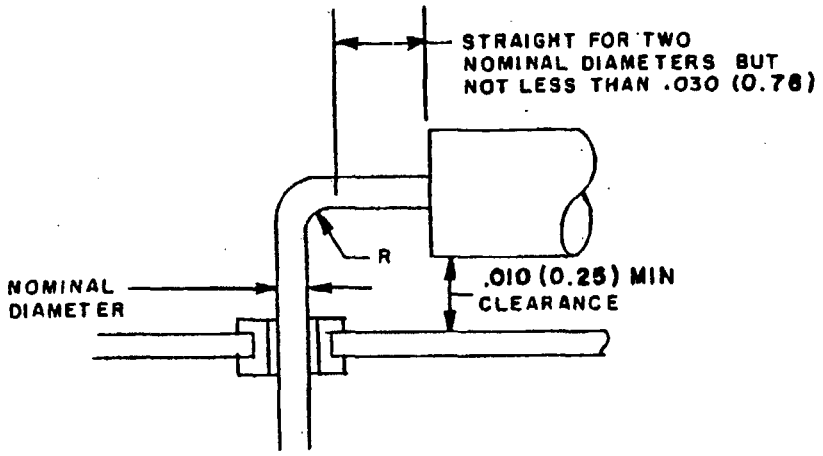
3.5.3.8.1 Spacers. Special spacers (such as feet, ribs, or projections) with minimal contact may be prescribed to go under the component, provided they will not impair soldering or the assembly's performance. Spacers must not inhibit cleaning under the spacer/part and must not prevent inspection of soldered connections.

3.5.3.8.2 Sealing. The need for a gap between component body and board may be avoided by requiring the interface under the component to be sealed with adhesive or a combination of adhesive and insulation material which is compatible with the board, parts, and conformal coating. This option exists only if all lead terminations and plated through-holes are external to the seal. Repairability shall not be degraded by the method or material selection.

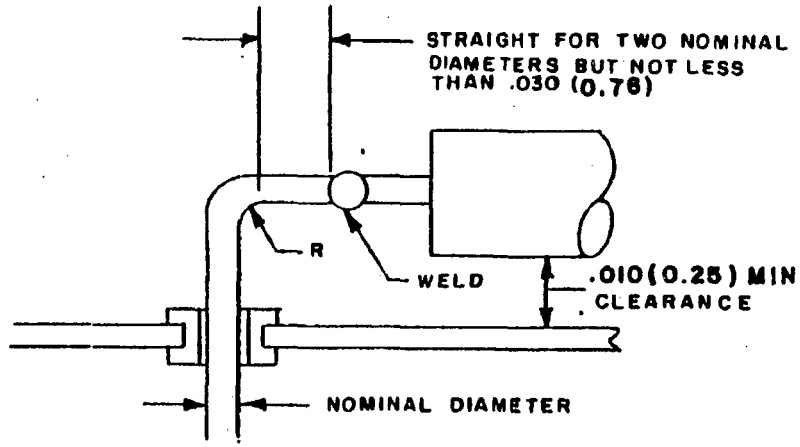
3.5.3.9 Heat dissipating components. All components dissipating 1 watt or more shall be mounted as specified on the approved assembly drawing or in such a manner that the body of the component is not in direct contact with the printed wiring board unless either a clamp or thermal groundplane, or both, is used which will dissipate sufficient heat so that the maximum allowable operating temperature of the printed wiring board is not exceeded.

3.5.3.9.1 Thermal transfer. Components, which for thermal reasons require extensive surface contact with the board or with a heat sink mounted on the board, shall be protected from processing solutions at the conductive interface. To prevent risk of entrapment, compatible materials or methods shall be used to seal the interface from entry of corrosive or conductive contaminants.

NOTE: Even totally nonmetallic interfaces that are prone to entrap fluids can have adverse effects on the fabricator's ability to pass required cleanliness tests.



STANDARD BEND

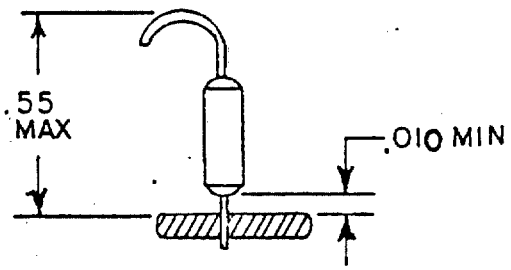


WELDED BEND

Nominal lead diameter in inches	Minimum radius in inches
≤.027 (.69 mm)	Nominal lead diameter
≥.029 (.71 mm) ≤.047 (1.19 mm)	1.5 times nominal diameter
≥.048 (1.22 mm)	2.0 times nominal diameter

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

FIGURE 1. Lead bend.



Inches	mm
.010	0.25
.55	14.0

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

FIGURE 2. Perpendicular part mounting.

3.5.3.10 Jumper wires. Jumper wires shall be as short as practical and shall not be applied over or under other components (including jumper wires). Jumper wires less than 0.5 inch in length whose path does not pass over conductive areas and does not violate the spacing requirements of 3.5.3.3.3 may be uninsulated. Jumper wires may be used on assemblies. Jumper wires may be terminated in holes or standoffs (preferred) or on lands. Jumper wires shall be considered a component. Jumper wires must be permanently fixed to the printed wiring board at intervals not to exceed 1 inch. Insulation or jumper wires shall be compatible with the conformal coating. Jumper wires included in the original design shall be green in color. Jumper wires added for repair or modification shall be red in color.

3.5.3.11 Surface mounted components. The requirements of the following paragraphs apply (see 3.5.3.12 through 3.5.3.17).

3.5.3.12 Flat-pack types with ribbon leads. Lead forming is a major design consideration and shall be detailed on the assembly drawing, or by reference to another document, to provide for lead stress relief, fit to the land pattern, underbody clearance for cleaning, and any designed-in provisions for thermal transfer. The foot shall not be held down or placed under tension during soldering.

3.5.3.13 Leadless components. Leadless components shall be attached to the surface of a land. The component shall be attached to the land of the printe-wiring board in a way that provides sufficient space under the body of the component to facilitate cleaning. Land pattern design shall facilitate adequate solder fillets between the conductor pattern and the component.

3.5.3.14 End-cap discrete components. End-cap discrete resistor and capacitor components and similar leadless end-cap discrete components shall be mounted to printed wiring or printed circuitry. The devices shall not be stacked nor shall they bridge spacing between other parts or components, such as terminals or other properly-mounted components. The devices shall meet the minimum spacing requirements.

3.5.3.15 Surface mounting of flattened round leaded components. Components with leads of round cross sections shall be utilized for surface mounting only if the leads are coined or flattened for positive seating. For flattened round leads with original diameter of 0.025 inch (0.635 mm) or greater, the flattened thickness shall be 70 percent of the original diameter, minimum. For leads with an original diameter less than the 0.025 inch (0.635 mm), and greater than .006 inch, the flattened thickness shall be 50 percent of the original diameter, minimum. For leads with diameters of .006 inch and less, the leads shall not be flattened.

3.5.3.16 Surface terminated ribbon leads. Flat-wire ribbon leads may be attached to lands on the board. Connections shall be made by soldering only. Minimum conductor spacing shall be maintained. Attachment details may be conveyed by an assembly drawing reference to IPC-S-815 or DOD-STD-2000/4.

3.5.3.17 Interfacial connections.

3.5.3.17.1 Clinched wires. When specified on the assembly drawing interfacial connections on type 2 boards with nonplated through-holes may be made by the use of uninsulated solid wire in accordance with QQ-W-343, type S, coated, extending through a hold and clinched. The wire shall make contact with the conductor pattern on each side of the assembly before soldering (see figure 3) and the end shall not extend beyond the edge of its land area greater than 0.03 inch or in violation of the minimum spacing requirements. The leads shall not extend beyond the land area down a connected conductor pattern in excess of 0.030 inch. Component lead wires do not qualify for interfacial connections. The top and bottom portions of the wire need not be aligned in the same vertical plane.

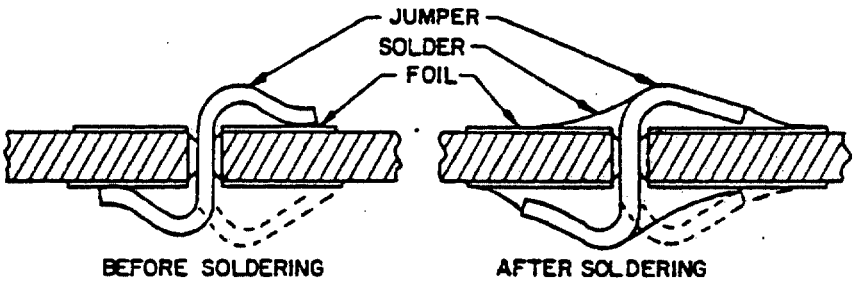


FIGURE 3. Clinched wire (interfacial connection) (direction of clinch optional) (type 2 boards only).

3.5.3.17.2 Plated through-holes. Plated through-holes used for interfacial connections, internal or inner layer connections shall not be used for mounting of eyelets, standoff terminals, rivets, or other devices which put the plated through-hole in compression. Interfacial connections on type 2 boards may also be made by the use of plated through-holes. Interfacial connections on multilayer boards shall be made only by the use of plated through-holes. Plated through-holes may be used for mounting components which place the hole in compression, provided a duplicate plated through-hole which is not in compression has been provided.

3.5.4 Component attachment. Component leads shall pass through lead component holes and be attached or the component leads shall be surface mounted to the land pattern. Components may also be attached to terminals. Part attachment shall be as described on the assembly drawing or by reference to IPC-S-815, DOD-STD-2000/2, or DOD-STD-2000/4.

3.5.4.1 Standoff terminals, eyelets, or fasteners.

3.5.4.1.1 Component attachment to standoffs. Component attachment to standoff terminals shall be defined on the assembly drawing and meet the requirements of IPC-S-815. Attachment of terminals shall be specified to suit each application. If attachment of the terminals is part of the assembly operation, the assembly drawing shall specify the mechanical and soldering requirements.

3.5.4.1.2 Attachment of standoffs to boards. A funnel flanged terminal shall be specified wherever the flange must be soldered for electrical connection to a land. The included angle of such flange shall be between 35 and 120 degrees.

3.5.4.1.3 Eyelets. Eyelets shall not be installed in functional plated through-holes.

3.5.4.1.4 Fastening hardware. The installed location and installation orientation shall be prescribed on the assembly drawing for any fastening devices such as rivets, machine screws, washers, inserts, nuts, and bracketing. Precautions, such as the specification of tightening torque values, shall be provided wherever general assembly practices might be inadequate or detrimental to the board assembly's structure or functioning.

3.5.4.2 Clinched leads. When maximum mechanical retention of a lead or terminal is required by design, the lead or terminal shall be clinched. The component holes may be plated through-holes, unsupported holes, or eyeletted holes. Clinching requirements shall be defined on the assembly drawing. The lead end shall not extend beyond the edge of its land or its electrically connected conductor pattern in violation of the minimum spacing requirement. Partial clinching of leads for part retention shall be considered under the requirements of 3.5.4.3.

3.5.4.3 Unclinched leads. Unless otherwise specified, unclinched leads (either straight or partially bent for retention) shall be soldered in component holes or eyelets in accordance with IPC-S-815. If no clinching requirements are specified on the assembly drawing, clinched or partial clinching lead termination shall apply.

3.5.4.3.1 Unsupported holes. Lead tip projection shall be required to extend from 0.020 inch (0.51 mm) minimum to 0.060 inch (1.5 mm) maximum from the surface of the foil.

3.5.4.3.2 Plated through- or eyeletted-holes. The outline of component leads shall be discernable in the solder joint. Lead protrusion shall not exceed 0.060 inch beyond the plating surface.

3.5.5 Soldering (see 4.5.1). Soldering shall be in accordance with IPC-S-815, class 3, DOD-STD-2000/1 through DOD-STD-2000/4 or MIL-STD-454, requirement 5. Solder shall not be used on surfaces specified to be free of solder. Solder and flux shall be in accordance with 3.4.4 and 3.4.5.

3.5.5.1 Metal. All metal surfaces shall be free of corrosion and contamination. All printed conductors shall be firmly bonded to the printed wiring board, except as specified in 3.5.6.

3.5.5.2 Solder plugs applicability. Solder shall be applied to component leads and to the assembly to create a continuous solder plug around the component leads in the plated through-holes and eyelets. In addition, boards subjected to wave or dip soldering are to be processed to fill any typical plated through-hole that is not intended to accept a lead attachment with a solid plug of solder.

a. As a minimum, solder plugs shall be required in:

(1) All electrically functional and nonfunctional plated through-holes with a lead; the lead is required to be surrounded 360° by the solder plug throughout the length of the plated through-hole no matter what technique for soldering is used.

(2) Any plated through-hole without a lead that is subject to wave or dip soldering and not exempted by (3) or (4) below.

b. Solder plugs are not required in:

(1) Any unsupported hole without a lead.

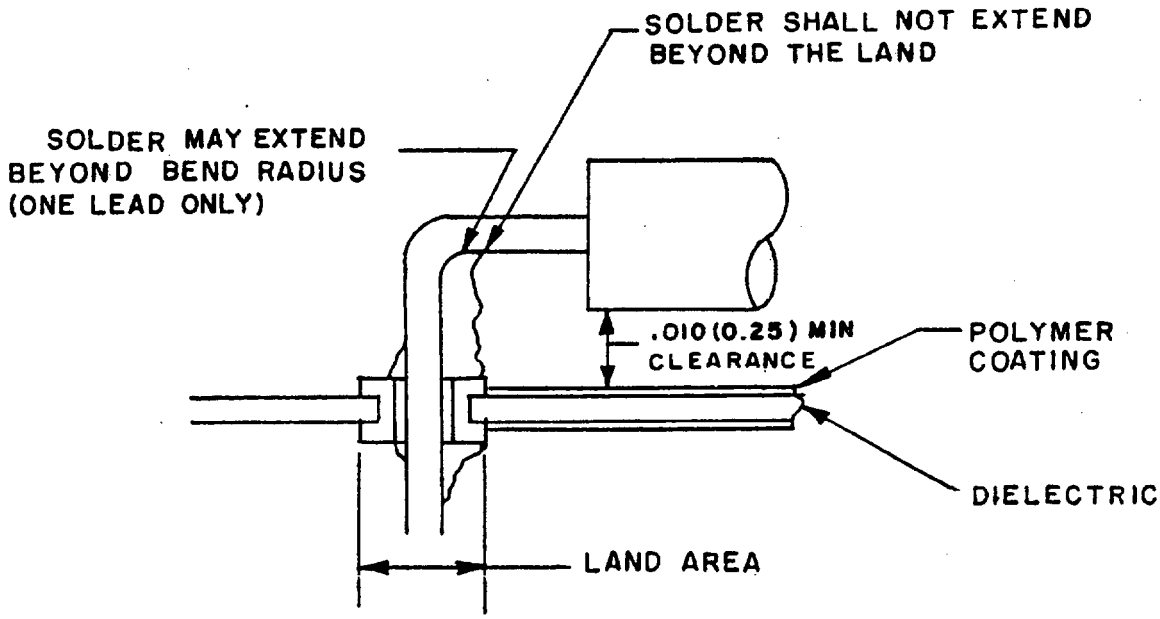
(2) Any electrically functional or nonfunctional plated through-hole (without a lead) when methods other than wave or dip soldering are used.

(3) Any plated through-hole covered with polymeric cover layer (not conformal coating) or previously filled with an appropriate polymer in order to prevent hole access during wave or dip soldering.

(4) Any plated through-hole, electrically functional or not, without a lead, where access to the hole is limited by component body, heat sinks, by-design (blind vias), and where access of solder to the hole is prevented during the solder process.

NOTE: In the event solder plugging due to natural capillary action is not possible such as when a heat sink is bonded directly over the plated through-hole, the assembly processor shall block these holes with some temporary technique that will prevent solder and flux access to the holes. Such techniques must have sufficient durability not to break up when exposed to the soldering process, yet be fully removable before the assembly is completed.

3.5.5.3 Solder fillets. Solder shall not extend beyond the land. Solder which extends into lead bend radius of horizontally mounted axial-leaded components is acceptable only into the lead bend radius on one lead of the component (the lead which is closest to the board (see figure 4)). The solder connection shall indicate evidence of wetting and adherence when the solder blends to the soldered surface, forming a small contact angle; this indicates the presence of a metallurgical bond and metallic continuity from solder to surface. Smooth clean voids or uneveness on the surface of the solder fillet or coating shall be acceptable. A smooth transition from land to connection surface or component lead shall be evident. The solder fillet should appear to be concave. The solder connection from a plated-through hole to a component lead may occur in the hole without exterior buildup provided that wetting of the wall and lead surface is evident. A line of demarcation or transition zone where applied solder blends with solder coating, solder plate, or other surfaces shall be acceptable providing that wetting is evident.



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

FIGURE 4. Solder in bend radius.

3.5.5.4 Post soldering cleaning. Each assembly shall be cleaned within 1 hour after application of soldering flux, using solvents or combinations of solvents, or other solutions which will remove polar and nonpolar contaminants. Subsequent handling should not contaminate the assembly prior to final cleaning and conformal coating.

3.5.5.5 Surface imperfections (printed wiring boards). After soldering and cleaning when inspected in accordance with 4.7.1, surface imperfections (such as haloing, scratches, pits, and dents) shall be acceptable providing the imperfection meets the following:

a. The laminate fiber is not cut or disturbed.

b. The minimum dielectric spacing is not violated.

c. Weave texture is allowable, providing there are not exposed fibers.

3.5.5.6 Subsurface imperfections (printed wiring boards). When inspected in accordance with 4.7.1, subsurface imperfections (such as haloing, blistering, and delaminating) shall be acceptable providing the imperfection meets the following:

a. Does not reduce conductor spacing below the minimum requirements of 3.5.3.3.3.

b. Does not propagate as a result of testing (such as bond strength, rework simulation, thermal stress, or thermal shock).

3.5.5.6.1 Foreign inclusions. Foreign inclusions shall be permitted when they are identified as nonconductive or are located at least 0.010 inch from the nearest conductor; if located between conductors and there is more than 50 percent space remaining; the longest dimension is no greater than .032 inch in noncircuitry areas; and there are no more than two inclusions per side of the printed circuit board.

3.5.5.6.2 Subsurface spots. Subsurface spots shall be permitted when they are known to be nonconductive; known to be weave texture other than delamination or measling; isolated white sports which are at least 0.010 inch from the nearest conductor; white spots which do not propagate as a result of any soldering operation (gelation particles are acceptable regardless of location); isolated black spots which are at least .010 inch from the nearest conductor.

3.5.5.6.3 Measling and crazing. After soldering, reflow, and cleaning processes have been completed, measling or crazing, or both, on the circuit card assembly shall not bridge more than 50 percent of the distance between electrical conductors and not exceed 3 percent of the total printed wiring board surface area on one side. A separate measurement and determination shall be made for each side of the circuit card assembly (see 4.7.1). If measling or crazing, or both, of any extent occurs on more than 10 percent of a circuit card assembly lot sample examined (see 4.6.1.2.2), the lot shall be rejected and corrective action shall be taken.

3.5.6 Lifted lands. When circuit card assemblies are inspected in accordance with 4.7.1, the maximum allowance of lifted land from the base material to the outer lower edge of the land shall be 0.003 inch (0.08 mm).

3.5.7 Prebake. Assemblies should be prebaked for a predetermined time prior to soldering operations at +105°C ±5°C (221°F ±9°F) to remove absorbed moisture. When the time interval between baking and soldering exceeds 8 hours, assemblies should be stored in a reduced moisture environment prior to soldering to minimize moisture reabsorption.

3.6 Conformal coating. Conformally coated circuit card assemblies furnished under this specification shall meet the requirements of this specification before and after repair (see 3.7). The coated assemblies shall have no blisters, cracking, crazing, peeling, wrinkles, mealing, or evidence or reversion or corrosion. A pin hole or bubble or a combination of pin hole(s) and bubbles(s) may bridge up to 50 percent of the distance between conductors, provided that the minimum dielectric spacing requirement is not violated. Solder mask shall not be considered as conformal coating. The conformal coating shall be compatible with all materials present on the assembly.

3.6.1 Coating area. Assemblies, except those using a board material of polytetrafluoroethylene shall be conformally coated with a coating material that conforms to 3.4.6. The coating shall be applied to both sides of the cleaned assembly, including part leads. Areas not to be conformally coated shall be defined on the assembly drawing.

3.6.2 Adjustable components. Assemblies having adjustable components shall not have the adjustable portion covered with coating, unless otherwise specified on the approved assembly drawing.

3.6.3 Mating surfaces. Electrical and mechanical mating surfaces, such as contacts, screw threads, etc., not to be coated, shall be specified on the assembly drawing.

3.6.4 Masking. The masking material used to prevent coating in unwanted areas shall have no deleterious effects on the assembly.

3.6.5 Cleaning agents. Cleaning agents and techniques shall have no deleterious effects on any part of the assembly.

3.6.5.1 Cleanliness. The assembly, just prior to conformal coating, shall be tested in accordance with 4.7.2. The test solution, after washing the uncoated assembly, shall have a resistivity of not less than 2,000,000 ohm-cm.

3.6.6 Thickness. The thickness of the conformal coating shall be as follows for the type specified, when measured on a flat unencumbered surface (see IPC-CC-830).

a. Types ER, UR, and AR: 0.003 ±0.002 inch (0.08 ±0.05 mm).

b. Type SR: 0.005 to ±0.003 inch (0.13 ±0.08 mm).

c. Type XY: 0.0005 to 0.002 inch (0.010 to 0.05 mm).

3.6.7 Electrical performance. Electrical testing shall be accomplished (see 6.1). If the assembly fails to pass the electrical tests, the defective parts and coating shall be removed and new parts added and recoated (see 3.7). The assembly shall then be retested.

3.6.8 Buffer material (see 3.4.12). Buffer material shall be as required on the approved assembly drawing.

3.7 Rework, repair, and modification. Rework, repair, and modification shall be accomplished as described in the following paragraphs. Assemblies reworked, repaired, or modified by these methods shall be processed as normal material.

3.7.1 Rework. Defective components may be replaced (see appendix). Solder touch up shall not exceed 3.0 percent of the solder joints on the assembly.

3.7.2 Repairs. Standard repairs (see 30.1.15) described by appendix (see 50.2) and authorized by appendix (see 10.2.1) may be performed within the limitation set forth. Such repairs shall be documented as specified in the appendix. Proposed methods of repair other than the standard repairs shall be submitted to the Government acquiring activity or delegated representative for approval. Approval for such repairs are applicable only to the contract under which the approval was granted.

3.7.3 Modifications. Modifications (see appendix, 50.1) may be made to prototype or production assemblies in accordance with the appendix. Modifications require written authorization (see 10.2.2) from the Government acquiring activity and shall be documented as specified in the appendix (see 40.4).

3.8 Circuit card assembly requirements. Upon completion of final assembly, the assemblies shall meet all visual, electrical, and all other operational requirements in accordance with the requirements of the approved assembly drawing(s) and test specifications.

3.8.1 Design envelope. When tested as specified in 4.7.3, all dimensions shall meet the requirements specified on the approved assembly drawing. Design envelope dimensions should include provisions for bow and twist.

3.8.2 Electrical parameters. When tested as specified in 4.7.4, assemblies shall function as specified on the approved assembly drawing.

3.8.3 Vibration (when specified, see 6.2). When tested as specified in 4.7.5, assemblies shall be capable of continuous operation as specified (see 3.8), and there shall be no evidence of physical damage.

3.8.4 Shock (when specified, see 6.2). When tested as specified in 4.7.6, assemblies shall be capable of continuous operation as specified (see 3.8), and there shall be no evidence of physical damage.

3.8.5 Thermal shock. After testing as specified in 4.7.7, assemblies shall be capable of operation as specified (see 3.8), and there shall be no evidence of physical damage.

3.8.6 Temperature-altitude (when specified, see 6.2). When tested as specified in 4.7.8, assemblies shall be capable of continuous operation as specified (see 3.8), and there shall be no evidence of physical damage.

3.8.7 Humidity. When tested as specified in 4.7.9, there shall be no evidence of corrosion on any component of the assembly. No crazing or measling (in excess of that allowed in 3.5.5.6.3), blistering, cracking, delamination, embrittlement, mealing, or softening shall become evident in the conformal coating or other constituent components and materials used in the assembly. The electrical performance of the assembly shall not be degraded (see 3.8).

3.8.8 Salt fog (when specified, (see 6.2). When tested as specified in 4.7.10, there shall be no evidence of corrosion on the assemblies.

3.8.9 Fungus. When tested as specified in 4.7.11, the materials or combination of materials used in the production of assemblies shall not serve as nutrients for fungi.

3.9 Marking. Circuit card assemblies shall be marked as specified on the approved assembly drawing(s) and MIL-STD-130, with the Commercial And Government Entity (CAGE) code. The marking may be produced by the same processes used in producing the conductive pattern; or by the use of a nonconductive, permanent fungistatic ink or paint, or by electrical pencil marking on a metallic area provided for marking purposes. All assemblies shall be serialized for traceability. The marking techniques are at the discretion of the contractor. Conductive marking shall not reduce the electrical spacing requirements of the circuit card assembly. All marking shall be compatible with materials, electrical components and parts. It shall be legible after all processing and testing and in no case affect assembly performance. The covering of markings used by the contractor for manufacturing aids shall not be cause for rejection. Traceability markings shall remain uncovered and legible.

3.10 Workmanship. Completed assemblies shall be clean; show no evidence of dirt, foreign matter, oil, corrosion, salts, flux residues, contaminants, and be free of defects as defined in 4.7.1.1.

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 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 the specification, where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must 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 assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.1.2 Test equipment and inspection facilities. Test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspection shall be established and maintained by the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-STD-45662.

4.1.3 Inspection conditions. Unless otherwise specified herein or in the individual specification, all measurements, tests and laboratories shall be at temperature of 15°C to 35°C (59°F to 95°F), air pressure of 85.0 to 105.0 kPa, and relative humidity of 45 percent to 75 percent. Whenever these conditions must be closely controlled in order to obtain reproducible results; for referee purposes, temperature, relative humidity, and atmospheric pressure conditions of 25°C +0°C, -2°C (77°F +0°F, -40°F), 50 percent ±2 percent, and 85.0 to 105.0 kPa, shall be specified.

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

a. Incoming component and materials inspection (see 4.3).

b. First article inspection (see 4.4.).

c. In-process inspection (see 4.5).

d. Quality conformance inspection (see 4.6).

4.3 Incoming component and materials inspection. Inspection shall, as a minimum, consist of certification supported by verifying data that the components and materials listed in table II, used in fabricating the assemblies, are in accordance with the applicable referenced documents, specifications, and requirements prior to such fabrication. Additional materials inspection shall be as specified in applicable engineering drawing(s), as specified in 3.4 through 3.4.12 and 4.3.1.

4.3.1 Solderability of component leads and wires. All component leads and wires of all electronic and electrical components to be soldered shall be inspected in accordance with 4.3.1.1 and shall meet the solderability requirements of IPC-S-805 or MIL-STD-202, method 208 (see table II).

4.3.1.1 Sampling plan for solderability test (see 4.3.1). Lot sampling shall be in accordance with MIL-STD-105, special inspection level S-4, with an AQL of 2.5. Samples for solderability test may be selected from components that failed to meet incoming electrical testing (see 3.8).

TABLE II. Component and materials inspection.

Component and materials	Requirement paragraph	Applicable specification
Printed wiring board	3.4.2 and 3.4.3	Master drawing and MIL-P-55110 or MIL-P-50884
Component lead and wire solderability	3.4.6 and 3.4.8	IPC-S-805 or MIL-STD-202, method 208 or assembly drawing
Incoming inspection	3.4.4	As specified on assembly drawings
Solder	3.4.9	QQ-S-571
Cored solder	3.4.9	QQ-S-571
Soldering flux	3.4.10	MIL-F-14256
Conformal coating	3.4.11	Assembly drawing IPC-CC-830
Buffer material	3.4.12	Assembly drawing

4.4 First article inspection. First article inspection shall be performed by the contractor at a location acceptable to the Government acquiring activity. First article inspection shall be performed on sample circuit card assemblies which have been produced with material, equipment, processes, and procedures which shall be used in production. Production is defined as one or more circuit card assemblies delivered on a contract. First article inspection is divided into two categories, design and type, as defined in 4.4.1.1 and 4.4.1.2. Minor modifications to design, production processes, or techniques do not necessarily require complete repetition of all first article design inspections. The extent of retest necessitated by such changes shall be determined by the contractor and approved by the Government acquiring activity. Where two or more circuit card assemblies are electrically direct wired (joined without the use of connectors) and mechanically packaged together to form a replaceable functional assembly, the electrical and environmental tests shall be performed at the assembly level. This level is normally identified as the lowest replaceable unit from the standpoint of equipment maintenance. First article approval is required and valid only on those contracts or purchase orders so designated by the Government acquiring activity concerned. Failure to pass the tests defined in table III per the sampling procedure shown in 4.4.1.1 and 4.4.1.2 shall necessitate corrective action to all assemblies that are to be delivered under the contract. Any corrective action requiring changes to the assembly procedure, design, process, etc. shall be reflected in the circuit card assembly drawing and must be approved by the Government acquiring activity.

4.4.1 Inspection routine. The first article inspection shall consist of the tests defined in table III and on the approved assembly drawing, contract, or purchase order.

TABLE III. First article inspection.

Test or inspection	Requirement paragraph	Method paragraph
Materials and parts	3.4 and see 1.2.1	4.3
Visual and mechanical examination, bow and twist, design envelope	3.5 to 3.6.8 (inclusive) and 3.8.1	4.7.1 to 4.7.3
Soldering	3.5.5	4.5.1
Cleaning agents	3.6.5	4.7.2
Electrical parameters	3.8.2	4.7.4
Vibration 1/	3.8.3	4.7.5
Shock 1/	3.8.4	4.7.6
Thermal shock	3.8.5	4.7.7
Temperature-altitude 1/	3.8.6	4.7.8
Humidity	3.8.7	4.7.9
Salt fog 1/	3.8.8	4.7.10
Fungus (separate sample) 1/	3.8.9	4.7.11

1/ When specified, the tests in table II must be conducted on the completed assemblies. Additionally, the contractor may wish to conduct certain of these tests at earlier stages of fabrication to ensure progress toward an acceptable assembly.

4.4.1.1 First article design inspection. One circuit card assembly of each new assembly design shall be subjected to the first article inspection in accordance with table III. Significant changes to existing designs may require additional design testing to assure design integrity is maintained. The contractor may wish to conduct certain of these tests at earlier stages of fabrication to ensure progress toward an acceptable assembly.

4.4.1.2 First article type inspection. Subsequent procurements of circuit card assemblies which have previously passed first article design inspection shall be submitted to first article type inspection. Circuit card assembly types are defined in 1.2.1. When type testing is to be performed, one circuit card assembly of each type, a representative of the most complex assembly of each type in a single contract, shall be selected by the contractor and agreed to by the Government representative. The assembly selected for type testing shall be the first component produced by the production process. This type representative shall be subjected to the first article inspection of table III.

4.4.2 Failures. When one or more samples fail to pass the first article inspection (see table III) this shall be cause for refusal to grant first article approval. Any corrective action requiring changes to the assembly design or materials shall be reflected in the assembly drawing and must be approved by the government acquiring activity.

4.4.3 Disposition of samples. Unless otherwise specified by the Government acquiring activity, sample assemblies, which have been subjected to and have passed first article inspection, shall be disposed of in accordance with the manufacturer's disposal procedures.

4.4.4 First article approval. Approval of the first article in no way relieves the contractor of responsibility for complying with all requirements of the specifications, applicable assembly drawings, and all other terms and conditions of the contract, nor shall an approved first article be construed as altering or taking precedence over any of these requirements.

4.5 In-process inspection. In-process inspection shall consist of the examinations of 4.5.1 and the test of 4.5.2 as shown in table IV. Inspection shall be performed by the contractor, at a location acceptable to the Government acquiring activity.

4.5.1 Soldered connections inspections. Each soldered connection on each circuit card assembly shall be visually inspected to the requirements of 3.5.5, using an optical apparatus or aid which provides a minimum magnification of 4X. If a defect is suspected, referee inspections may be accomplished at a magnification of up to 10X.

4.5.2 Inspection lot for cleanliness verification. An inspection lot for cleanliness verification shall consist of all circuit card assemblies processed through the cleaning process during a single 8-hour shift. Circuit card assemblies shall be cleaned prior to conformal coating. Cleanliness verification samples shall be subjected to the cleanliness and resistivity of solvent extract test just prior to conformal coating in accordance with one of the following sampling plans.

4.5.2.1 Lot sampling. Five circuit card assemblies per production shift selected at random.

4.5.2.2 Continuous sampling:

a. The first sample cleaned on each shift.

b. At least one sample from a shift for every 2 hours of operation during a shift.

c. The last assembly cleaned on each shift.

4.5.3 Failures. If one or more of the circuit card assemblies in an inspection lot fail to meet the cleanliness and resistivity of solvent extract test of table IV, the lot shall be rejected (see 4.5.4).

4.5.4 Rejected lots. When a lot is rejected as a result of a failure to pass the test specified in table IV, the manufacturer shall withdraw the lot, take corrective action in connection with the cleaning materials and procedures, reclean the lot, and resubmit the lot to the test of table IV. Such lots shall be separated from new lots and shall be clearly identified as reinspected lots.

TABLE IV. In-process inspection.

Test or inspection	Requirement paragraph	Method paragraph	Sampling plan
Visual of soldered connections	3.5.5	4.5.1	100 percent
Cleanliness and resistivity of solvent extract	3.6.5.1	4.7.2	4.5.2

4.6 Quality conformance inspection.

4.6.1 Inspection of circuit card assemblies for delivery. Inspection of assemblies for delivery shall consist of group A. Except as specified in 4.6.1.3.5, delivery of assemblies which have passed the group A inspection shall not be delayed pending the results of the group B inspection.

4.6.1.2 Group A inspection. Group A inspection shall consist of the inspections specified in table V. Inspection shall be performed by the contractor at a location acceptable to the Government acquiring activity.

4.6.1.2.1 Group A inspection lot. An inspection lot for group A inspection shall consist of circuit card assemblies on a specific contract using the same processing procedures, produced under essentially the same conditions, and offered for inspection at one time.

4.6.1.2.2 Sampling plan. Statistical sampling and inspection shall be in accordance with MIL-STD-105 for general inspection level II. The acceptable quality level (AQL) shall be as specified in table V. Major and minor defects shall be as defined in MIL-STD-105 and 4.7.1.1.

TABLE V. Group A inspection.

Test or inspection	Requirement paragraph	Method paragraph	AQL (percent defective)	
			Major	Minor
Visual and mechanical	3.5 to 3.6 inclusive, 3.8 through 3.10	4.7.1 4.7.1.1	1	4
Thermal shock	3.8.5	4.7.7	100 percent inspection	
Electrical parameters	3.8.2	4.7.4	100 percent inspection	

4.6.1.2.3 Rejected lots. If an inspection lot (see 4.6.1.2.1) is rejected, the manufacturer shall withdraw the lot and take corrective action, or screen out the defective units and reinspect. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

4.6.1.2.4 Disposition of sample units. Samples subjected to group A inspection may be delivered with the order if the inspection lot passes.

4.6.1.3 Group B inspection. When required on the contract or purchase order, group B inspection shall consist of the inspection specified in table VI. in the order shown, and other such tests specified on the approved assembly drawing. Inspection shall be performed at a location acceptable to the Government acquiring activity and when prescribed by contract or purchase order.

TABLE VI. Group B inspection.

Test or inspection	Requirement paragraph	Method paragraph
Thermal shock	3.8.5	4.7.7
Humidity	3.8.7	4.7.9
Electrical parameters	3.8.2	4.7.4

The tests in table VI must be conducted on the completed circuit card assemblies. Additionally, the contractor may wish to conduct certain of these tests at earlier stages of fabrication to ensure progress toward an acceptable assembly.

4.6.1.3.1 Group B inspection lot. An inspection lot for group B inspection shall consist of all circuit card assemblies of the same type (see 1.2.1) which have passed group A inspection. Board assemblies of the same type and fabricated to this specification may be grouped from different contracts to form a group B inspection lot.

4.6.1.3.2 Sampling plan. Once every 60 days, one circuit card assembly of each assembly type (see 1.2.1) representative of the most complex assembly of each type shall be selected by the contractor and agreed upon by the Government representative and subjected to tests in table VI. The assembly selected shall have passed group A inspection and may be from one or more contracts unless otherwise specified on the approved assembly drawing.

4.6.1.3.3 Failures. If one or more samples fail to pass group B inspection, the lot shall be considered to have failed.

4.6.1.3.4 Disposition of samples. Unless otherwise specified by the Government acquiring activity, sample assemblies which have been subjected to and have passed group B inspection shall be disposed of in accordance with the manufacturer's disposal procedures.

4.6.1.3.5 Noncompliance. If a sample fails to pass group B inspection, the manufacturer shall take corrective action on the materials or processes, or both, as warranted, and on all circuit card assemblies which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance of the circuit card assemblies shall be discontinued until corrective action acceptable to the Government has been taken. After the corrective action has been taken, the group B inspection shall be repeated on additional sample assemblies. Group A inspection may be reinstituted; however, final acceptance shall be withheld until the group B reinspection has shown that the corrective action was successful. In the event of failure, after reinspection, information concerning the failure and corrective action taken shall be furnished to the Government acquiring activity for those circuit card assemblies warranting corrective action.

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

4.7 Methods of examination and test.

4.7.1 Visual and dimensional examination. Completed assemblies shall be examined to verify that the materials, construction, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.4, 3.5, 3.6, 3.8, 3.9, and 3.10). Examination shall be accomplished utilizing an optical apparatus or aid which provides a minimum magnification of 4X. If a defect is suspected, referee inspections may be accomplished at a magnification of up to 10X.

4.7.1.1 Classification of defects. The classification of defects for visual and dimensional examination shall meet the intent of the categorization specified herein. A suggested coding system is indicated to allow the use of an automatic data processing system so that a particular coded number will be applicable only to a specific kind of defect. The letter "A" is for major defects and "B" for minor defects.

Defect code number	Major defects
A1	Wrong components used.
A2	Wrong printed wiring board used.
A3	Solder bridging between adjacent circuits, protrusions, or peaks that reduce the distance between an element of one circuit and an adjacent circuit or conducting material below the minimum specified on the printed wiring board assembly drawing.
A4	Features, conductor patterns, interfacial connections, jumpers, and components not in accordance with the assembly drawing or approved drawing referenced therein.
A5	Corrosion on the metal surfaces.
A6	Printed wiring conductors loose or missing.
A7	Components mounted in the wrong locations on the board.
A8	Wrong orientation of polarized components.
A9	Misalignment of lead wires with respect to land areas (see 3.5.3.4).
A10	Jumper wires not as specified on the assembly drawing.
A11	Jumper wires that terminate at locations other than terminal areas.
A12	Component leads used as jumper wires.
A13	Jumper wires routed over or under components.
A14	Inadequate spacing between uninsulated jumper wires or lead wires and adjacent conductors.
A15	Absence of insulation sleeving on jumper wires, when specified (see 3.5.3.10).
A16	Poor wetting of solder to the basis metal, as evidenced by convex fillets, nonwetting and dewetting (in excess of that allowed in IPC-S-815), cold joints, rosin joints, etc.
A17	Cracked solder joints, as evidenced by cracks or other discontinuities.
A18	Excess solder on joints.
A19	Insufficient solder on joints.
A20	Welds not in compliance with the assembly drawing.
A21	Bow and twist in excess of that permitted by the assembly drawing.
A22	Inadequate cleanliness of the circuit card assembly as evidenced by the presence of dirt, foreign matter, oil, corrosion, salts, flux residues, and contaminants.
A23	Measling in excess of that allowed in 3.5.5.6.3.
A24	Conformal coating containing bubbles or pin holes in excess of that allowed in 3.6.
A25	Conformal coating exhibiting blisters, cracking, crazing, mealing, peeling, wrinkles, or reversion.
A26	Unauthorized repair.
A27	Circuit card assemblies that are charred, burned, blistered, chipped, gouged, delaminated, or otherwise damaged.
A28	Identification markings illegible or missing from the circuit card assembly.
A29	Incorrect identification marking on the circuit card assembly.
A30	Leakage from oil-impregnated or electrolytic components.
A31	Physical damage to components resulting from the straightening, cutting, bending, inserting, or clinching of wire leads.
A32	Chipped, cracked, or broken components.
A33	Wire leads which have been broken or nicked exposing base metal.
A34	Loose components not securely attached or supported on the board.
A35	Deformation of lead diameter greater than 10 percent.

Defect code number	Major defects
A36	Electrically functional plated through-hole with a lead, without solder plug.
A37	Greater than 2 percent of all plated thorugh-holes (electrically functional or not, without a lead) that are subjected to wave or dip soldering without a solder plug.
A38	More than one solder ball in a 1 square inch area.
A39	Any voids or pin holes in solder joints of surface mounted components which expose basis metal.
A40	Any solder ball which violates electrical clearances.
A41	Any solder ball .005 inch or greater in diameter.
A42	Any voids or pin holes in solder joints which expose basis metal.
B1	Component polarity markings illegible (except as permitted for automatic insertion and lead forming equipment).
B2	Component identification markings illegible (except as permitted for automatic insertion and lead forming equipment).
B3	Thickness of conformal coating not within specified limits.
B4	Inadequate coverage of conformal coating on the printed wiring assembly.
B5	Solder on component side of single-sided boards.
B6	Solder on surfaces designated to be free of solder.
B7	Holes in the board which are not specified on the assembly drawing or master drawing referenced therein.

4.7.2 Cleanliness (see 3.6.5.1).

4.7.2.1 Ionic or resistivity of solvent extract. Circuit card assemblies shall be tested in accordance with method 2.3.26 of IPC-TM-650. Other methods shall have prior approval of the acquiring activity.

4.7.3 Design envelope (see 3.8.1). Completed circuit card assemblies shall be tested as specified in 4.7.1.

4.7.4 Electrical parameters (see 3.8.2). Completed circuit card assemblies shall be tested as specified on the assembly drawing.

4.7.5 Vibration (see 3.8.3). Completed circuit card assemblies shall be tested in accordance with method 514, procedure 1, of MIL-STD-810 with the following details:

a. Curve: E, unless otherwise specified (see 6.2).

b. Fixture: Hard mount.

c. Test procedures: The accelerometer shall be mounted at the center of the unit. The "g" input to the board shall be reduced so that the maximum unit output, at the center of the board, does not exceed 100 g's.

d. Electrical tests: Unless otherwise specified (see 6.2), the electrical tests shall be conducted as specified in 4.7.4 after the vibration test.

4.7.6 Shock (see 3.8.4). Completed circuit card assemblies shall be tested in accordance with method 516, procedure 1, of MIL-STD-810 with the following details:

a. Shock pulse: Half sine, 6.5 ±0.1 ms; 100 g's, unless otherwise specified (see 6.2).

b. Fixture: Hard mount.

c. Electrical tests: Unless otherwise specified (see 6.2), the electrical tests shall be conducted as specified in 4.7.4 after the shock test.

4.7.7 Thermal shock (see 3.8.5). Completed circuit card assemblies shall be tested in accordance with method 107, test condition A-3, of MIL-STD-202.

4.7.8 Temperature-altitude (see 3.8.6). Completed circuit card assemblies shall be tested in accordance with method 504 of MIL-STD-810. Temperature and altitude shall be as specified in the assembly drawing (see 6.2).

4.7.9 Humidity (see 3.8.7). Completed circuit card assemblies shall be tested in accordance with method 507, procedure 1, of MIL-STD-810.

4.7.10 Salt fog (see 3.8.8). Completed circuit card assemblies shall be tested in accordance with method 509, procedure 1, of MIL-STD-810.

4.7.11 Fungus (see 3.8.9). Completed circuit card assemblies shall be tested in accordance with method 508, procedure 1, of MIL-STD-810. Documentation or data stating materials conformance with method 508 will suffice.

5. PACKAGING

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

5.1.1 Leve A.

5.1.1.1 Cleaning. Circuit card assemblies shall be cleaned in accordance with MIL-P-116, process C-1.

5.1.1.2 Drying. Circuit card assemblies shall be dried in accordance with MIL-P-116.

5.1.1.3 Preservative application. Preservatives shall not be used.

5.1.1.4 Unit packs. Each circuit card assembly shall be individually unit packed in accordance with submethod IA-8 of MIL-P-116 ensuring compliance with the applicable requirements of that specification. Cushioning shall be as specified in 5.4.1. The unit container (the bag or envelope) shall conform 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. Each assembly exceeding 5 inches (12.7 centimeters) in any dimension shall be placed in a supplementary container conforming to variety 2 of PPP-B-566 or PPP-B-636, class weather resistant.

5.1.1.5 Intermediate packs. Circuit card assemblies, unit packed as specified in 5.1.1.4, shall be placed in intermediate containers conforming to variety 2 of PPP-B-566, or variety 2 of PPP-B-676 or class weather resistant of PPP-B-636. Intermediate containers shall be uniform in size, shape, and quantities, shall be of minimum tare and cube, and shall contain multiples of 5 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 circuit card assemblies 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 circuit card assemblies 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 supplier.

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

5.2.1 Level A. Circuit card assemblies, 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 1 cubic foot (0.0283 cubic meter).

5.2.2 Level B. Circuit card assemblies, 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. Circuit card assemblies, 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.

5.2.4 Unitized loads. Unitized loads, commensurate with the level of packing specified in the contract or order, shall be used whenever total quantities for shipment to one destination equal 40 cubic feet (1.1328 cubic meters) or more. Quantities less than 40 cubic feet need not be unitized. Unitized loads shall be uniform in size and quantities to the greatest extent practicable.

5.2.4.1 Level A. Circuit card assemblies, packed as specified in 5.2.1, shall be unitized on pallets in conformance with the MIL-STD-147, load type I, with a wood cap (storage aid 5) positioned over each load.

5.2.4.2 Level B. Circuit card assemblies, packed as specified in 5.2.2, shall be unitized as specified in 5.2.4.1 except that weather resistant fiberboard caps (storage aid 4) shall be used in lieu of wood caps.

5.2.4.3 Level C. Circuit card assemblies, packed as specified in 5.2.3, shall be unitized as specified in 5.2.4.2 except that the fiberboard caps shall be class domestic.

5.3 Marking. The following marking is mandatory for shipments both to U.S. Government and non-Government activities.

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, and unitized load shall be marked in accordance with MIL-STD-129. The complete military or contractor's type or part number, as applicable (including the CAGE), 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 of type of packaging specified, all units, supplementary, intermediate, and exterior containers, and unitized loads shall be marked with the sensitive electronic device unit pack label and the sensitive electronic device caution label (as applicable) specified in MIL-STD-129.

5.4 General. The following general requirements apply, as applicable, to levels A, B, and C as well as to shipments to non-Government activities.

5.4.1 Wrapping and cushioning. Circuit card assemblies shall be wrapped and cushioned with materials conforming to PPP-C-795, class 2; PPP-C-1752, type VII, class 4; PPP-C-1797, type II; or PPP-C-1842, type III. For shipment to non-Government activities, cushioning materials shall be noncorrosive, nonstatic generating, and shall not crumble, flake, powder, or shed.

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

5.4.3 Packaging inspection. The inspection of these packaging requirements shall be in accordance with 4.6.2.

6. NOTES

6.1 Intended use.

6.1.1 Waiver of testing. The Government acquiring activity may wish to waive certain environmental tests based on testing the next higher assembly; however, the cleanliness test and electrical tests should not be waived. Relying solely on tests at the next higher assembly may result in inadequate or unproven documentation for acquisition of replacement items. This consideration should be made prior to request for quote.

6.1.2 Packaging requirements. The preservation, packing, and marking herein are intended for direct shipments to the Government. Unless otherwise designated, the marking requirements (see 5.3) and general requirements (see 5.4) are applicable for the preparation of these circuit card assemblies for shipment from the parts manufacturer to non-Government activities.

6.2 Ordering data. The acquisition document should specify the following:

a. Title, number, and date of this specification.

b. Type of circuit card assembly required (see 1.2.1).

c. Title, number, and date of applicable assembly drawing (see 3.1).

d. Environmental tests and electrical tests which may be deferred to testing of the next higher assembly (see 3.1 and 6.1).

e. Continuous electrical operation during vibration, if required (see 3.8.3).

f. Shock force, if other than specified (see 3.8.4).

g. Continuous electrical operation during shock, if required (see 3.8.4).

h. Thermal shock test condition required (see 3.8.5).

i. Temperature-altitude, if required (normally for airborne applications only) (see 3.8.6).

j. Salt fog, if required (see 3.8.8).

k. Delivery of first article samples (see 4.4).

l. Whether or not group B inspection is to be performed (see 4.6.1.3).

m. Disposition of group B samples (see 4.6.1.3.4).

n. Vibration frequency, if other than specified; maximum size of accelerometer, where critical; normal mounting means where used in lieu of the hard mounting specified (see 4.7.5).

o. Levels of preservation and packing required (see 5.1 and 5.2).

p. Quantity per unit pack, if other than supplier's option (see 5.1.3).

q. If special or additional identification marking is required (see 5.3).

6.3 First article inspection. Information pertaining to first article inspection of products covered by this specification should be obtained from the acquiring activity for the specific contracts involved.

6.4 Flux removal. Selection of procedures for flux removal is at the contractor's discretion. A procedure must be chosen which will enable the circuit card assembly fabricator to produce results enabling compliance with 3.5.5.3. Both polar and nonpolar solvents may be required to effect adequate flux removal.

6.5 Condition for use of level B preservation. When level B preservation is specified (see 5.1.2), this degree of protection should be used for acquisition of circuit card assemblies for resupply worldwide under known favorable handling, transportation, and storage conditions.

6.6 Ultrasonic cleaning. Ultrasonic cleaning may damage certain components, particularly integrated circuits and semiconductors, and should not be used where these parts are present.

6.7 Handling of circuit card assemblies. The prevent damage from environmental field forces (electrostatic, electromagnetic, or radioactive), these assemblies should be carefully handled in accordance with manufacturer's instructions. For example, individuals should be grounded prior to touching or handling assemblies containing sensitive electronic devices (e.g., microcircuits and certain semiconductors and resistors).

6.8 Solderability. During soldering operations, particularly when 500°F (260°C) is exceeded, components utilizing solder seals or internal solder during manufacturing may suffer internal damage unless a thermal barrier is employed.

6.9 Changes from previous issue. Asterisks are not used in this revision to denote changes with respect to the previous issue, due to the extensiveness of the changes.

6.10 Subject term (key word) listing).

a. Assemblies.

b. Clinched wires.

c. Component mounting.

d. Conformal coating.

e. Jumper wires.

f. Modifications.

g. Circuit card assemblies.

h. Repair.

i. Rework.

APPENDIX

REPAIR AND MODIFICATION OF CIRCUIT CARD ASSEMBLIES

10. SCOPE

10.1 Scope. This appendix establishes requirements for the repair and modification of circuit card assemblies produced in accordance with this specification. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance only.

10.2 Authorization.

10.2.1 Repair authorization. Standard repairs (see 30.1.16 and 50.2) covered by this appendix may be used when the contractor has Material Review Board (MRB) delegation on the contract. Authorization for these standard repairs shall be individually authorized by the contractor's material review procedure, with concurrence by the cognizant Government representative. Alternately, the contractor may request authorization to perform standard repairs using in-house control systems other than MRB action. These alternate methods require approval of the Government acquiring activity and must demonstrate that standard repairs are documented and that there is traceability to the assemblies to which the repairs are applied. Repairs other than the standard repairs contained herein require written authorization of the Government acquiring activity or delegated Government representative. Authorization of other repairs is applicable only to the contract under which the repair authorization was granted.

10.2.2 Modification authorization.

10.2.2.1 Prototype modification authorization. Modification of prototype assemblies may be performed by the contractor when the details of the modification are determined and defined in sufficient detail, acceptable to the Government acquiring activity, to assure adequate documentation of the modification(s). Details of the modifications shall be added to the design package and shall be submitted to the Government acquiring activity for post incorporation review. Prototype modifications which are to be incorporated in the production articles shall be incorporated into the design prior to the start of production.

10.2.2.2 Production modification. Modification of production circuit card assemblies requires written authorization of the Government acquiring activity. Documentation of modifications shall be as specified herein (see 40.4). Modification authorizations are limited to the contract under which the authorization was granted, until the printed wiring master drawing or the assembly drawing, or both, has been changed and approved to reflect the modification.

20. APPLICABLE DOCUMENTS

20.1 Government documents.

20.1.1 Specification and standard. Unless otherwise specified, the following specification and standard, of the issue listed in that issue of the Department of Defense Index of Specifications and Standards specified in the solicitation, form a part of this appendix to the extent specified herein.

APPENDIX

SPECIFICATION

MILITARY

MIL-I-22129 - Insulation Tubing, Electrical, Polytetrafluoroethyene Resin, Nonrigid.

STANDARD

MILITARY

DOD-STD-100 - Engineering Drawing Practices.

(Copies of the specification and standard required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

20.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the non-Government documents which is current on the date of the solicitation.

INSTITUTE FOR INTERCONNECTING AND PACKAGING ELECTRONIC CIRCUITS

IPC-SM-840 - Qualification and Performance of Permanent Polymer Coating (Solder Mask) for Printed Boards.

(Application for copies should be addressed to IPC, 7380 North Lincoln Avenue, Lincolnwood, IL 60646).

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

30. DEFINITIONS

30.1 Terms and definitions. The definitions of all terms used herein shall be as specified in ANSI/IPC-T-50 and the following.

30.1.1 Approved assembly drawing. An assembly drawing that has been authorized and approved by the acquiring activity or an authorized representative.

30.1.2 Automated component insertion. Automated component insertion is the act or operation of assembling individual components to printed boards by means of computer-controlled component-insertion equipment.

30.1.3 Buffer material. A resilient material which is used to protect crack-sensitive components from excessive stresses generated by the conformal coating.

30.1.4 Circuit card assembly. A circuit card assembly is a group of two or more physically connected or electrically/electronically related components, which are capable of being disassembled. Each component of the assembly must be capable of functioning in accordance with its own item name. Consists of a printed-wiring board upon which are mounted separately manufactured electronic components, such as capacitors, inductors, resistors, and the like. It may also include printed electronic components.

30.1.5 Component mounting. Component mounting is the act of mechanically attaching the component to the printed board, or the manner in which they are attached, or both.

30.1.6 Component orientation. Component orientation is the direction in which the components, on a printed board or other assembly, are lined-up physically with respect to the polarity of polarized components and also with respect to one another and to the board.

30.1.7 Hard wiring. Hard wiring is electrical wiring that interconnects two or more components or assemblies into an assembly which is inseparable without the use of special tools and techniques.

30.1.8 J-lead. (See figure 5).

30.1.9 LCC. Leadless chip carrier.

30.1.10 Leadless component or chip carrier.

30.1.11 PLCC. Plastic leadless chip carrier.

30.1.12 Ribbon lead. (See figures 5 and 6).

30.1.13 SOIC. Small outline integrated circuit.

30.1.14 SOT. Small outline transistor.

30.1.15 Standard repairs. Standard repairs are those repair techniques described by this specification, not exeeding the numerical limits set.

30.1.16 Standoff terminal. A standoff terminal is a terminal generally postlike, having an axial portion of its body designed for projecting through or into a board for mounting (see figure 7).

40. GENERAL

40.1 Quality. Limited repair or modification of assemblies may be necessary in the interest of economy or delivery. It is essential that such repairs and modifications be accomplished in a manner which will not degrade the quality of the products.

40.2 Performance. Repaired or modified assemblies shall meet the performance requirements and quality assurance provisions of this specification.

40.3 Spacings. Repair shall not reduce circuitry spacing below that provided by design. The cross-sectional area of wires, leads, or copper strips shall be equal to or larger than the replaced conductor.

40.4 Documentation of modification. Documentation of modification on prototypes and assemblies under production shall be as specified herein.

40.4.1 Documentation of prototypes. Details of the modification to a prototype of a circuit card assembly shall be prepared and added to the engineering drawings and data design package.

40.4.2 Documentation of production. Upon approval from the Government acquiring activity of a modification change, the assembly fabricator shall take the appropriate action to reflect the approved change and production will continue on the next assemblies. At all times, the engineering drawings and data package shall be kept updated with documentation to reflect modified or unmodified assemblies and their approved changes. Part numbers shall be changed if the modified and unmodified assemblies changed in such a manner that any of the conditions of DOD-STD-100 requiring new identification occur. Re-identification marking may be manually marked.

40.5 Cleanliness. Coated and uncoated, modified or repaired circuit card assemblies shall be free of flux, flux residues, and other contaminants prior to the application of conformal coating (see 40.6.2.1). The Government reserves the right to require confirmation that all coated and uncoated, modified or repaired circuit card assemblies were inspected for flux residues after modification or repair.

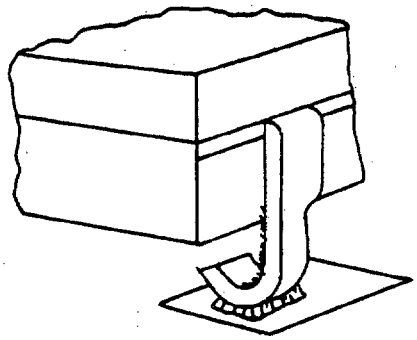


FIGURE 5. J-lead (form of ribbon lead).

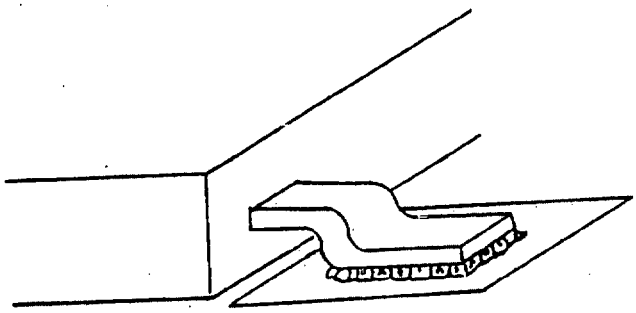


FIGURE 6. Z-lead (form of ribbon lead).

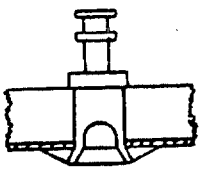


FIGURE 7. Standoff terminal.

40.6 Materials. Materials used in modification and rework shall be as specified herein or on the assembly drawing.

40.6.1 Solder. The solder used shall be in accordance with composition Sn 60, Sn 62 or Sn 63 of QQ-S-571.

40.6.2 Soldering flux. Soldering flux shall be a liquid flux conforming to MIL-F-14256, type R, RMA. Water soluble fluxes shall not be allowed for soldering.

40.6.2.1 Flux removal. Selection of procedures for flux removal is at the contractor's discretion. A procedure shall be chosen which will enable the circuit card assembly to be in compliance with 40.5. Both polar and nonpolar solvents may be required to effect adequate flux removal. The procedure chosen should not degrade markings, components, or board materials.

40.6.3 Adhesive. Structural adhesive shall be as specified on the approved assembly drawing or approved standard repair procedure. Conformal coating shall not be relied upon in place of adhesive.

40.6.4 Conformal coating. Conformal coating shall be type UR, ER, AR, SR, or XY in accordance with IPC-CC-830. The thickness of the conformal coating shall be as follows for the type specified. Measurement shall be on a flat unencumbered surface (see IPC-CC-830 or MIL-I-46058). Coating thickness in any areas of overlap may be within twice the specified coating thickness. Conformal coating used for repairs shall be compatible with the original conformal coating.

a. Types ER, UR, and AR: 0.003 ±0.001 inch (0.08 ±.02 mm).

b. Type SR: 0.005 ±0.003 inch (0.13 ±.08 mm).

c. Type XY: 0.0005 to 0.002 inch (0.013 ±.05 mm).

40.6.4.1 Removal of conformal coating. The removal of the conformal coating for repair shall be by a method which does not degrade components located near the affected area (e.g., electrostatic discharge).

40.6.4.2 Solder mask removal. The removal of solder mask for repair shall be by a method which does not degrade components located near the affected area (e.g., electrostatic discharge). The repair shall meet the requirements of IPC-SM-840 or, conformal coat may be substituted for solder mask after the assembly has been flow soldered.

40.6.5 Hook-up wire. Hook-up wire for added wires shall be as follows:

a. Solid copper conductor, solderable, with a compatible jacket.

b. Copper wire, in accordance with QQ-W-343, soft or drawn and annealed.

40.6.6 Insulation tubing. Polytetrafluorethylene tubing used for insulating hook-up wires shall be in accordance with MIL-I-22129, etched for bonding.

40.7 Coating area. Repaired circuitry shall be covered with epoxy adhesive or conformal coating for a minimum of 0.030 inch beyond the end of the repair area except in special areas (e.g., printed edgeboard contacts, etc.) where the assembly drawing specifies that these areas be exposed. The conformal coating shall be a material that conforms to 40.6.4.

40.8 Component replacement. Repairs shall be made so that components may be replaced without damaging the repaired area.

40.9 Workmanship. Modified or repaired circuit card assemblies shall be clean and free of dirt, foreign matter, oil, fingerprints, corrosion, salts, flux residues, and other contaminants, and meet the requirements of this specification.

40.10 Unassembled boards. The repair of unassembled (bare) printed wiring boards shall not be permitted.

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40.11 Soldering. Soldering shall be in accordance with IPC-S-815 or DOD-STD-2000/1 through DOD-STD-2000/4. Solder shall not be used on surfaces specified to be free of solder. Solder and flux shall be in accordance with 40.6.1 and 40.6.2.

50. DETAIL REQUIREMENTS

50.1 Standard modification.

50.1.1 Conductor removal.

50.1.1.1 Minimum removal. Unless otherwise limited by design constraints, a minimum of the width of the conductor shall be removed where the circuit is to be interrupted (see figure 8).

50.1.1.2 Circuit junctions. Unless otherwise limited by design constraints, conductors shall not be cut or removed within 0.010 inch of land areas or circuit junctions (see figure 8), where conductors are 0.010 inch in width. For conductors equal to or less than 0.010 inch, a minimum of 0.005 inch is required.

50.1.1.3 After removal. The area under the circuits removed shall be inspected to assure that all traces of conductor are removed. The glass cloth fibers shall not be exposed. This area shall then be covered with epoxy adhesive or approved conformal coating (see 40.6.4).

50.1.2 Added wires.

50.1.2.1 Insulation and sleeving. All added wires greater than 0.50 inch in length shall be insulated or sleeved. Jumper wires added for repair or modification shall be red in color.

50.1.2.2 Number of attachments. Wires should be coated or insulated to meet the design requirements. Wires should be routed in the X-Y direction. A maximum of two wires or leads may be attached to any termination except:

a. Wires or leads shall be attached to any flat pack lead in accordance with figures 9 and 10.

b. When wires or leads are to be attached to DIP type components, terminations shall be made in accordance with figure 11.

c. No more than one wire shall be added to each connector tang and shall be attached in accordance with figure 12.

d. When large standoff terminals are used which have provision for additional attachments.

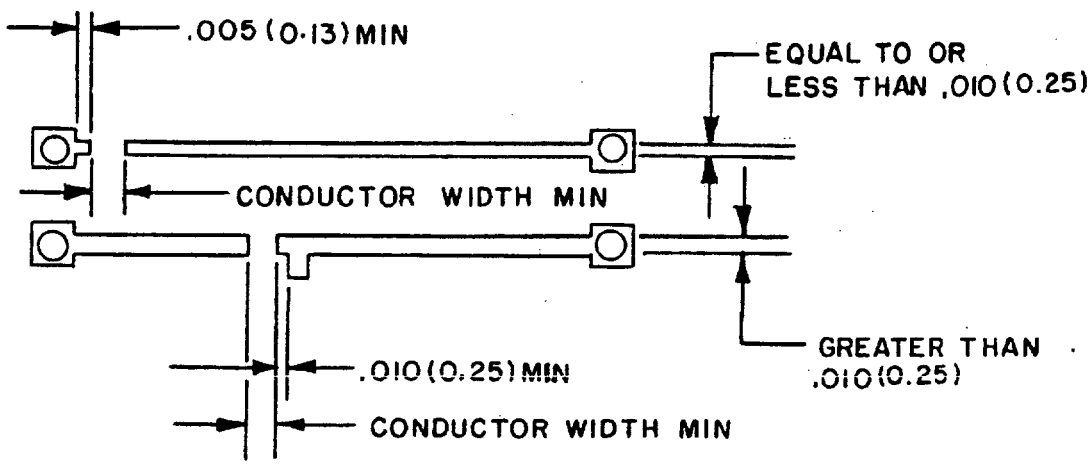
e. No wires shall be attached to the mating contact surfaces of connectors.

f. Modifications of internal circuits shall not be permitted.

g. Total maximum number of circuit changes of all types permitted per board shall be in accordance with table VIII.

TABLE VIII. Total number of circuit changes of all types permitted.

Board size (x)	Maximum number allowed
Square inches	
$x < 20$	6
$20 \leq x < 50$	12
$50 \leq x < 100$	18
$100 \leq x$	24



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

FIGURE 8. Removal of conductors.

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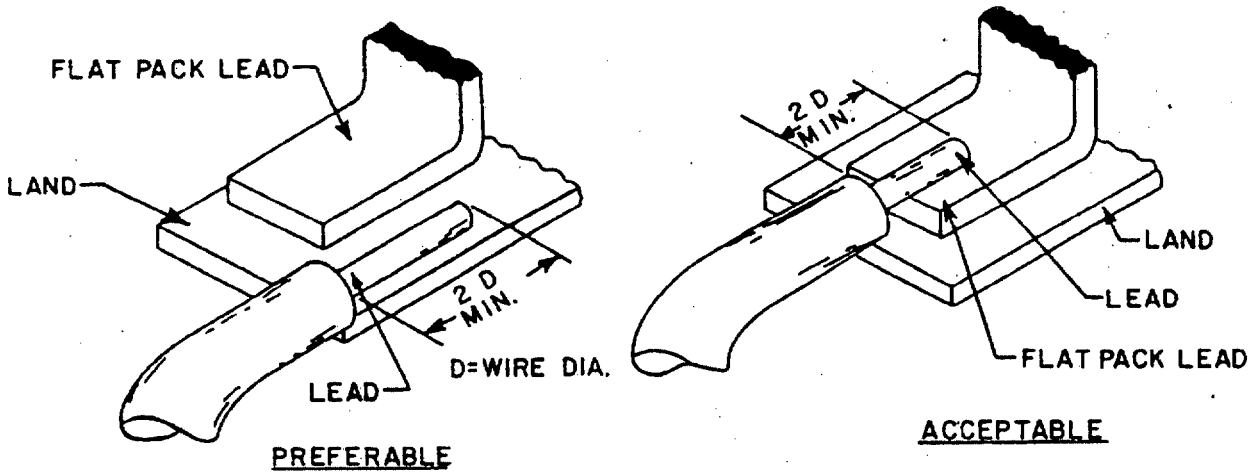


FIGURE 9. Flat pack (one wire or lead attached).

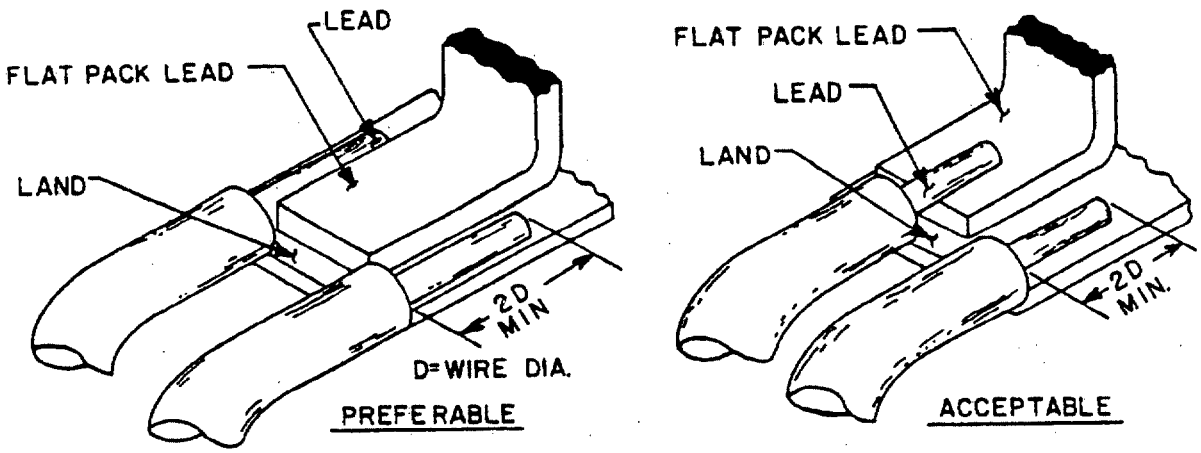
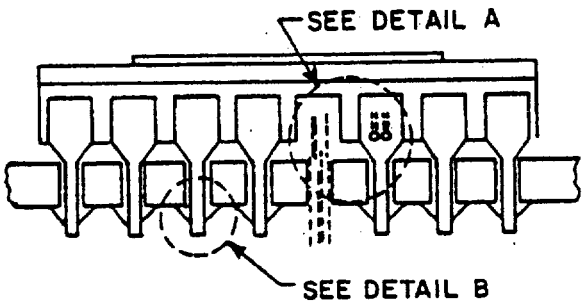
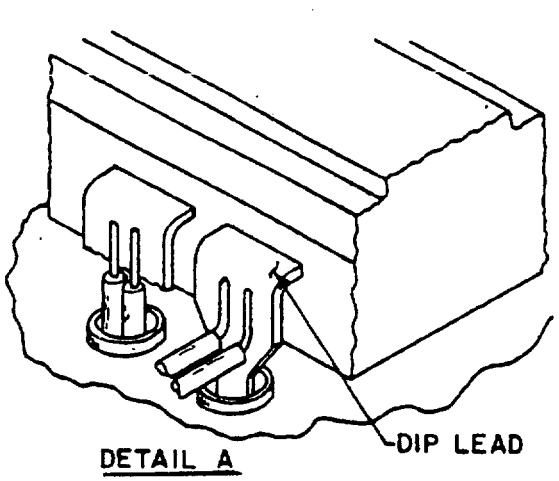


FIGURE 10. Flat pack (2 wires or leads attached).





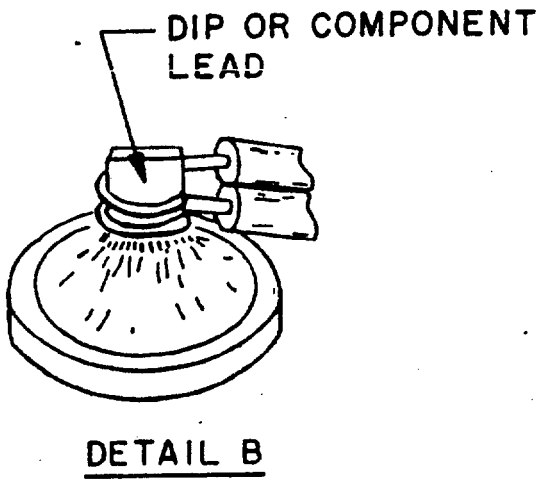


FIGURE 11. Dip type component.

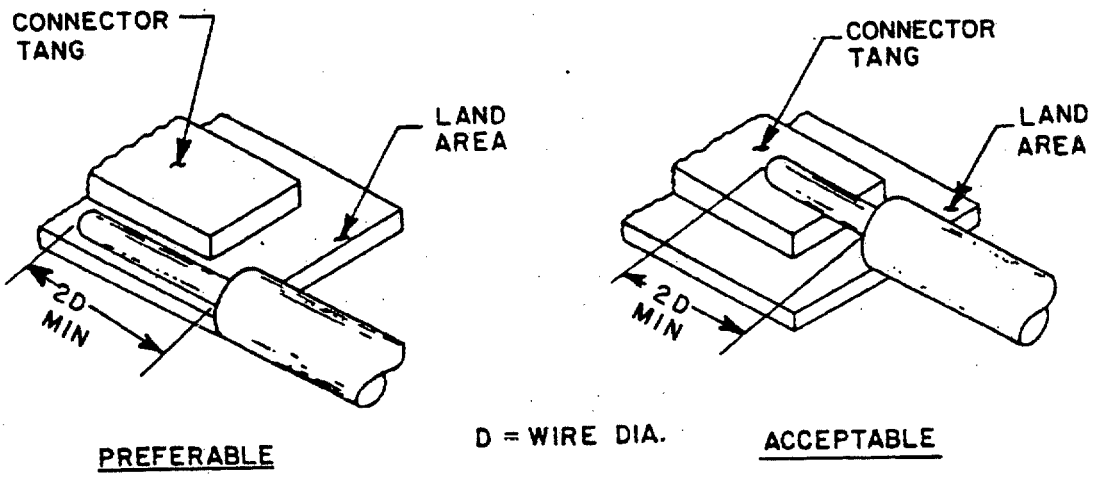


FIGURE 12. Connector tang.

50.1.2.3 Routing. Wires should be routed in the X and Y directions, by the shortest practical route and minimizing wire crossings unless otherwise specified by the revision. Added wires shall not cover plated-through component mounting holes. Wire routings on boards having the same component number shall be routed the same.

50.1.2.4 Preferred termination. Wires shall be connected at a point where heating to remove an adjacent component will not cause the wire to become unsoldered. Unused through-holes are the preferred termination for wires.

50.1.2.5 Land area distance. Unless otherwise limited by design constraints, when wires are soldered directly to the conductor there shall be a minimum distance of 0.050 inch from the land area (see figure 13).

50.1.2.6 Wire diameter. The diameter of the wire soldered directly to a conductor path shall not exceed the width of the conductor path and shall be positioned, where possible, as shown on figure 13 and in such a manner that the minimum electrical spacing is maintained. The wire shall contact the conductor path a minimum of two wire diameters at each end (see 40.3).

50.1.2.7 Securing of wires. Wires shall be secured to the board except where they pass through pin fields or where a 1 inch or shorter wire has ends terminated in accordance with 50.1.2.2.

50.1.2.8 Existing terminals. When wires or leads are added to existing terminals, they shall be attached above the conformally coated area or the conformal coating shall be removed prior to attachment.

50.1.2.9 Wires/insulations of leadless devices.

50.1.2.9.1 Castellations. For LCCs with castellations on 40 mil (or greater) centers, a maximum of two jumper wires shall be allowed to be attached to any single castellation.

50.1.2.9.2 Unoccupied component pad. A maximum of two jumper wires shall be allowed to be attached to any single unoccupied component pad.

50.1.2.9.3 Routing. Jumper wires shall be routed in the X and Y directions, and there shall be no kinks or nicks in wires.

50.1.2.9.4 Placement. Jumper wires shall be as short as practical, and shall not be applied over or under components.

50.1.2.9.5 Contact length. Jumper wire contact length shall be attached to an area no less than one-half of the metallized termination length/height of the component (see figure 14). Uninsulated jumper wires between adjacent castellations need not comply with this requirement, but shall comply with 50.1.2.9.10 and shall not be in contact with (or underneath) the surface mounted device (see figure 15).

50.1.2.9.6 Solder joints. If more than one jumper wire is to terminate in a single solder joint, the uninsulated portion of the wires may be twisted together tight enough to prevent relative movement between the wires.

50.1.2.9.7 Adhesives. Jumper wires shall be held rigidly in place by an adhesive compatible with the conformal coating wherever required to hold in position.

50.1.2.9.8 Insulation material. Isolation of an LCC castellation from a printed wiring board component pad shall be accomplished securing an insulation material between the LCC and the printed wiring board. The insulation material shall overlap on all sides the pad being isolated, and shall be thin enough so that no additional stresses are imposed on the remaining LCC solder joints.

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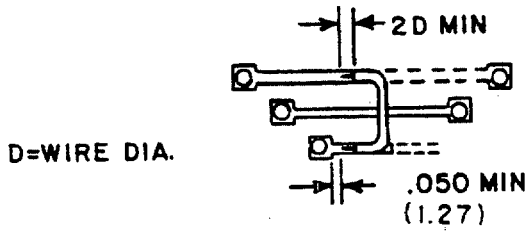


NOTES:
1. Dimensions are in inches.
2. Metric equivalents are for general information only.
3. Metric equivalents are in parentheses.

FIGURE 13. Wire position on circuits.

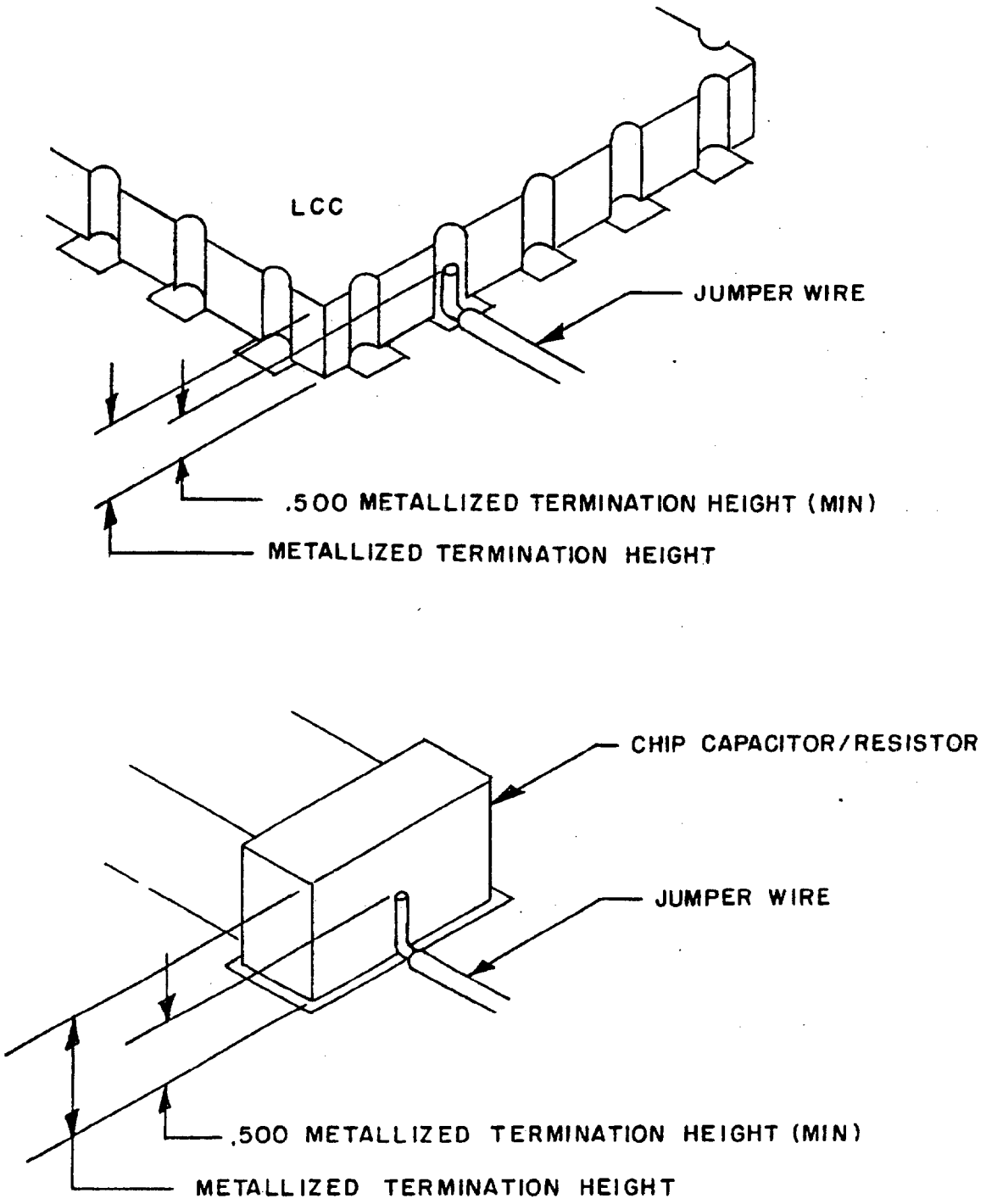


FIGURE 14. Jumper wire contact length/height to surface mounted devices.

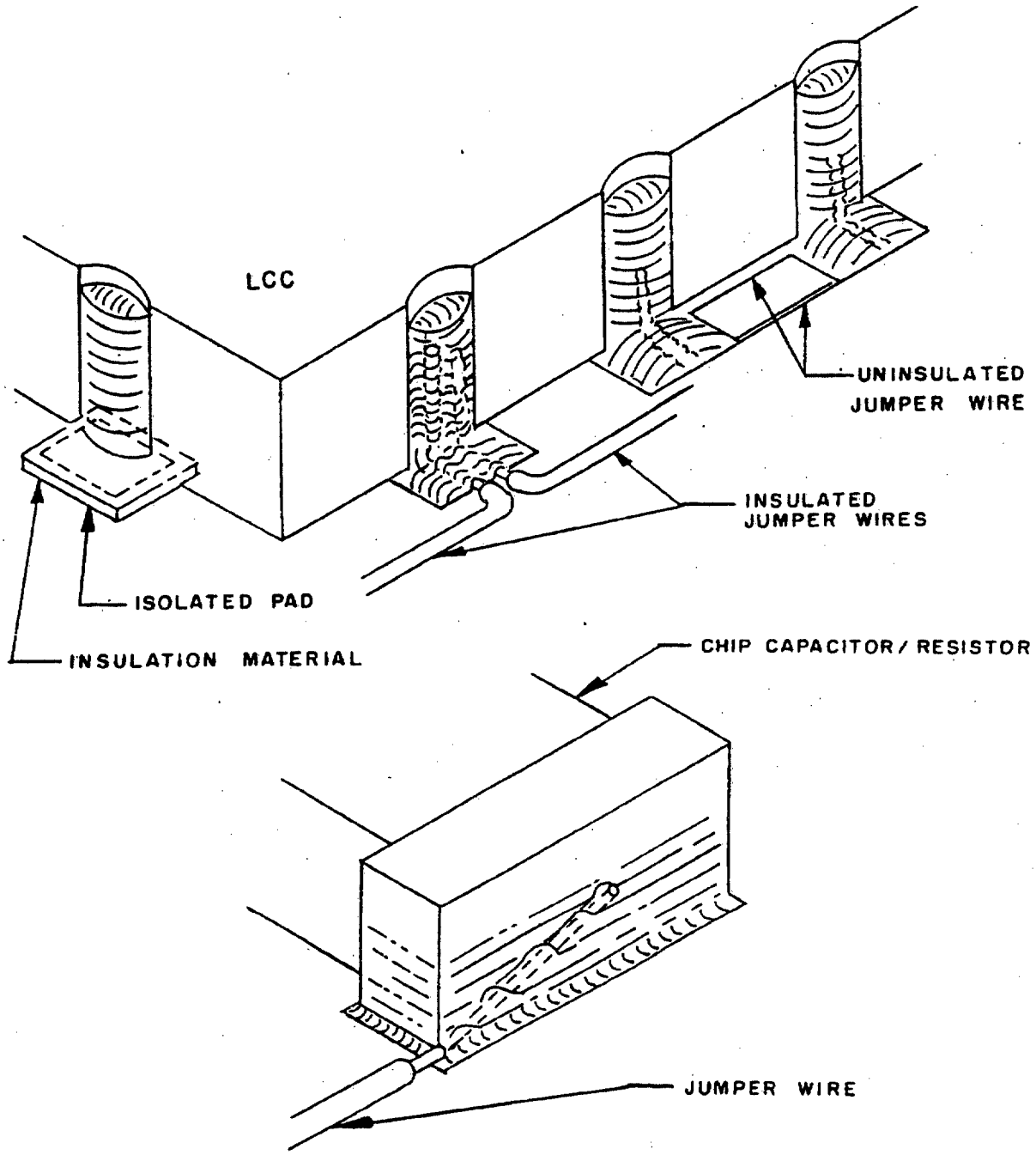


FIGURE 15. Portions of jumper wire contour visible in completed solder connection.

50.1.2.9.9 Insulation characteristics. Jumper wires greater than 0.50 inch (12.7 mm) in length shall be insulated in accordance with MIL-STD-454, requirement 20, and the insulation shall be compatible with the conformal coating used. The insulation shall not be loose from the wire diameter. Jagged insulation edges are permissible as they are inherent to the stripping process of these small diameter wires. Slight discoloration of the insulation resulting from thermal stripping is acceptable.

50.1.2.9.10 Contours. Jumper wire contour shall be visible at the entrance and exit points in the solder joint, or visible at the entrance point to the solder joint and the wire contour discernible through the solder in the contact area for the completed connection.

50.1.2.9.11 Conformal coating. All uninsulated jumper wire and reworked solder joints shall be covered with conformal coating. Conformal coating is not required to adhere to Kapton and Teflon coated wire insulation.

50.1.3 Added components.

50.1.3.1 Land area distance. When component leads are soldered directly to the conductor, there shall be a minimum clearance of 0.050 inch (1.27 mm) from a land area (see figure 13).

50.2 Standard repairs.

50.2.1 Land area.

50.2.1.1 Maximum permitted. The maximum number of land area repairs permitted per board shall be in accordance with table IX.

TABLE IX. Maximum number of land repairs.

Board size (x)	Maximum number allowed
Square inches	
$x < 20$	3
$20 \leq x < 50$	6
$50 \leq x < 100$	9
$100 \leq x$	12

50.2.1.2 Connecting land areas. Repair of both land areas on both sides of a hole which connects internal circuits is prohibited (see figure 16).

50.2.1.3 Lifted land areas. Any land which has been separated, loosened, lifted or which has otherwise become unbonded from the base material in excess of that specified in 3.5.6 may be repaired by rebonding with an approved adhesive (see 40.6.3).

50.2.1.4 Repair visibility. All repairs shall be visible after soldering. Repairs to land areas that will subsequently be covered by flush mounted components (transistors, transformers, etc.) shall be inspected prior to installation of said components.

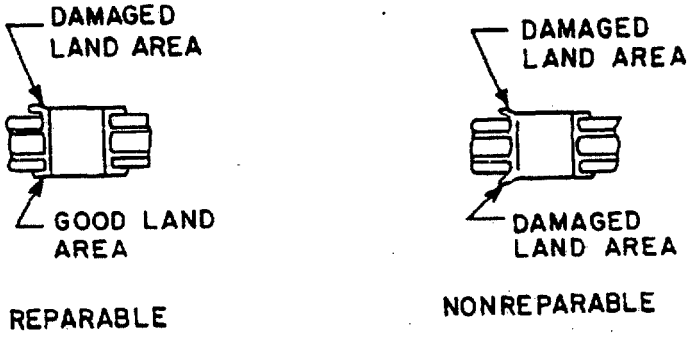


FIGURE 16. Repair limitations.

50.2.2 Conductor.

50.2.2.1 Maximum permitted. The maximum number of conductor repairs permitted per board shall be in accordance with table X.

TABLE X. Maximum number of conductor repairs.

Board size (x)	Maximum number allowed
Square inches	
$x < 20$	3
$20 \leq x < 50$	6
$50 \leq x < 100$	9
$100 \leq x$	12

50.2.2.2 Unbonded conductors. Unless otherwise limited by design constraints, unbonded conductors no more than 0.500 inch in length may be rebonded to the base laminate with approved adhesive material (see 40.6.3) extending a minimum of 0.030 inch beyond the lifted area in all directions.

50.2.2.3 Conductor breaks and defects. Unless otherwise prohibited by design constraints, conductor breaks, scratches, or similar defects no more than 0.500 inch in length may be repaired by use of a repair conductor, which shall overlap the original conductor by 0.125 to 0.250 inch at each end. If the conductor is lifted in the defective area, it shall be trimmed back to where a good bond exists. The repair conductor shall be centered over the original conductor. The repair conductor shall be formed to the board unless the conductor break is small (less than 0.100 inch) (see figure 17).

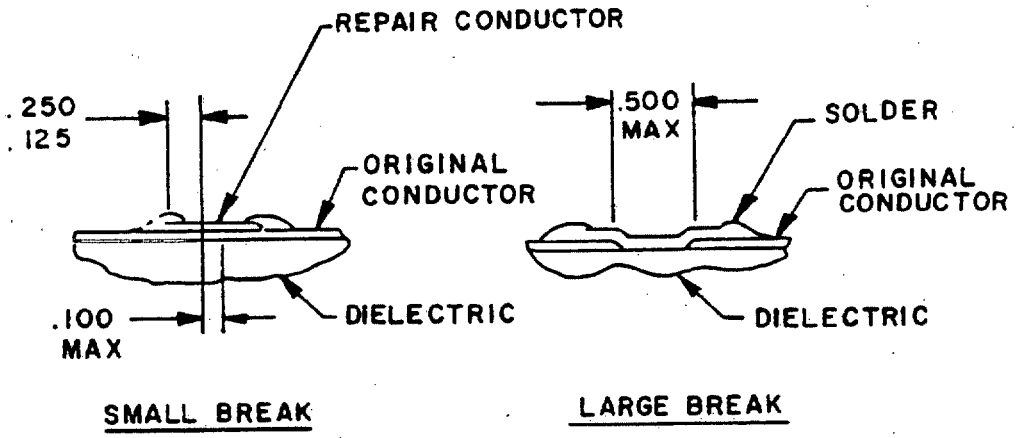
50.2.2.4 Sleeved conductors. Conductor defects of any length may be repaired by routing a sleeved conductor between the breaks or between terminations. When attached to a conductor line only, the repair conductor shall contact the original conductor a minimum of 0.125 inch from each end, unless otherwise limited by design constraints. The sleeved conductor shall be firmly secured to the board by an approved epoxy adhesive (see 40.6.3). Jumper wires shall be on the component side of the board and shall be routed in the X and Y directions by the shortest practical route minimizing wire crossings.

50.2.3 Plated through-holes with no internal connections.

50.2.3.1 Maximum permitted. The maximum number of open plated through-hole repairs permitted per board shall be in accordance with table XI.

TABLE XI. Maximum number of open plated through-hole repairs.

Board size (x)	Maximum number allowed
Square inches	
$x < 20$	3
$20 \leq x < 50$	6
$50 \leq x < 100$	9
$100 \leq x$	12



Inches	mm
.100	2.54
.125	3.18
.250	6.35
.500	12.70

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

FIGURE 17. Repair of conductor breaks.

50.2.3.2 Shorted plated through-holes. Shorted plated through-holes in multilayer boards may be repaired by drilling out the short provided no other conductors are cut and then filling the hole with resin.

50.2.3.3 Open plated through-holes.

50.2.3.3.1 Double-sided boards. Open plated through-holes in double-sided boards may be repaired by insertion of a wire or flat ribbon through the hole, clinching it on both sides, or a funnel flanged eyelet. With soldered holes, solder must completely fill the hole and must form a fillet around with wire or eyelet on both sides of the board (see 3.5.5.2).

50.2.3.3.2 Multilayer boards. Open plated through-holes in multilayer boards shall not be repaired.

50.2.4 Surface mounted components.

50.2.4.1 Method. The entire assembly may be reheated once. A method which affects only the faulty component's connections shall be used. The component to be removed shall be moved slightly sideways to prevent lifted lands prior to lifting the component from the board.

50.2.5 Measling and crazing. Repair is not permitted.

50.2.6 Holes and slots in boards. Unplated holes and slots may be repaired by filling with a resin and re-drilling.

50.2.7 Internal circuits. Repair is not permitted, except that external conductors may be added to replace open internal or external conductors when approved by the acquiring authority or authorized representatives.

50.2.8 Total maximum repairs permitted. The total maximum number of repairs of all types permitted per board shall be in accordance with table XII.

TABLE XII. Total number of repairs of all types permitted.

Board size (x)	Maximum number allowed
Square inches	
$x < 20$	6
$20 \leq x < 50$	12
$50 \leq x < 100$	18
$100 \leq x$	24

APPENDIX

CONCLUDING MATERIAL

Custodians:
Army - ER
Navy - EC
Air Force - 17

Review activities:
Army - AR, AT, ME, MI
Navy - SH, OS
Air Force - 20, 85, 99
DLA - ES
NS - S5

User activity:
Navy - AS
Air Force - 11

Preparing activity:
Navy - EC

Agent:
DLA - ES

(Project 5999-0181)