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MILITARY STANDARD

STANDARD REQUIREMENTS FOR SOLDERED ELECTRICAL AND ELECTRONIC ASSEMBLIES

AMSC N/A

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FOREWORD

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Engineering Center, Code 5321, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. Successful implementation of this standard will involve a team effort between design, fabrication, and quality assurance personnel. Manufacturers employing a total quality management (TQM) philosophy will find that the combination of interdepartmental teamwork (between design, production, and quality) and the TQM steps of process planning, process improvement, and the elimination of unnecessary operations will increase yields and reduce costs.

4. Proper material, part, and process definition, process control, and continuous process improvement to increase quality, first pass yield, and reduce costs are the primary goals which this standard seeks to accomplish.

5. The surface mounted component requirements for leadless parts are generally new. These requirements are intended to provide a good baseline for developing requirements. Procuring activities are encouraged to work with their technical advisors to provide manufacturers with the flexibility needed to aid in the implementation of this developing technology.

CONTENTS

CONTENTS

CONTENTS

CONTENTS

PARAGRAPH PAGE

CONTENTS

CONTENTS

APPENDIX A

CONTENTS

CONTENTS

CONTENTS

CONTENTS

1. SCOPE

1.1 Scope. This standard establishes requirements for materials and procedures for making soldered connections in electrical and electronic assemblies. Soldered connections for leads and wires inserted in holes, surface mounted to lands, or attached to terminals shall be in accordance with this standard. In addition, component mounting requirements and acceptance criteria are provided to permit evaluation of complete assemblies.

1.2 Discrete device exclusion. The manufacture of discrete devices, microcircuits, multichip microcircuits, and film microcircuits is outside the scope of this standard. Unless specifically required by contract, this document is not intended for application to the manufacture of transformers or similar magnetic devices (see 6.1).

1.3 Other applications.

1.3.1 Nonelectrical soldered connections. Soldered connections utilized to join surfaces in nonelectrical applications shall be in accordance with DOD-STD-1866.

1.3.2 High frequency applications. High frequency applications (i.e. radiowave and microwaves) may require part spacings, mounting systems, and assembly designs which vary from the requirements stated herein. When high frequency design requirements prevent compliance with the design and part mounting requirements contained herein, manufacturers may use alternative designs with prior approval of the government procuring activity.

1.3.3 High voltage or high power applications. High power applications such as high voltage power supplies may require part spacings, mounting systems, assembly designs, and soldering techniques which vary from the requirements stated herein. When high voltage or high power design requirements prevent compliance with the design and part mounting requirements contained herein, manufacturers may use alternative designs with prior approval of the government procuring activity.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards and handbooks. The following specifications, standards and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

QQ-N-290	Nickel Plating, Electrodeposited

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

MILITARY

MIL-T-27	Transformer and Inductor (Audio, Power, and High Power Pulse); General Specification for
MIL-F-14256	Flux, Soldering, Liquid (Rosin Base)
MIL-E-22118	Enamel, Electrical, Insulating
MIL-C-28859	Connector Component Part, Electrical Backplane, Printed Wiring; General Specification for
MIL-A-28870	Assemblies, Electrical Backplane, Printed Wiring; General Specification for
MIL-C-45224	Cable and Harness Assemblies, Electrical, Missile System, General Specification for
MIL-I-46058	Insulating Compound, Electrical for Coating Printed Circuit Assemblies
MIL-P-50884	Printed Wiring, Flexible and Rigid-Flex
MIL-P-55110	Printed Wiring Boards
MIL-P-81728	Plating, Tin Lead, Electrodeposited
MIL-S-83519	Splice, Shield Termination, Solder Style, Insulation, Heat Shrinkable, Environment Resistant; General Specification for

STANDARDS

MILITARY

MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-275	Printed Wiring for Electronic Equipment
MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-883	Test Methods and Procedures for Microelectronics

MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically-Initiated Explosive Devices) (Metric)
DOD-STD-1866	Soldering Process, General (Nonelectrical) (Metric)
MIL-STD-2118	Flexible and Rigid-Flex Printed Wiring for Electronic Equipment, Design Requirements for
MIL-STD-2119	Design Requirements for Printed Wiring Electrical Backplane Assemblies
MIL-STD-2166	Connection, Electrical, Compliant Pin

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building #4, Section D, Philadelphia, PA 19111-5094.

2.2 Nongovernment publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

INSTITUTE FOR INTERCONNECTING AND PACKAGING ELECTRONIC CIRCUITS (IPC)

ANSI/IPC-T-50	Terms and Definitions for Interconnecting and Packaging Electronic Circuits
IPC-DW-425	Design and End Product Requirements for Discrete Wiring Boards
IPC-A-610	Acceptability of Electronic Assemblies
IPC-SM-840	Printed Board, Permanent, Polymer Coating (Solder Mask) for Qualification and Performance of
IPC-HM-860	Specification for Multileaded Hybrid Circuits

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

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document supersedes applicable laws and regulations.

3. TERMS AND DEFINITIONS

3.1 Terms and definitions. In addition to those listed below, the definitions applicable to this standard shall be in accordance with ANSI/IPC-T-50.

3.1.1 Capability. A measurable property of a process which is in statistical control and produces output which falls within specification limits.

3.1.2 In-statistical-control. The condition describing a process which exhibits stability and minimized variability, and remains predictable over time.

3.1.3 MELF. MELF denotes devices with Metal ELectrode Face bonding as the termination attachment.

3.1.4 Rework. Rework is the repetition of prior operations or the use of alternate operations to bring an item into conformance with the original solder connection or assembly requirements.

3.1.5 Stacking (piggybacking). A technique of mounting components in which the component leads or terminations are attached to the leads or terminations of another component.

3.1.6 Statistical process control. The use of statistical techniques to analyze a process or its outputs to take appropriate actions to achieve and maintain a state of statistical control and to improve the process capability.

3.1.7 Touch-up. Touch-up is rework. As stated within the requirements of this document, touch-up and rework shall not be performed until defects have been documented.

4. GENERAL REQUIREMENTS

NOTE: The requirements of 4.1 through 4.26 are intended to define design, material, and end-item characteristics.

4.1 Interrelation of applicable documents.

4.1.1 Conflict. In the event of conflict between the requirements of this standard and the applicable assembly drawing(s), the applicable government approved assembly drawing(s) shall govern. In the event of conflict between the requirements of this standard and an assembly drawing that has not been approved by the government, differences shall be referred to the designated government activity for approval. Upon such approval, the provisions shall be officially documented (by notice of revision or equivalent) on the assembly drawing(s) which shall then govern.

4.1.2 Existing designs. The requirements of this standard shall not constitute the sole cause for redesign if the design has been approved. However, when existing designs undergo change which impacts hardware configuration, the design should be reviewed and changes made that allow for maximum practical compliance with the requirements of this standard.

4.1.3 Requirements flowdown. The applicable requirements of this standard shall be imposed by each contractor on all applicable subcontracts and purchase orders. The contractor shall not impose or allow any variation from this standard on subcontracts or purchase orders other than those which have been approved by the government for the applicable prime contract.

4.1.4 Specialized technologies. Mounting and soldering requirements for specialized technologies not specified herein shall be considered peculiar and shall be identified on the drawing and performed in accordance with documented processes which are subject to review.

4.2 Visual aids. Line drawings and illustrations depicted herein are provided as aids for determining compliance with the written requirements of this standard. The written requirements take precedence.

4.3 Workmanship. Workmanship shall be of a level of quality adequate to assure that the processed products meet the performance requirements of the engineering drawings and the criteria specified herein. Rework of soldered assemblies shall be minimized since any heating cycle may induce damage that will affect product reliability. Parts shall not be cracked, scored, chipped, broken, or otherwise damaged beyond the limits of the original part specification. There shall be no evidence of flux residue or other contamination. See table I, defects 1 and 7.

4.3.1 Inspection. The acceptance criteria of this standard requires evaluation of hardware characteristics for acceptance. Where a characteristic is not clearly rejectable, it shall be accepted. See 5.3.7 for inspection and 5.3.7.4 for magnification aids.

4.4 Disposition of defects. Table I lists the defects which are unacceptable in Department of Defense equipment. Assemblies which contain these defects shall be rejected and either reworked to conformance or processed in accordance with the contract requirements for nonconforming material (i.e. repair or scrap). The table I defects shall not be dispositioned "use as is." Only defects in table I require mandatory scrap, rework or repair. The contractor is responsible for identifying other areas of risk (critical parameters) for addition to table I. Such items shall be documented on the assembly drawing and shall be treated as ad hoc additions to table I. Additions to table I shall consider product operational environment and contractor manufacturing risks associated with assembly, design and fabrication techniques. Variances other than those included in table I shall be considered process variances. While mandatory rework or repair of process variances is not required, the contractor shall evaluate these variances (e.g. for criticality, frequency, location, size, etc.). Where there is a significant risk of hardware failure, the contractor should rework (repair) the variance.

Table I. Defects

1. Part damage beyond the limits specified in the part specification.
2. Charred (burned or blackened) printed wiring, wire insulation or components.
3. No stress relief provision(s). (NOTE: Solder in the stress relief bends does not constitute elimination of stress relief.)
4. Cuts or nicks that reduce the cross-sectional area of the solid wire, leads, or stranded wires to less than 90% of the original cross-sectional area (see paragraph 4.24.3). For stranded wires, there shall be no severed or broken strands.
5. Birdcaging of stranded wire with separation between strands greater than one strand diameter.
6. Violation of the minimum electrical spacing requirement. This condition includes potential movement of conductors (including conductive part bodies, leads, wires, etc.), excessive solder and bridging.
7. Flux residue or foreign material.
8. Fractured, cracked or disturbed solder connections.
9. More than 10 percent of the periphery of the solder connection nonwetted or dewetted.
10. Lifted lands or conductors separated more than the thickness (height) of the conductor.
11. Delaminated or blistered printed wiring base material (this does not include measling or haloing).
12. Damage to circuit traces which reduces the cross-sectional area of the circuit trace by more than 20%.
13. No fillet visible with the unaided eye between the lead or wire and terminal and less than 75% solder fill of solder cups.

Table I - Defects (continued)

14. Voids or blowholes in conjunction with the minimum allowable solder volume. This applies to all types of solder connections.
15. Plated-through hole with or without leads with more than 25% recession of the solder.
16. Leaded surface mount solder connection where less than 75% of the heel has a fillet, visible with no greater than 10X magnification.
17. Leadless chip carrier solder connection with a solder fillet which does not rise vertically above the lower edge of the outer castellation surface or with less than 75% of the part termination width over the land or pad.
18. Bottom only metallized leadless chip carrier solder connection with fillet height less than 0.2 mm (0.008 inch) on a non-CTE-compensated printed wiring assembly or with less than 75% of the part termination width over the land or pad.
19. Chip device solder connection with a fillet of less than 75% of the chip termination width, visible with no greater than 10X magnification.
20. Cracks in conformal coating. Conformal coating with bubbles, foreign material or mealing which violates minimum electrical spacing.

4.4.1 Process variances. Variances to the requirements of this standard not listed in table I shall be monitored for process control and their occurrence shall be minimized with the goal of elimination (where economically practicable) through process corrective actions. Evidence of ineffective process control or ineffective process corrective action shall be grounds for disapproval of the process and associated documentation.

4.5 Harness and cable assemblies. Harnesses and cable assemblies shall conform to the requirements of MIL-C-45224 or an equivalent specification approved by the procuring activity. The soldering and related processes and acceptance criteria shall be as stated herein. Where the physical configuration of the cable assembly and related hardware prohibits cleanliness testing in accordance with this document, the contractor may use controlled processes (procedures) which provide adequate cleanliness without performing the cleanliness testing. Periodic process (procedure) validation shall be performed. Wax-impregnated lacing tape shall be utilized only for harnesses which will not be subjected to cleaning solvents subsequent to lacing operations. Tape impregnated with bee's wax shall not be used.

4.6 Materials. Materials used in the soldering processes stipulated in this standard shall be as specified herein. The materials and processes specified herein may be incompatible in some combinations. The manufacturer is responsible for selecting those materials and processes that will produce acceptable products.

4.6.1 Solder. Solder composition Sn60, Sn62, or Sn63, solder form optional, conforming to QQ-S-571 shall be used. High temperature solder conforming to QQ-S-571 may be used when specified on the government approved assembly drawing. The flux of cored solder shall be type R or RMA. Other flux cores may be used according to 4.6.3. Core conditions and flux percentages are optional.

4.6.2 Flux. Liquid rosin based fluxes conforming to types R or RMA of MIL-F-14256 shall be used for making soldered connections. When used, the flux contained within solder (wicking) braid shall be type R or RMA. Other fluxes may be used according to 4.6.3.

NOTE: The cleanliness test methods designed for rosin based fluxes may not be adequate for cleanliness testing when nonrosin fluxes are used.

4.6.3 Use of nonrosin fluxes. Other fluxes may be used for tinning or soldering component leads of sealed devices, epoxy bodied parts, solid bus wire, and terminals when performed as part of an integrated fluxing, soldering, cleaning, and cleanliness test system and one of the following conditions is met:

a. Usage is approved by the procuring activity.

b. Material is used to solder printed wiring assemblies and data demonstrating compliance with the testing requirements of Appendix A is available for review.

c. Material is used for tinning and data demonstrating compliance with the requirements of Appendix A is available for review.

4.6.4 Rosin based flux for component tinning. Rosin based flux conforming to Type RA of MIL-F-14256 may be used for tinning component leads of sealed devices, epoxy bodied parts, solid bus wire, and terminals provided that:

a. The tinning process is performed in a closed area isolated from fabrication or production areas;

b. The contractor maintains controls to prevent distribution or use of Type RA flux outside the prescribed tinning area and the Type RA flux is not stored in uncontrolled storage areas; and

c. Items processed are not returned to production or fabrication processes until the residues have been removed. The Government may review flux removal procedures, processes, and processing. If at any time flux residue is detectable after these processes are completed, the use of RA flux shall be suspended until acceptable corrective action is implemented.

4.7 Printed wiring. Rigid printed wiring shall be designed to MIL-STD-275 and built in accordance with MIL-P-55110 except as modified herein. Flexible and rigid-flex printed wiring shall be designed to MIL-STD-2118 and built in accordance with MIL-P-50884 except as modified herein. When used, blind and buried vias shall be incorporated in all test coupons. Multiwire boards, designed and built in accordance with IPC-DW-425, may be used when they pass the quality conformance inspection tests (Group A and B tests) of MIL-P-55110. The minimum electrical spacing on both printed wiring and multiwire boards shall be identified on the assembly drawing. See table I, defect 6.

4.7.1 Conductor spacing for uncoated assemblies. If the printed wiring assembly will not be conformally coated or encapsulated, the minimum spacing between conductive patterns of printed wiring boards shall be in accordance with tables II and III. Larger spacings should be used whenever possible. The use of uncoated printed wiring boards shall be documented on the government approved assembly drawing.

4.8 Solder mask. Polymer solder mask coatings shall conform to IPC-SM-840 and shall not contain cracks, wrinkles, peeling, or otherwise trap contaminants.

4.8.1 Solder mask over nonmelting metals. Conductor areas not covered by solder mask shall be nickel plated ceramic boards), tin/lead plated and fused, or solder coated. Bonding/adhesion promoters may be required (used). Solder mask shall not be placed over metals which will become liquid or semi-liquid during processing. Minor coverage of melting metals, which shall be less than 0.1 mm (0.004 in), is permissible provided it occurs where the solder mask meets a termination area.

4.8.2 Solder mask coverage. Solder mask shall be continuous in all areas designated to be covered. There shall be no chipping or fracturing of solder mask, nor shall there be separation of the solder mask from laminate or metallic foil. The solder mask shall not cover materials foreign to the laminate or foil. Adherence between solder mask and laminate and between solder mask and foil shall be complete for the total area. Temporary solder masking materials, if used, shall be removed.

4.9 Conformal coating of all assemblies. Unless otherwise specified on the government approved assembly drawing, all assemblies shall be conformally coated. Conformal coating requirements for printed wiring assemblies, including the type of coating (i.e. the material), shall be specified on the Government approved assembly drawing. When used, conformal coating shall conform to MIL-I-46058. See table I, defect 20.

TABLE II. Conductor spacing (uncoated printed wiring boards) (sea level to 10,000 feet).

Voltage between conductors DC or AC peak (volts)	Minimum spacing
0-150	0.64 mm (0.025 inch)
151-300	1.3 mm (0.050 inch)
301-500	2.5 mm (0.10 inch)
Greater than 500	0.005 mm (0.0002 inch) per volt

TABLE III. Conductor spacing (uncoated printed wiring boards) (over 10,000 feet).

Voltage between conductors DC or AC peak (volts)	Minimum spacing
0-50	0.64 mm (0.025 inch)
51-100	1.5 mm (0.060 inch)
101-170	3.2 mm (0.125 inch)
171-250	6.4 mm (0.250 inch)
251-500	12.7 mm (0.500 inch)
Greater than 500	0.03 mm (0.001 inch) per volt

4.10 Interference spacing. Components and parts shall be mounted with no portion overhanging the edge of the printed wiring assembly, terminal panel, or chassis member, except for connectors, edge clips or associated circuitry.

4.11 Eyelets. Eyelets are unacceptable for electrical connections.

4.12 Detailed part mounting. Unless otherwise specified on the government approved assembly drawing, parts shall be mounted according to Appendix B. Alternate mounting techniques equivalent to or better than Appendix B may be used by the contractor when detailed on the government approved assembly drawing. Improvements equivalent to or better than Appendix B are encouraged and shall be supported with data available for review.

4.12.1 Component selection and mounting. Components shall be selected and mounted so that the final assembly will be capable of meeting the vibration, mechanical shock, humidity, and other environmental conditions for which the assembly is designed. Components shall be mounted such that the operating temperature of the component does not reduce component life below design limits. The component mounting technique shall ensure that the maximum allowable temperature of the board material is not exceeded under operating conditions. See table I, defect 2.

4.12.2 Mechanical support. All parts weighing 7.1 g (0.25 ounce) or more per lead shall be supported by clamps, spacers, or other means which ensure that the solder connections and leads are not relied upon for mechanical support.

4.12.3 Component interconnection. Leads and wires shall be mounted to through-holes, terminals, or lands (including offset lands). All terminations shall be soldered.

4.12.4 Interfacial and interlayer connections. Interfacial connections of circuitry on double sided printed wiring boards or assemblies shall be either plated-through holes or the clinched wire configuration of Appendix B (see 40.10.1.3). Interfacial and interlayer connections of circuitry of multilayer printed wiring boards or assemblies shall be of the plated-through hole configuration. Electrically non-functional plated-through holes shall be identified as such on the assembly drawing and do not need to meet the electrical connection requirements.

4.12.5 Parts mounted in plated-through holes used for interconnection. Standoff terminals, eyelets, rivets, snug fit pins, or braided sleeves shall not be used to provide interfacial or innerlayer connection. Plated-through holes used for functional interfacial connections shall not be used for the mounting of devices which put the plated-through hole in compression. Terminals, eyelets, rivets, or snug fit pins shall not be installed in any plated-through hole utilized for interfacial or innerlayer connection.

4.12.6 Compliant pins (connectors). As an exception to 4.12.3 and 4.12.5, compliant pins in accordance with MIL-STD-2166 and connectors in accordance with MIL-C-28859 may be inserted in the plated-through holes of backplanes and mother boards designed to MIL-STD-2119 and fabricated to MIL-A-28870 and the requirements contained herein.

4.12.7 Terminal selection. Terminals shall be of the flat shoulder configuration (see figure 1).

4.12.8 Identification of via hole fill requirements. All via holes (no lead or wire inserted in the plated-through hole) designated to be filled by the design requirements shall be identified on the government approved drawing.

4.12.9 Attachment points for interconnect wires. Interconnect wiring connected directly to assemblies shall be installed in plated-through holes or on terminals. Bare tinned wire with added insulating sleeving shall not be used. Wires shall be installed on terminals if the wires are subject to removal for normal maintenance action.

4.12.10 Maximum attachments to terminals. There shall be no more than three attachments to any terminal other than turret or bifurcated terminals and there shall be no more than three attachments to any terminal section of turret and bifurcated terminals.

4.12.11 Part selection.

4.12.11.1 Sockets. Components shall not be mounted in sockets. Additionally, components shall not be mounted in plug-in devices which rely upon contact pressure for part retention or electrical connection.

4.12.11.2 Heat shrinkable soldering devices. Heat shrinkable soldering devices shall be self-sealing and shall encapsulate the solder connection. The devices shall meet the requirements of MIL-S-83519. Terminations made with self-sealing heat shrinkable solder devices, shall be exempt from the cleaning requirements of this standard.

4.13 Component misregistration. Misregistration of components shall not reduce the spacing to adjacent printed wiring or other metallized elements by more than the minimum electrical spacing.

4.14 Coefficient of Thermal Expansion (CTE) mismatch compensation. The part mounting technique or the printed wiring design shall compensate for the CTE mismatch between the part and printed wiring to the extent necessary to assure the reliability of the design. Mounting techniques shall be limited to part leads, specialized mounting devices, and normal solder connections (see 4.14.1). Leadless components shall not be soldered into place utilizing redundant interconnect wiring between the component castellation and the land. When bottom only terminations on leadless chip carriers are used, see paragraph 4.23.5.

4.14.1 Solder connection contours. Designs which utilize special solder connection contours as part of the CTE mismatch compensation system are prohibited.

4.15 Lead bends. Lead bends shall not extend to the part body or weld. The radius of bends shall be one lead thickness, one lead diameter, or one lead diameter prior to coining (see figure 2).

4.16 Stress relief. Axial or opposed lead devices with leads terminating at a connection point shall have a minimum lead-connection-to-body offset of at least 2 lead diameters or thicknesses, but not less than 0.75 mm (0.030 inch). Where the component body will not be secured to the mounting surface by bonding, coating, or other means, the lead(s) on only one of the opposing sides of the component need be so configured. Typical examples of stress relief are included in figure 3. See table I, defect 3.

4.17 Devices mounted over circuitry. Parts mounted over protected surfaces, insulated parts over circuitry, or surfaces without exposed circuitry, may be mounted flush. Parts mounted over exposed circuitry shall have their leads formed to allow a minimum of 0.25 mm (0.010 inch) between the bottom of the component body and the exposed circuitry. The clearance between the bottom of the component body and the printed wiring surface shall not exceed 1.0 mm (0.040 inch).

NOTE: Nonelectrical planes and vias used for heat dissipation are not considered circuitry.

4.18 Stacking (piggybacking). Unless a component or part is specifically designed to accept another part into its configuration, there shall be no stacking (piggybacking) of parts or components.

4.19 Adhesive coverage limits. If a component is secured to the printed wiring board utilizing an adhesive bonding resin, the area of resin coverage shall not flow onto or obscure any of the terminal areas. Part attachment processes shall control the quantity and type of bonding material such that the parts are removable without damage to the assembly. The adhesive used shall be compatible with both the printed wiring and the part.

4.20 General solder connection characteristics.

4.20.1 Finish. The appearance of the solder connection surface shall be nonporous, noncrystalline, continuous and properly wetted. As an exception, the solder connections may have a matte grey appearance if:

a. the solder connection is made with other than Sn 60, Sn 62 or Sn 63 solder,

b. one or more of the connection elements is gold or silver plated, solid silver, or

c. the appearance is the result of a slow cooling rate for the solder connection (e.g. high assembly thermal mass after wave or vapor phase soldering). There shall be no overheated, cold, or disturbed solder connections.

4.20.2 Physical attributes. The solder connection shall be free of scratches which expose basis metal, sharp edges, spikes, flux residue, and inclusions of foreign material. Pits, and pin holes may be present provided they are so located or of a size and shape that connection integrity is not degraded. Solder shall not appear as strings, or bridging between adjacent conductor paths. Probe marks in solder connections shall not be in a location nor of a size, shape, or number which causes degradation of connection elements or solder integrity. See table I, defect 6.

4.20.3 Fractures. There shall be no split, crack, fracture, or separation within the solder or between the solder and connection elements. See table I, defect 8.

4.20.4 Voids. Voids or blowholes in conjunction with the minimum allowable solder volume are unacceptable. This applies to all types of solder connections. See table I, defect 14.

4.20.5 Coverage. The solder quantity shall be sufficient to cover all elements of the connection. The outline of any included lead or wire shall be discernible in the solder. Lead ends need not be covered with solder. In the case of stranded wires, the outlines of the strands shall be discernible.

4.20.6 Wetting and filleting. Solder shall wet the surfaces of all connection elements and form a fillet between elements around the complete periphery of the termination. Solder fillets are not required to extend to the edge of the termination area. A nonuniform flow line, where the solder fillet blends to a surface being joined, is acceptable provided good wetting is evident. Solder shall not gather in droplets or balls. There shall be no solder dewetting or nonwetting in excess of 10% of the lead periphery. See table I, defect 9.

4.21 General printed wiring requirements

4.21.1 Conductor finish. The conductive pattern on printed wiring shall be covered with solder mask, a solder coating or reflowed tin-lead plating. The solder coating or reflowed tin-lead plating shall have a smooth, noncrystalline, and continuous surface and shall be fused to the base metal. Vertical edges of conductors need not be covered.

4.21.2 Conductor condition. The width or thickness of printed wiring conductors (including lands) and part conductors (e.g. leads or castellations) shall not be reduced by more than 20 percent (e.g. from cuts, notches, etching, abrasion, scoring, etc.). Cuts, scores and abrasions which expose basis metal are undesirable. The conductor pattern shall have no tears or cracks. There shall be no combination of edge roughness, nicks, pinholes, or scratches exposing basis metal greater than 13 mm (0.50 inch) in a conductor length. Unless otherwise specified, plating for parts and all printed wiring shall be complete and continuous with no separation from the base material. See table I, defect 12.

4.21.3 Conductor separation from the board. Conductors and ground planes (excluding terminal pads or lands) shall not be separated either partially or totally from the board surface. After soldering, the maximum allowed lifted land distance from the board surface to the outer, lower edge of the land shall be the thickness (height) of the terminal area or land. Normal undercut shall not be considered a lifted land. See table I, defect 10.

4.21.4 Cleanliness of printed wiring, boards, and assemblies. Printed wiring, boards, and assemblies shall be free of foreign matter. This includes grease, silicones, flux residue, dirt, chips, solder spatter, solder balls, insulation residue, and wire clippings. See table I, defect 7.

4.21.5 Weave exposure. The weave of glass laminates shall not be exposed on either surface beyond the limits of MIL-P-55110 or MIL-P-50884.

4.21.6 Delamination. Printed wiring shall not be blistered or delaminated beyond the limits of MIL-P-55110 or MIL-P-50884. See table I, defect 11.

4.21.7 Measles. The printed wiring assembly shall include no measled area between two conductors on the same plane, at different electrical potentials, which reduces the unmeasled area to less than 50% of the minimum design electrical spacing. Measling in excess of this limit shall be treated as a delamination (see table I, defect 11 and 4.21.6). As an aid in identifying measles, see IPC-A-610.

4.21.8 Haloing. Haloing is permissible provided it is mechanically induced (i.e. it occurs during the mechanical mounting of terminals, tines, etc.) and is not in evidence around plated-through holes used for electrical connection. Evidence of haloing around soldered plated-through holes used for electrical connection shall be treated as measling and the requirements of 4.21.7 apply. As an aid in identifying haloing, see IPC-A-610.

4.21.9 Bow and twist. The bow and twist of the printed wiring assembly circuit board shall not exceed 0.015 mm per mm (0.015 inch per inch). Where the assembly drawing has a tighter requirement, then the drawing requirement shall prevail.

4.22 Through-hole solder connections.

4.22.1 Holes with leads or wires inserted. When a lead or wire is inserted in a plated-through hole, the hole shall be filled with solder. The solder shall be continuous from one side of the printed wiring assembly to the other and extend onto the terminal areas. The solder shall flow onto the component side (top or opposite from the solder application side) of the printed wiring and shall cover at least 90% of the solder side (bottom or solder application side) land. Solder may be recessed back into the hole provided that wetting to both the lead and the terminal areas is acceptable. The total recession of solder in a plated-through hole with a part lead shall not exceed 25 percent of the hole depth as measured from the surface of the terminal area. See figure 4. See table I, defect 15.

4.22.2 Solder in the lead bend radius. Solder may be present in the formed bends of components which results from normal wetting action. The topside bend radius shall be discernible. Solder climb (wetting) on the lead shall not extend to within 1 lead diameter of the component body (see figure 5).

4.22.3 Visual characteristics of acceptable unsupported hole solder connections. The solder shall have a contact angle to the surfaces being joined which is not greater than 90 degrees. An unsupported through hole need not be covered with solder.

4.22.4 Plated-through holes without leads or wires inserted. The holes may be left unfilled. When filled, the solder plug shall meet the requirements of 4.22.1 (see figure 4). See table I, defect 15.

4.22.5 Partial hole fill. Partially filled holes are not acceptable. When the unfilled hole option is used, the process shall be designed to preclude the empty holes(s) from becoming partially filled with solder. Temporary solder masking materials, if used to prevent solder fill, shall be removed from unfilled holes prior to final cleaning.

4.22.6 Tenting of plated-through holes. Permanent solder mask shall not tent empty plated-through holes (i.e. via holes) which are greater than 0.5 mm (0.020 inch) in diameter. When tenting plated-through holes, solder mask shall not be placed over melting metals beyond the limits of 4.8.1.

4.23 Surface mount solder connections.

4.23.1 Surface mounted device lands. Components shall be mounted to land surfaces specifically designed to accept those components. These lands may be located on either the printed wiring board or a specially configured part.

4.23.2 Devices with external deposited elements. Components with electrical elements deposited on an external surface (such as chip resistors) shall be mounted with that surface facing away from the printed wiring board or substrates (see figure 6). See table I, defect 19.

4.23.3 Chip devices.

4.23.3.1 Stacking of chips. Chip devices shall be mounted only to printed wiring or parts specifically configured to receive them (see figure 7).

4.23.3.2 Chip device solder fillet. As a minimum, 75% of the end metallization width (the end face, not including the side of end caps) shall be positioned over the land and shall have a solder fillet. At least 75% of the end metallization shall be over the termination area. A side fillet is not required. The solder fillet shall extend at least 25% or 1.0 mm (0.040 inch) up the end of the device, whichever is less. Solder may be present on the top of the end cap, however, the end cap shall not be fully encapsulated by solder. The wetting angle of the solder to the part and to the land shall be less than 90 degrees except when the quantity of solder results in a rounded contour which extends over the edge of the land. Solder shall not encase any nonmetallized portion of the body of a component. See figures 8, 9, 10, and 11.

4.23.4 MELF solder connection contours. The solder connection shall form a fillet which extends at least 0.1 mm (0.004 inch) or 25% of the part height up the side of the MELF, whichever is greater. At least 75% of the width and length of each metallized end shall extend over the land and shall have a solder fillet (see figures 12 and 13).

4.23.5 Solder fillet on surface mounted, leadless, castellated parts. At least 75% of each metallized castellation width of a leadless chip carrier shall be over the land and shall have a solder fillet which, as a minimum, rises vertically above the lower edge of the outer castellation surface. The wetting angle of the solder to the part and to the land shall be less than 90 degrees except when the quantity of solder results in a rounded contour which extends over the edge of the land. In all cases, there shall be evidence of good wetting. When the leadless chip carrier has bottom only terminations, the minimum solder connection height shall be 0.2 mm (0.008 inch) unless the design effectively compensates for the CTE mismatch between the part and printed wiring which is less than 13 ppm. See figure 14. See table I, defects 17 and 18.

4.23.6 Leadless device part spacing and parallelism. The space between the body of the leadless surface mounted device and the terminal areas shall be selected in conjunction with the cleaning process such that contaminants do not remain under the part after cleaning. After soldering, the difference between the thicknesses of the solder under each end of the part shall be less than 0.4 mm (0.016 inch) (see figure 15).

4.23.7 Leaded surface mounted devices.

4.23.7.1 Surface mounted device lead bend configuration. Lead bends shall not extend into the part body lead seal. The angle of that part of the lead between the upper and lower bends in relation to the mounting pad shall be 45° minimum to 90° maximum (see figure 16).

4.23.7.2 Surface mounted device lead and land contact. The minimum design contact length shall be equal to the lead width for flat leads and two times the diameter (2D) for round leads (see figure 17). Side overhang is permissible provided it does not exceed 25 percent of the lead width, diameter, or diameter prior to coining, or 0.5 mm (0.02 inch), whichever is greater. Toe end overhang is permissible provided the total overhang does not exceed 25 percent of the lead width or diameter (round leads) or 0.5 mm (0.02 inch), whichever is less, and the minimum contact length is maintained (see figure 18). The heel shall not overhang the land (see figure 19).

NOTE: It is preferred that leads be seated in contact with the terminal area for the full length of the foot. Leads shall be formed such that foot twist is minimal.

NOTE: The heel begins where the lead begins to curve at the lead bend.

4.23.7.3 Surface mounted device lead height off land. Round or coined leads may have their minimum seating plane raised off the land surface a maximum of one-half of the original lead diameter. Flat or ribbon leads may have their minimum seating plane raised off the land surface a maximum of two times the lead thickness or 0.5 mm (0.020 inch), whichever is less. All points within the minimum seating plane shall be within one-half diameter or two lead thickness maximum spacing. The minimum seating plane is area bounded by the minimum lead length (see 4.23.7.2) and the lead diameter or thickness. Toe up or toe down on flat and round leads shall be permissible provided that separation between leads and termination area does not exceed 2T and 1/2 D limits, respectively. This dimension may be measured prior to soldering (see figure 20).

4.23.7.4 Minimum solder coverage. The minimum solder fillet height on round or coined leads shall be 25 percent of the original lead diameter. The minimum solder fillet height on flat leads shall exhibit a visible fillet rising from the land a minimum of 50% up the side of the lead. The solder shall extend the length of the lead termination. The outline of the lead shall be discernible in the solder (see figure 21). See table I, defect 13.

4.23.7.5 Lead heel fillet. The solder may extend into the upper lead bend but shall not contact the part body or lead seal. The heel fillet shall be continuous between the heel of the lead and the circuit land. The heel fillet shall extend beyond (above) the bend radius. The heel shall not overhang the land. See table I, defect 16.

4.23.7.6 Heater bar marks on a surface mounted device solder fillet. Tool marks resulting from heater bar operation shall not be cause for rejection.

4.23.7.7 J-leaded and V-leaded device solder fillet. At least 75% of the lead width shall be over the land and shall have a solder fillet. The solder fillet shall extend up the side of the lead to the height of the inner surface of the lead. The solder shall not contact the bottom of the part package. The solder shall form a fillet at least one lead width along the curve of the "J" or "V" (see figure 22).

4.23.7.8 Parallelism of J-leaded and V-leaded devices. J-leaded and V-leaded devices shall be mounted and soldered approximately parallel to the surface of the printed wiring board wiring. The space between the soldered-in-place device and the board shall not exceed 2.5 mm (0.10 inch) (see figure 23).

4.24 Attachment of leads and wires.

4.24.1 Wire and lead wrap. Leads and wires shall be wrapped around terminals for a minimum of one-half turn and shall not overlap (see figure 24). On terminals with square or rectangular posts, the wire or lead shall be in contact with the flat surfaces of two non-adjacent sides. For AWG size 30 or smaller wire, a maximum of 3 turns may be used. Continuous runs and small parts to which such mechanical securing would be impracticable (e.g. connector solder cups, slotted terminal posts and heat shrinkable solder devices) are exempt from this requirement.

4.24.2 Insulation clearance. Clearance between the solder of the connection and the end of either separable or fixed insulation on the wire in the connection shall be as follows:

a. Minimum clearance. The insulation may abut the solder. It shall not, however, be embedded in or surrounded by the solder. The insulation shall not be melted, charred, seared, or diminished in diameter.

b. Maximum clearance. The maximum clearance shall be two wire diameters (including insulation) or 1.6 mm (1/16 inch), whichever is larger, but shall not be such that it permits shorting between adjacent conductors.

c. High voltage clearance: The insulation clearance for high voltage wires (greater than 6kV) shall be 3.2 $\pm$ 1.6 mm (1/8 $\pm$ 1/16 inch) unless otherwise specified in the assembly drawing.

4.24.3 Wire and wire strand condition. Wires or wire strands shall not be broken, severed or birdcaged. Wires and strands shall be inspected at 4X magnification. Nicks, cuts, scrapes, stretching, or other observable damage which exceeds 10 percent of the original wire cross-sectional area is unacceptable. Discoloration of the wires or strands that shows evidence of overheating is undesirable. See table I, defects 2, 4 and 5.

NOTE: The cross-sectional area of a stranded wire is the sum of the cross-sectional areas of the individual strands.

4.24.4 Wicking. Wicking under the insulation of stranded wire soldered to a terminal area is permissible provided that the insulation is of a type which can withstand soldering temperatures, the application does not require that the wicked portion of wire be flexible and the criteria for wicking is not otherwise specified for the particular application on applicable drawings.

4.24.5 Soldering of wires and leads to terminals. Solder shall form a fillet with that portion of the wire or lead in contact with the terminal. Solder shall not obscure the contour of the wire or lead. For slotted terminals, solder may completely fill the slot (see figure 25). See table I, defect 13.

4.24.6 Soldering of wires and leads to solder cups. No more than three (3) wires shall be installed in the cup, and in no instance shall the lay of the strands of any wire be disturbed, nor shall strands be removed. The wire or wires shall be inserted for the full depth of the cup and a fillet shall be formed along the surfaces of contact. Solder shall wet the entire inside of the cup. Solder shall follow the contour of the cup and shall fill at least 75 percent of the mouth of the cup. Solder shall be visible in the inspection hole and may rise slightly above it (see figure 26). Solder may overfill the cup. Any solder on the outside of the cup shall be in the form of a thin film (see figure 27). See table I, defect 13.

4.24.7 Connections made with heat shrinkable solder devices. The solder fillet and connection elements shall be clearly discernible. The solder shall lose all appearance of ring shape and the contour of the solder preform shall not be visible. Inserts shall melt and flow along the wires. The outer sleeve may be darkened, but the connection area shall be visible. With the exception of minor "browning," the wire insulation shall not be damaged outside of the sleeve.

4.25 Terminal and connector configuration. Terminals and connector pins shall be approximately perpendicular to the surface upon which they are mounted. Terminals and connector pins shall not be bent or otherwise deformed.

4.26 Part markings and reference designations. Parts markings and reference designations, when used, shall remain legible after processing.

5. DETAIL REQUIREMENTS

NOTE: The requirements of this section are intended to prevent the occurrence of latent defects, prevention of rework through process control, and provide consistent inspection and quality assurance provisions.

5.1 Latent failure prevention.

5.1.1 Electrostatic discharge. Electrostatic discharge (ESD) control for the protection of electrical and electronic parts, components, assemblies and equipment shall be in accordance with MIL-STD-1686. ESD controls shall be maintained during receipt and test of parts, through the manufacture and inspection cycles, storage, and shipping.

5.1.2 Selection of facilities.

5.1.2.1 Equipment. Soldering irons, soldering machines and systems, and associated process equipment (including fluxers, preheaters, solder pots, cleaning systems, and cleanliness test equipment) shall not compromise functional integrity by injecting electrical energy to the item(s) being soldered or being cleaned.

5.1.2.2 Soldering irons. Soldering irons shall be temperature controlled and shall be capable of maintaining the measured idling tip temperature within ± 5.5°C (± 10°F). Uncontrolled (constant output) soldering irons may be used when approved by the procuring activity. Resistance between the tip of the hot soldering iron and the workstation ground shall not exceed 5.0 ohms. The potential difference between the workstation ground and the tip of the hot soldering iron shall not exceed 2 millivolts RMS. Three-wire cords and tip grounding shall be used. The soldering iron shall be of such design as to provide zero voltage switching. Soldering guns of the transformer type shall not be used.

5.1.3 Solder pot and solder bath temperatures. The solder pots used for cleaning and tinning of areas to be soldered, drag soldering pots, and wave solder baths shall be temperature controlled. Solder pots or baths shall be set at a preselected temperature within the range of 245° to 275°C (475° to 525°F). The temperature shall be maintained within ± 5.5°C (± 10°F) of the preselected temperature.

5.1.4 Certification of personnel.

5.1.4.1 Certification. Personnel performing tasks in accordance with this standard shall be trained and certified to the appropriate job functions and procedures of this standard. The training and testing program for certification shall be based on the requirements of this standard and shall reflect the actual work being performed. The contractor shall designate an individual responsible for employee certification.

5.1.4.2 Certification record. Each employee's certification shall be documented and the record shall include the date and location of training, the jobs or skills the employee is certified to perform, the date of the most recent training or recertification, method and results of the contractor's evaluation of student's performance or graded test, and the signature of the contractor designated person responsible for training and certification (see 5.1.4.1).

5.1.4.3 Training program. The contractor's training program is subject to review by the government.

5.1.4.4 Maintenance of certification. The contractor shall perform periodic audits of the employee's performance to verify conformance with this standard. Certification shall be revoked when work produced by the employee does not meet the requirements of this standard.

5.1.5 Mounting of components. Components shall be designed for and capable of withstanding the processing conditions to which they are exposed. The component mounting processes (steps) and the subsequent processes (e.g., soldering, cleaning, etc.) shall be designed and scheduled such that components are capable of withstanding temperatures incident to the processes to which they are subjected. When a design requires the mounting and soldering components which are incapable of withstanding subsequent soldering and cleaning processes, these components shall be mounted and soldered to the assembly in an separate operation which minimizes stress to the part.

5.1.6 Cooling. Solder connections shall not be subjected to movement or stress at any time during the solidification of the solder. There shall be a smooth transition after completion of the soldering operation to prevent formation of disturbed solder connections. When machine soldered, the printed wiring assembly shall be retained on the conveyor until the solder has solidified. Prior to solidification of the solder, no liquid shall be used to cool a soldered connection. Heat sinks may be used to expedite cooling. Accelerated cooling may be used provided the cooling process is controlled and no thermal shock damage results.

5.1.7 Tempered lead cutting. Tempered leads (sometimes referred to as pins) shall not be cut with diagonal cutters or other tools which impart shock to connections internal to the component.

5.1.8 Lead cutting after soldering. The cutting of component leads or wires after soldering shall be followed by the reflow of the solder connection.

5.1.9 Single point soldering of surface mounted devices. Single point soldering shall not be used on multicastellated components during initial soldering operations. Single point rework operations are permissible provided that adjacent solder connections are not simultaneously reflowed.

5.1.10 Hold down of surface mounted device leads. Except for lead compression during resistance reflow soldering, surface mounted device leads shall not be held down under stress (e.g. probes) during solder solidification. The resistance reflow systems should not deflect leads more than two times the lead thickness during reflow. Residual tensile stresses greater than 13.8

kPa (200 psi) shall not remain in the solder connection after cooling.

5.1.11 Storage containers. Containers or bags which are utilized to store printed wiring boards, solderable components, or solderable wire shall be of a material that does not introduce gases or chemicals which are detrimental to the item or its solderability. In the case of tape and reel components, the tape and reel materials shall not detrimentally affect the solderability of the surfaces to be subsequently soldered. Bags, containers and tape and reel materials used for storage of electrostatic sensitive devices shall provide device protection in accordance with MIL-STD-1686.

NOTE: Containers, bags, tape and reel materials, or combinations may be verified under accelerated aging test conditions to determine whether item solderability is detrimentally affected. Silicones, sulphur compounds, polysulphides, etc., have been found to be detrimental to component solderability.

5.2 Defect prevention.

5.2.1 Solderability. The contractor's material control system shall establish a solderability testing schedule which ensures parts are solderable at the start of manual or machine soldering operations. The contractor shall establish material control and storage procedures which ensure minimal part solderability degradation.

5.2.1.1 Solderability testing of components and printed wiring boards. Unless otherwise specified in the part specification, the solderability of parts shall meet the requirements of MIL-STD-750 Method 2026 for semiconductors, MIL-STD-883 Method 2003 for microelectronics, MIL-P-55110 for rigid printed wiring boards, MIL-P-50884 for flexible and rigid-flex printed wiring boards, MIL-STD-202 Method 208 with only one hour of steam aging (insulation removed) for wire, and MIL-STD-202 Method 208 for all other parts not listed above. Where the part specification does not require solderability testing, then solderability shall be tested to MIL-STD-202 Method 208. Electroplated tin-lead finishes shall be fused and shall conform to MIL-P-81728. As an exception, magnet wire need not be solderability tested.

5.2.1.2 Solderability testing of ceramic boards. Metallic elements of ceramic printed wiring boards shall be tested as specified in IPC-HM-860 or an equivalent method. Testing may be performed on coupons in lieu of actual boards provided that the coupons were prepared at the same time, from the same lot of materials, and stored under the same conditions as the boards in question.

5.2.1.3 Solderability testing for low temperature soldering processes. Components to be soldered at a temperature below 230°C (450°F) shall be solderability tested per the applicable requirements of 5.2.1.1, except that the solder test temperature shall be at least 8°C (15°F) below the soldering process temperature.

5.2.2 Cleanliness. Work areas and tools shall be maintained in a clean and orderly condition. There shall be no visible foreign material including dirt, chips, grease, silicones, flux residue, solder splatter, solder balls, insulation residue and wire clippings at any work station. Eating, smoking, or drinking at a work station shall be prohibited. Containers of hand creams, ointments, perfumes, cosmetics, and other materials unessential to the fabrication operation, except hand creams approved and controlled for use in electronics areas, are prohibited at the work station.

5.2.3 Insulation stripping. Chemical stripping agents shall be neutralized or removed prior to soldering. After insulation removal, insulation deformation shall not exceed 20% of the insulation thickness. Insulation discoloration resulting from thermal stripping is permissible.

5.2.4 Lead forming. Lead forming shall not damage the part-to-lead interface, the lead seal, lead material or part body beyond the damage limits allowed in the part specification. See table I, defect 1.

5.2.4.1 Surface mounted device lead forming. Leads shall be supported during forming to protect the lead-to-body seal. Bends shall not extend into the seal (see figure 16).

5.2.5 Maintenance of solder purity. Solder purity shall be maintained. Before soldering a printed wiring board, all dross appearing on the solder contact surface shall be removed. Dross blankets may be used provided the blankets do not contaminate the solder. If the amount of any individual contaminant or the total of contaminants listed exceeds the percentages specified in table IV, the solder shall be replaced or altered to be brought within specifications.

5.2.5.1 Inspection for solder purity. Solder in solder baths shall be chemically or spectrographically analyzed or renewed at the testing frequency levels shown in table IV, column B. These intervals may be lengthened to the eight hour operating days shown in column C, when the results of analyses provide definite indications that such action will not adversely affect the purity of the solder bath. If contamination exceeds the limits of table IV, intervals between analyses shall be shortened to those eight hour operating days shown in column A or less until continued purity has been assured by analyses. Records containing the results of all analyses and solder bath usage shall be available for Government review.

5.3 Process controls and defect reduction.

5.3.1 Preparation for soldering.

5.3.1.1 Wire and lead wrap around. Leads and wires shall be mechanically secured to their terminals before soldering. Such mechanical securing shall prevent motion between the parts of a connection during the soldering operation.

5.3.1.2 Tinning of stranded wire. Portions of stranded wire which will be soldered shall be tinned prior to mounting. The solder shall penetrate to the inner strands of the wire and shall wet the tinned portion of the wire.

Table IV. Contamination limits.

Contaminant 1/	Maximum Contamination Limits Percent by Weight: Preconditioning (Lead/Wire Tinning)	Maximum Contamination Limits Percent by Weight: Assy Soldering 2/ (Pot, Wave, Etc.)	Interval Between Testing 8 Hr Operating Day 3/: A	B	C	Solder Joint Characteristic Guidelines (If Solder is Contaminated) 4/
Copper	.75	.30	15	60	60	Sluggish solder flow, solder hard and brittle
Gold	.50	.20	15	60	60	Solder grainy and brittle
Cadmium	.01	.005	15	30	60	Porous and brittle solder joint, sluggish solder flow
Zinc	.008	.005	15	30	60	Solder rough and grainy, frosty and porous High dendritic structure
Aluminum	.008	.006	15	30	60	Solder sluggish, frosty and porous
Antimony	.50	.50	15	60	120	
						Too much: Solder brittle
Iron	.02	.02	15	60	120	Iron tin compound FeSn2 is not solderable Compound on surface presents resoldering problems.
Arsenic	.03	.03	15	60	120	Small blister-like spots
Bismuth	.25	.25	15	60	120	Reduction in working temperature
Silver 5/	.75	.10	15	60	120	Dull appearance - retards natural solvent action
Nickel	.025	.01	15	60	120	Blisters, formation of hard insoluble compounds

1/ The tin content of the solder bath shall be within 1% of the limits of QQ-S-571 for the solder specified and tested at the same frequency as testing for copper/gold contamination. The balance of the bath shall be lead and/or the items listed above.

2/ The total of copper, gold, cadmium, zinc and aluminum contaminants shall not exceed .4% for assembly soldering.

3/ An operating day constitutes any 8-hour period, or any portion thereof, during which the solder is liquified and used.

4/ See paragraph 4.19.2.2.

5/ Not applicable for Sn62 solder - limits to be 1.75—2.25 (both operations).

5.3.1.3 Gold removal. Except for surface mounted parts, gold shall be removed from the to-be-soldered surfaces of parts plated with 100 microinches or more of gold. For surface mounted parts, the gold shall be removed from at least 95% of the total gold plated surface and there shall be no gold on to-be-soldered areas of the part.

5.3.2 Process controls. The contractor shall prepare, maintain and conform to process control procedures for all processes, inspections and tests required in this standard. These procedures shall describe in detail the operating procedures and parameters for the proper operation of automatic soldering machines, automatic lead forming, cutting, clinching, and part mounting equipment, cleaning and cleanliness test equipment, and associated equipment. These procedures shall provide sufficient detail to allow accomplishment by personnel of the appropriate skill level. They shall also delineate the accept/reject criteria and any special inspection requirements. For the soldering machine, these procedures, as a minimum, shall define the preheat temperature, soldering temperature, rate of travel, and frequency of temperature verification measurements. When process parameters must be adjusted for different assemblies, the process documentation shall identify the parameter values for each assembly, drawing number, or other positive identification means. The process documentation shall address maintenance schedules and contamination testing. Ineffective process control shall be grounds for disapproval of the process and associated documentation.

5.3.2.1 Process capability. The manufacturer is encouraged to offer objective evidence of controlled manufacturing processes as an alternative to some of the examinations and tests specified herein. Such evidence should demonstrate achievement and maintenance of a Process Capability Index (C_p) of at least 1.33 (i.e. demonstrating that the process is capable of producing product within the requirements of this standard) and a Process Performance Index (C_{pk}) of at least 1.33 (i.e. demonstrating that the process fits and is centered within the requirements of this standard) for the product characteristics specified in table I. The contractor may develop C_p and C_{pk} indices and process data for variances other than those listed in table I (process variances). C_p's and C_{pk}'s shall be established which reflect the concept of continuous process improvement. Objective evidence may be in the form of control charts derived from application of process control or variables data (attributes data is not acceptable) from inspection, non-destructive evaluation, data from machines operating under adaptive controls or periodic testing of production samples. The decision to accept the process control evidence as a suitable alternative will be at the discretion of the government representative designated in the contract for product acceptance.

5.3.2.2 Machine soldering processes. As part of the machine soldering process and its documentation (for all systems, including wave, vapor phase reflow, infrared reflow, etc.), manufacturers shall define a preheat schedule, dependent on the process selected, the flux, and the board and assembly design such that the assembly is properly preheated prior to soldering. The soldering process and its documentation shall provide consistent thermal profiles for each assembly type processed. The preheat and thermal profile requirements shall ensure proper flux activation, proper solder wetting, and shall ensure that thermal shock and excessive thermal stresses are avoided.

5.3.2.3 Processes affecting hole fill.

5.3.2.3.1 Via holes. Via holes shall not be filled by manual soldering operations. Via holes may be either filled or left unfilled by machine soldering operations in accordance with the government approved drawing. If an unacceptable hole fill results, the solder shall be removed and the hole left unfilled.

5.3.2.3.2 Through holes. When filling a plated-through hole with a lead or wire inserted, the hole shall be filled with solder from one side only.

5.3.2.3.3 Cup and hollow cylindrical terminal soldering. Wires shall be soldered into solder cup terminals in a manner which assures complete solder fill of the cup and precludes entrapment of the flux.

5.3.3.3 Lead forming. The leads of leaded surface mounted components shall be formed to their final configuration prior to mounting. Leads shall be formed with dies or other appropriate tools such that they may be soldered into place by subsequent processes without application of external loads. When the leads of DIPs, flatpacks, and other multileaded devices become misaligned during processing or handling, they shall be straightened to ensure parallelism and alignment prior to mounting. The leads of DIPs, flatpacks, and other multileaded devices shall be bent outward by the lead forming operation.

5.3.3 Defect reduction. Continuous process improvement techniques shall be implemented to reduce the occurrence of defects. When processes vary beyond established process control limits, corrective action shall be taken to prevent reoccurrence. When corrective action is ineffective within 30 days of implementation, the problem shall be escalated to plant management for resolution.

5.3.3.1 Variance reduction. The defects listed in table I require mandatory scrap, repair, or rework. All other variances from the requirements of this standard shall be minimized with the goal of elimination (where economically practical) through process corrective action. Failure to implement process corrective action and continuously ineffective process corrective action shall be grounds for disapproval of the process and associated documentation.

5.3.4 Cleaning. The contractor shall develop a documented cleaning process or processes. The maximum time between other processes (part mounting, soldering, rework, etc.) and cleaning shall be selected to assure that parts, subassemblies, and assemblies can be completely cleaned. Complete cleaning shall be performed prior to the end of the production shift. The cleaning process shall have no deleterious effect on the parts, connections, and materials being cleaned. Items shall be cleaned in a manner that will prevent both thermal shock and moisture intrusion into components which are not totally sealed.

NOTE: Chlorofluorocarbon (CFC) based solvents have been proven to be hazardous to the environment. Their continued use is not recommended and should be phased out. Use of solvent reclamation systems is encouraged.

5.3.4.1 Ultrasonic cleaning. Ultrasonic cleaning is permissible:

a. on bare boards or assemblies, provided only terminals or connectors without internal electronics are present, or

b. on electronic assemblies with electrical components, provided the contractor has documentation available for review showing that the use of ultrasonics does not damage the mechanical or electrical performance of the product or components being cleaned.

5.3.5 Cleanliness testing. Periodic testing of ionic cleanliness of the product after final cleaning (i.e. the cleaning prior to conformal coating, encapsulation, or incorporation into the next higher assembly) shall be conducted to ensure the adequacy of the cleaning process(es). As a minimum, a representative sample of each product type (i.e. part number, etc) or the most complex assemblies processed through final cleaning shall be tested on a daily basis. If any assembly fails, the entire lot shall be recleaned and retested. The resistivity of solvent extract test, or the sodium chloride (NaCl) salt equivalent ionic contamination test, or an equivalent test, which is fully documented and available for review by the government, shall be used to test for ionic cleanliness. The resistivity of solvent extract test shall have a final value greater than 2 megohm-centimeters. The sodium chloride salt equivalent ionic contamination test shall have a final value less than 1.55 micrograms per square centimeter (2.2×10^{-8} lb_m/in^2) of board surface area. There shall be no visible evidence of flux residue or other contamination. The resistivity of solvent extract test and the sodium chloride salt equivalent ionic contamination tests are defined in Appendix C. Alternative equipment, with the appropriate equivalence values, may be used to verify cleanliness.

NOTE: 2.2×10^{-8} lb_m/in^2 is equivalent to 10 micrograms/in^2.

5.3.5.1 Qualification of cleaning and cleanliness testing processes for surface mounted assemblies. Prior to use on production hardware which includes surface mounted components, the manufacturer shall test representative control assemblies and define acceptable ionic cleanliness testing equipment, processes and control parameters. The combined action of the equipment, process and controls shall consistently verify that the sodium chloride or equivalent ionic contamination test value for the production hardware is less than 1.55 micrograms per square centimeter (2.2×10^{-8} lb_m/in^2) of board surface area. The representative control assemblies used for establishing the test method shall be processed using the same materials, parts and designs that will be used in the production hardware.

> NOTE: As a general rule, the combination of the ionic cleanliness testing equipment, processes and control parameters used for through-hole mounted devices and assemblies are not adequate for verification of the ionic cleanliness of surface mount assemblies.

5.3.6 Conformance verification. The contractor shall be responsible for conformance to the product and process requirements specified in this standard. All process and product inspections and tests required by this standard shall be performed either directly or by subcontract. The contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein unless such other facilities are disapproved by the Government. The Government reserves the right to perform an audit or survey addressed to any requirements set forth herein when such an audit is deemed necessary to assure that the supplies and services conform to the prescribed requirements.

5.3.7 Inspection of soldered connections and assemblies. Assemblies shall be inspected to assure conformance with the end-item requirements of this document and the assembly drawings. One hundred percent inspection of all solder connections and assemblies shall be performed. During inspection, the contractor shall document the occurrence of all defects and variances (see paragraph 4.4) except as provided in 5.3.7.2. Rework shall not be performed until the defects and process variances have been documented. This data shall be used to provide an indication of possible causes and to determine if corrective actions are required.

> NOTE: Through-out this document, part mounting and solder fillet requirements contain dimensions in the form of actual numbers and percentages. Except for referee purposes, actual measurement of these dimensions is not required provided the contractor has implemented a system of periodic verification to ensure conformance. Where actual measurements are performed, nominal dimensions specified in the part drawing may be substituted for actual measurement of hidden (e.g., underside metallization) dimensions.

5.3.7.1 Hidden connections. Component side connections on densely populated printed wiring assemblies and hidden connections shall be inspected to the extent that the component side connections are visible provided that:

a. it may be demonstrated to the government that the design does not prevent adequate solder flow to any connection element on the component side of the assembly;

b. the visible portions of the connection (both component and solder side) fully conform to the requirements specified herein; and

c. process controls are maintained in a manner assuring repeatability of assembly techniques.

5.3.7.1.1 Connectors with hidden cavities. When connectors contain hidden cavities (for stress relief and to facilitate solder flow) (see figure 28) which precludes visual inspection to the criteria contained herein, acceptability of hidden connections shall be based on verification that the connector design includes internal provision for stress relief and cavities which permit solder flow.

5.3.7.2 Sample based inspection. As an exception to 5.3.7, sample based inspection may be used when done as part of a process control system which is fully documented and subject to review. When sample based inspection is used, the process control system shall include the following elements as a minimum:

a. Training, commensurate with their responsibilities, shall be provided to personnel assigned to the development, implementation, and utilization of process controls and statistical methods.

b. Quantitative evidence shall be maintained that the process is in statistical control and is a capable process.

c. Sampling techniques shall be statistically based and consistent with data collection requirements for maintaining process control.

d. Criteria for switching between sampling and 100% inspection shall be defined. Sampling may not be used unless the defect rate is less than 2,700 parts per million. When processes become out of control, the contractor shall revert to 100% inspection for the lot which is represented by the sample hardware.

e. When defects in table I are identified in the inspected sample, all hardware in that lot shall be 100% inspected for other occurrence of that defect or defects. The reinspection of the lot shall be documented.

5.3.7.3 Automated inspection (AI). Automated inspection processes may be used in lieu of portions of the visual inspection requirement where:

a. the AI system is part of an overall inspection and process verification system which provides report data and feedback for process control correction (where corrections are required);

b. the AI system accurately verifies that the assembly meets the requirements of this document for the conditions the AI system is designed to test for;

c. the AI system is used to inspect only for the defects which the system is capable of recognizing and is not used as a general waiver of the visual inspection requirement; and

d. the manufacturer has characterized his assembly (both design and final product) and defined inspection criteria such that the AI system is implemented using manufacturer defined inspection criteria which correspond to the requirements of this document.

5.3.7.4 Magnification aids and lighting. When visual inspection is used, it shall be performed using the magnification power specified herein. The tolerance for magnification aids is 15 percent of the selected magnification power (i.e. ± 15% or a range of 30 percent centered at the selected magnification power). Magnification aids and lighting used for inspection shall be commensurate with the size of the item being processed. The magnification used to inspect solder connections shall be based on the minimum width of the lands or termination areas used for the device being inspected. The following magnification shall apply:

Land Width	Inspection	Referee
> 0.5 mm (0.020 inch)	4X	10X
0.25 - 0.5 mm (0.010 - 0.020 inch)	10X	20X
< 0.25 mm (0.010 inch)	20X	30X

Referee conditions shall only be used to verify product rejected at the inspection magnification. For assemblies with mixed land widths, the greater magnification may be used for the entire assembly if the smaller land width is common to more than 50% of the connections inspected (see 6.3). Where different magnification powers are specified in table I (see defects 13, 16, and 19), the power specified in table I shall be used only for the characteristic (defect) described.

NOTE: Table I specifies magnification powers as a means for specifying solder quantities.

5.3.8 Inspection of reworked defects. Reworked defects, including each resoldered or reheated connection, shall be reinspected and shall conform to the acceptance criteria.

6. NOTES

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

6.1 Manufacture of devices incorporating magnetic windings. MIL-STD-2000 is very limited in its applicability to the manufacturing processes associated with the mounting of internal electronic elements and the soldering of the internal connections of transformers, motors, and similar devices. Unless a user has a specific need for the controls provided by MIL-STD-2000, it should not be imposed relative to the manufacture of the internal elements of these devices. However, the external interconnect points (i.e. terminals, pins, etc) shall meet the solderability requirements of this document and the device shall be adequately sealed to ensure it does not contaminate the final assembly (i.e. when active fluxes are used internally).

6.2 Guidance on requirement flowdown. Prime contractors are responsible for delivering fully compliant hardware to the government. The flowdown of MIL-STD-2000 requirements is generally stopped when the contractor reaches the commercial off-the-shelf or standard military part level. Where a part is adequately defined by a basic part specification (e.g. MIL-T-27 for transformers), then the requirements of MIL-STD-2000 shall be imposed on the manufacture of that part only when necessary to meet the end item requirements. When it is unclear where flowdown should stop, it is the responsibility of contractors to work with their cognizant government activities to determine which parts shall be considered commercial off-the-shelf or standard military parts.

6.3 Guidance on inspection power selection and defect identification. If the presence of a defect cannot be determined at the inspection power, the item shall be accepted. The inspector need not be able to accurately determine which defect is present at the inspection power. He need only recognize the presence of a defect. The referee power may be used to identify the defect accurately for documentation and process corrective action purposes. The referee power is intended for use only after a defect has been identified at the inspection power.

6.4 Supersession note. This standard is intended to replace all prior documents for electrical and electronic soldering. Where possible, this document should be used in lieu of prior documents on reprocurements. This will enable manufacturers to achieve a simpler manufacturing environment, eliminate the requirement for multiple production set-ups, and reduce errors induced by imposition of multiple sets of contracting requirements.

6.5 Subject term (key word) listing.

Connector
Electronic components assembly
Flux, soldering
Insulation sleeving, electrical
Printed circuit board
Printed wiring, flexible
Printed wiring board
Solder
Soldering iron
Wiring harness

6.6 Use of metric units. While inch, pound, and Fahrenheit units continue to be used by the United States Industry for manufacturing electronic assemblies, a move toward metric units has been led by the introduction of surface mount components. In this document, measurements are provided in metric units followed by either the inch-pound equivalent or an approximation of the inch-pound equivalent. Some conversions were approximate to facilitate the continued processing of older design assemblies where direct conversion would yield unreasonable values. It is recommended that manufacturers transition to the metric system. In the event of conflict or referee measurement, the metric measurement shall take precedence.

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

Custodian:
Air Force 20
Army MI
Navy AS
NSA NS

Preparing Activity:
Navy AS
(Project No. SOLD-0035)

Review activities:
AF 11, 15, 17, 19, 84, 99
Army AR, CR, ER, MR
Navy EC, OS
DLA ES, DH

User activities:
Army AV
Navy MC
DLA DH

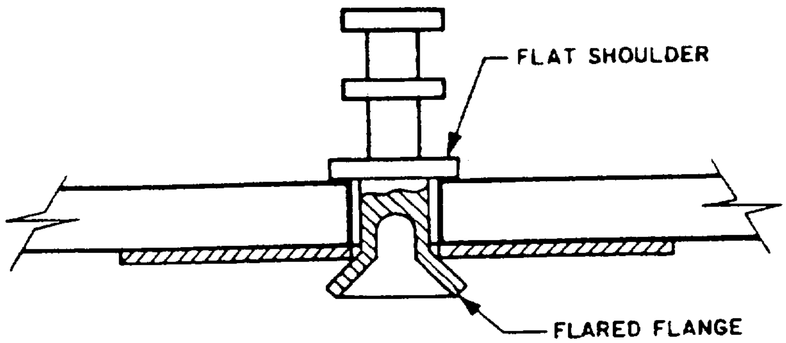


FIGURE 1. Turret terminal (see 4.12.7).

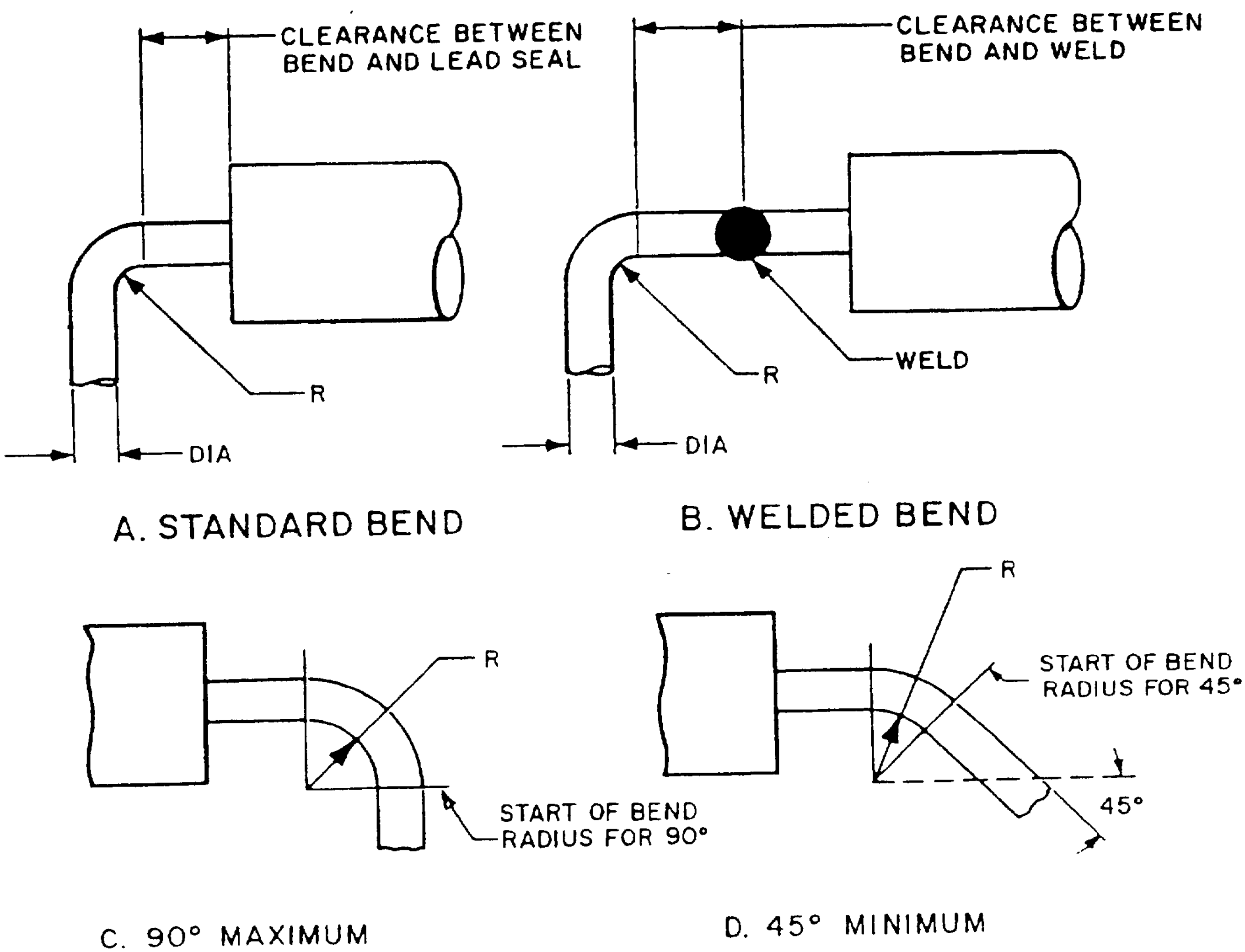
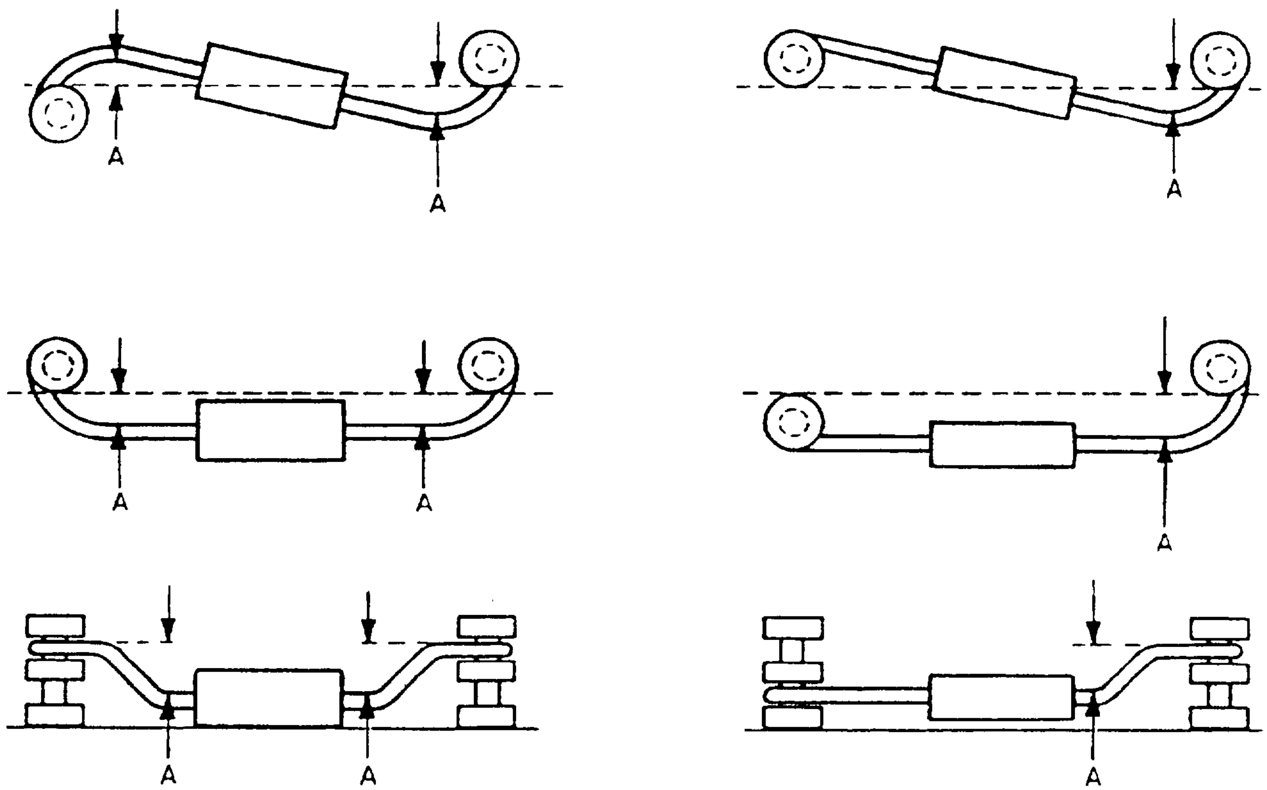


FIGURE 2. Lead bends (see 4.15).



Devices with bodies either secured or unsecured to the mounting surface

Alternate method for devices with bodies unsecured to the mounting surface

Measurement "A" is equal to or greater than two times lead diameter or thickness but not less than 0.75 mm (0.030 inch).

FIGURE 3. Typical stress relief bends (see 4.16).

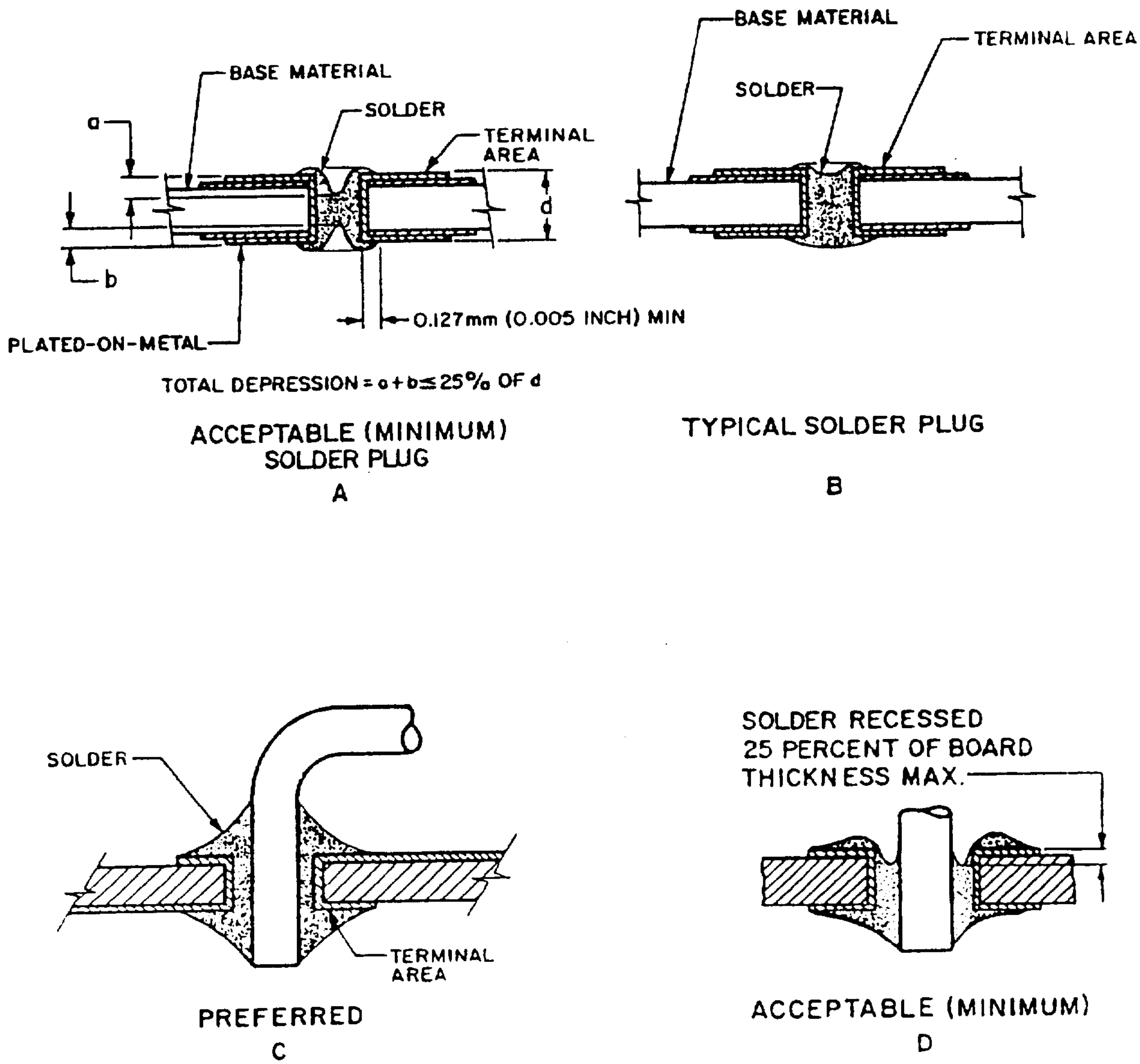


FIGURE 4. Plated-through hole interfacial and interlayer connections (see 4.22.1).

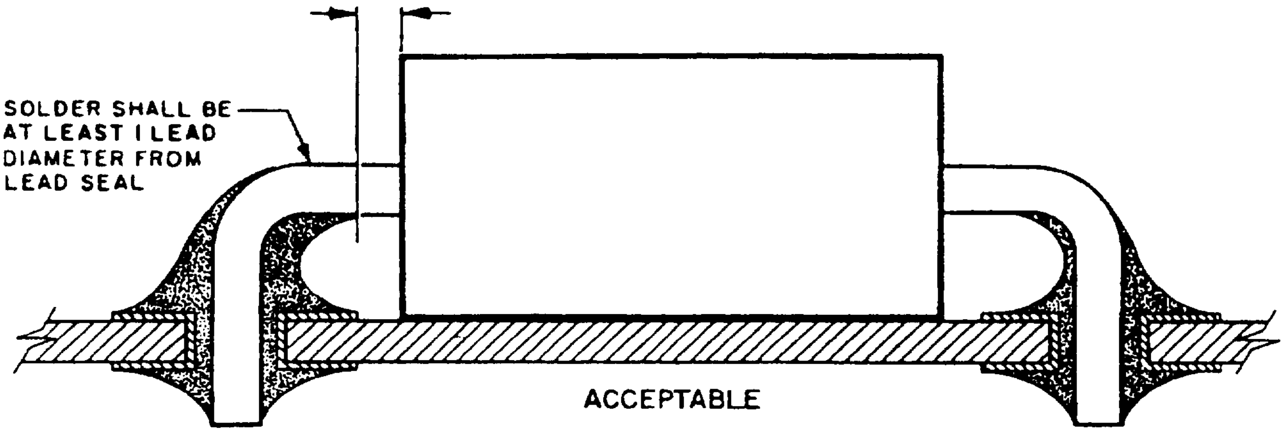


FIGURE 5. Solder in the lead bend radius (see 4.22.2).

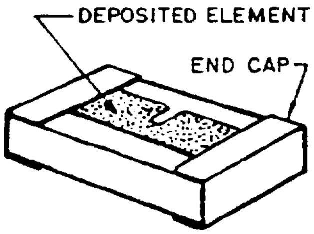


FIGURE 6. Chip resistor (see 4.23.2).

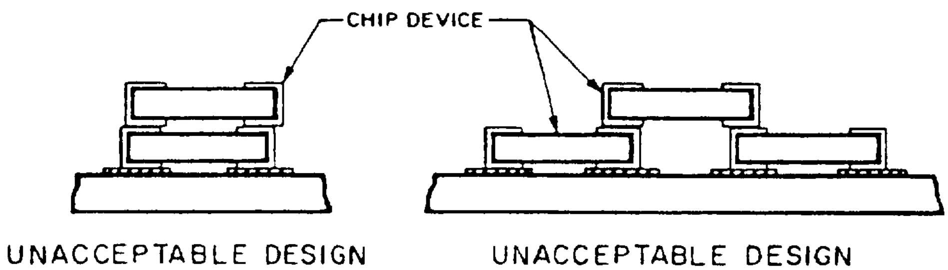


FIGURE 7. Mounting of chips (see 4.23.3.1).

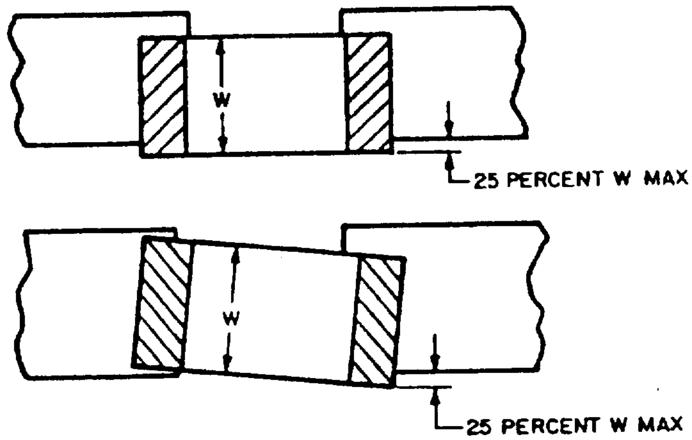


FIGURE 8. Chip side overhang (see 4.23.3.2).

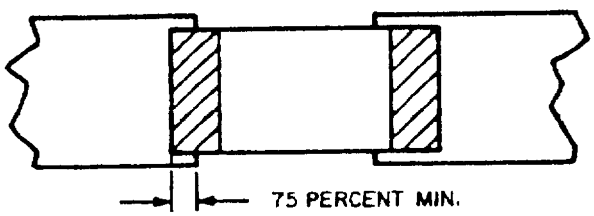


FIGURE 9. Minimum lap of chip on terminal area (see 4.23.3.2).

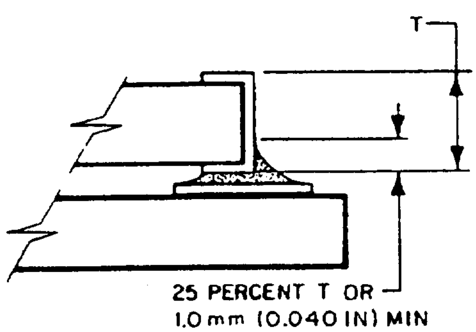


FIGURE 10. Solder fillet - chip devices (see 4.23.3.2).

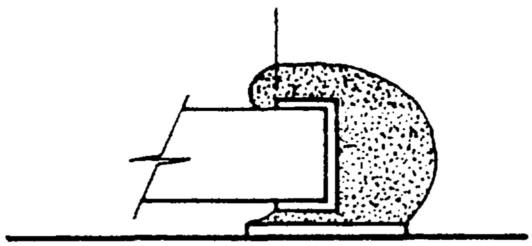


FIGURE 11. Excessive solder - parts encased (see 4.23.3.2).

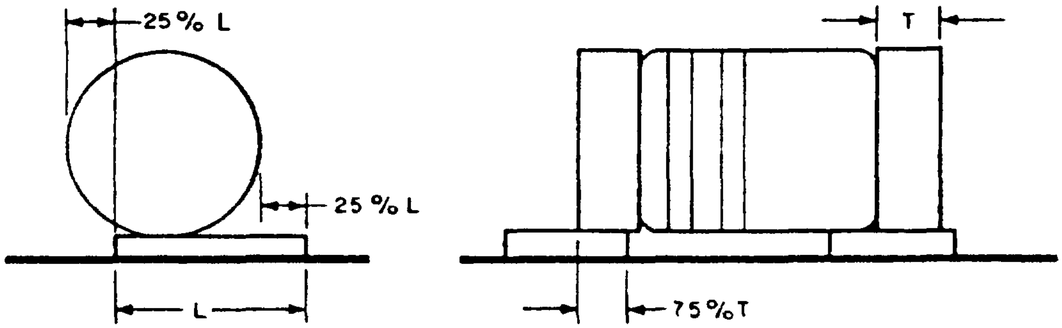


FIGURE 12. Mounting of MELFs (see 4.23.4).

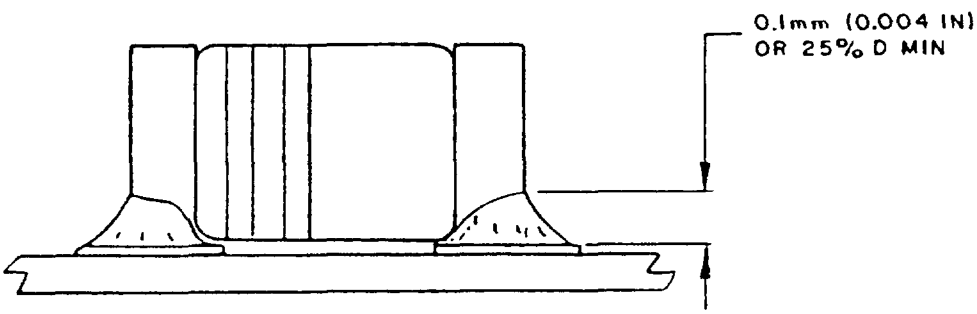


FIGURE 13. MELF solder fillet (see 4.23.4).

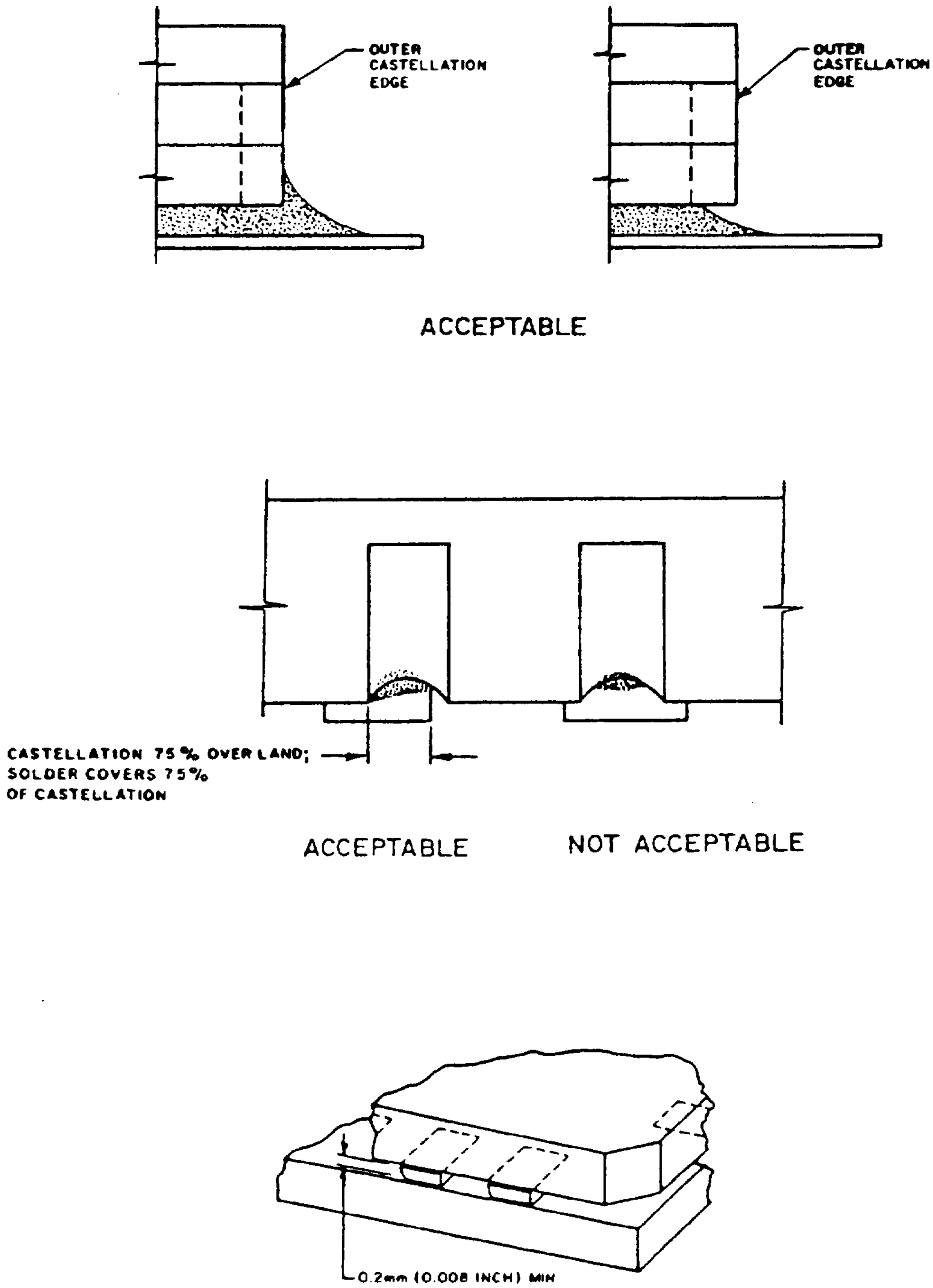


FIGURE 14. Leadless chip carrier solder fillet (see 4.23.5).

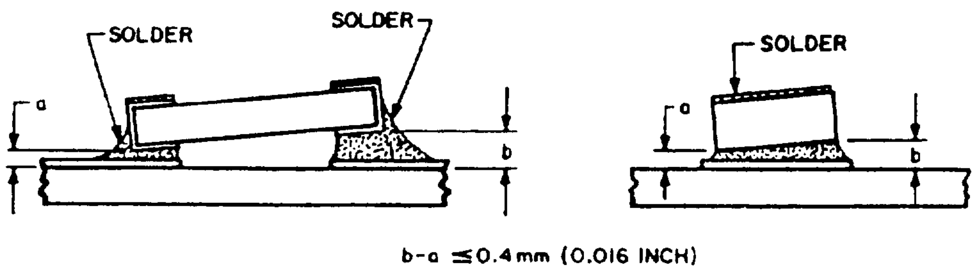


FIGURE 15. Parallelism of chip devices (see 4.23.6).

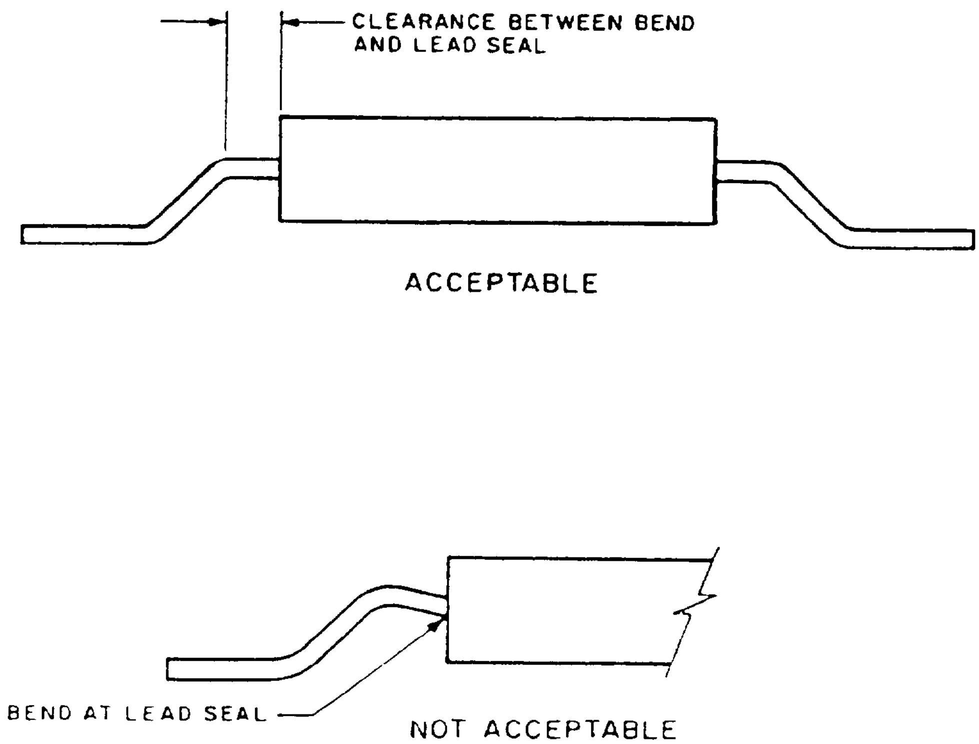


FIGURE 16. Surface mounted device lead forming (see 4.23.7.1).

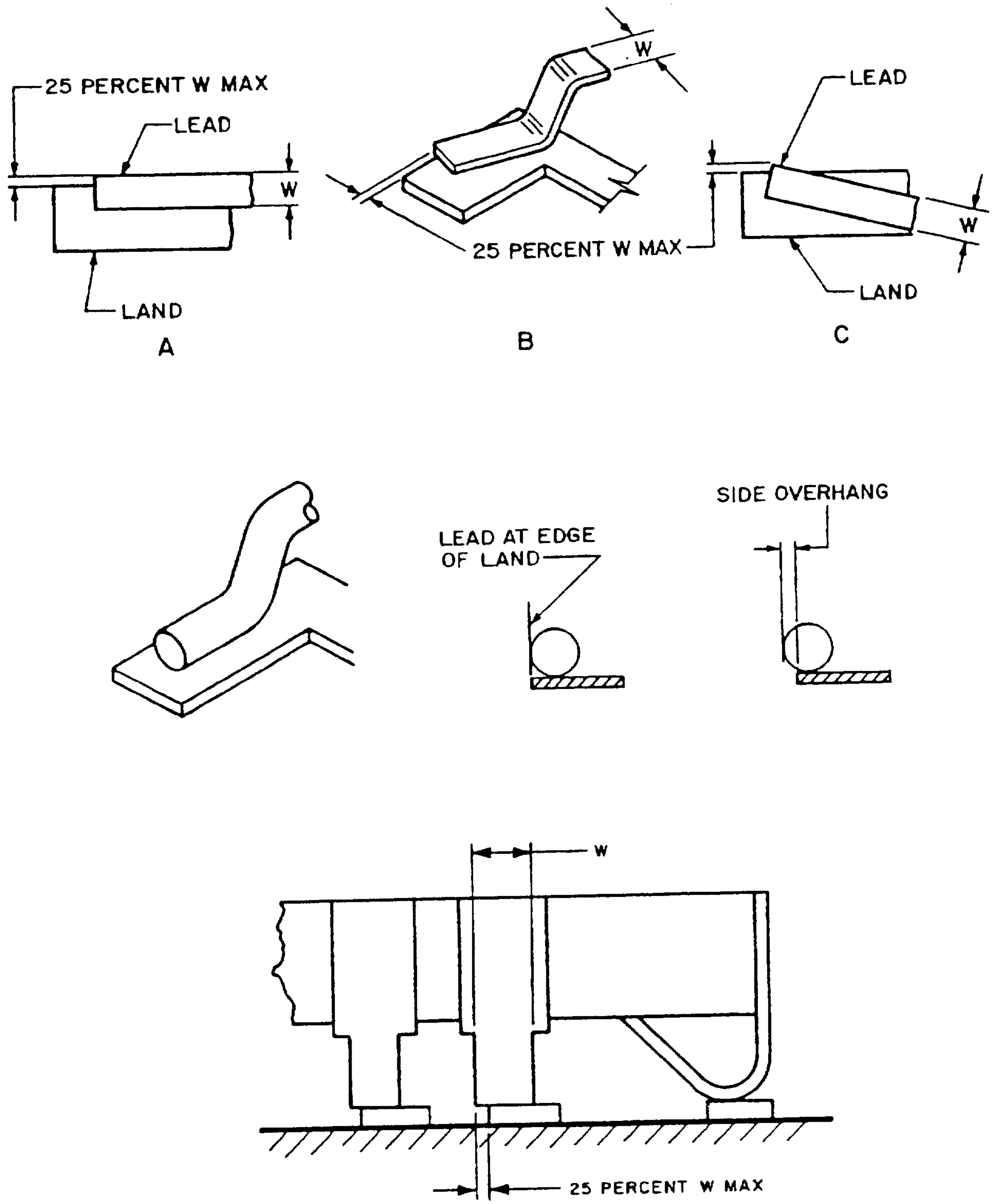


FIGURE 17. Lead overhang (see 4.23.7.2).

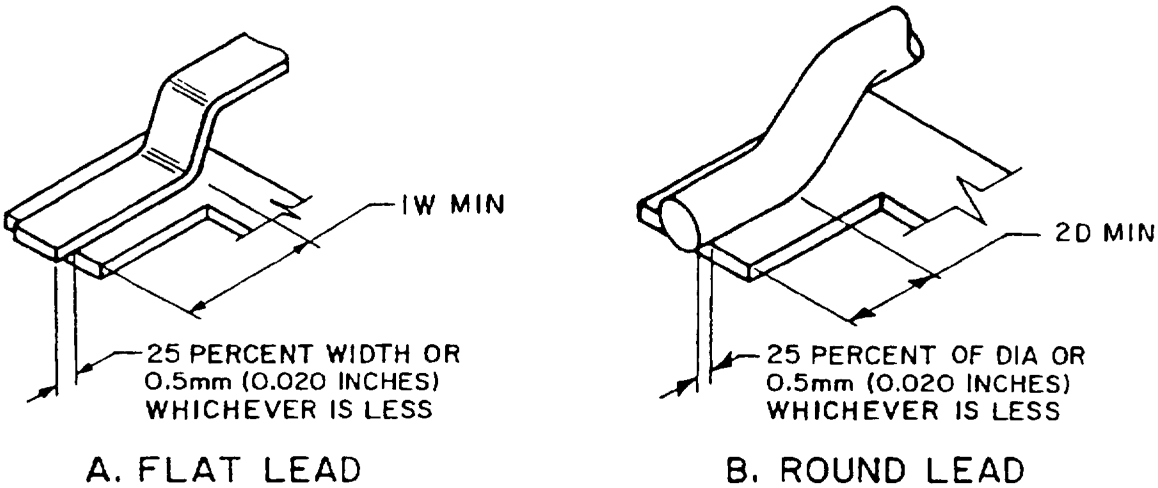


FIGURE 18. Surface mounted device lead toe overhang (see 4.23.7.2).

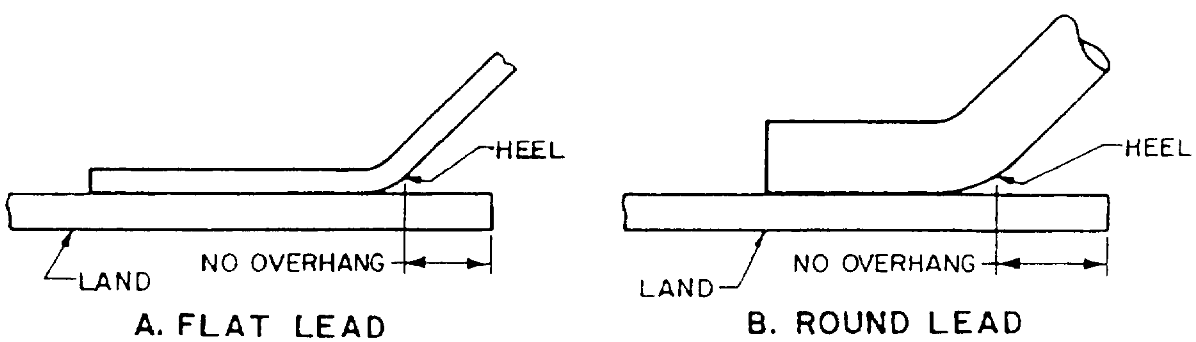


FIGURE 19. Surface mounted device lead heel clearance (see 4.23.7.2).

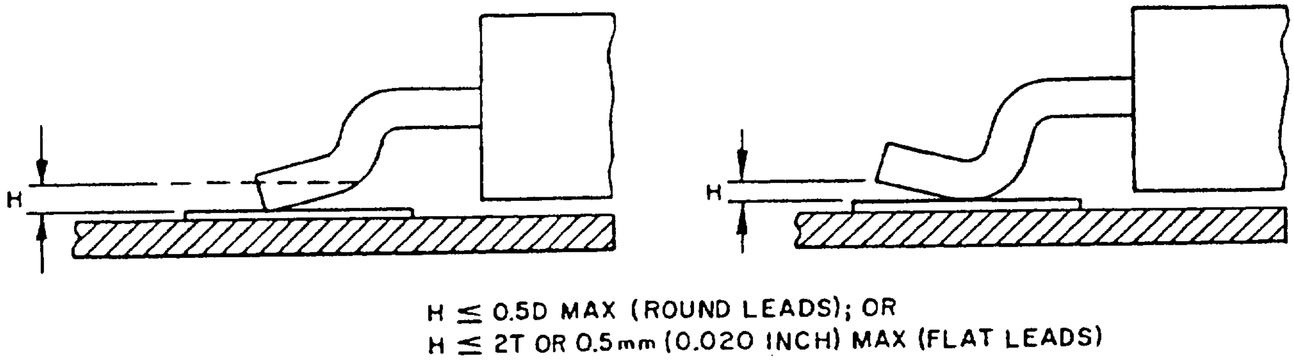


FIGURE 20. Surface mounted device lead height off land (see 4.23.7.3).

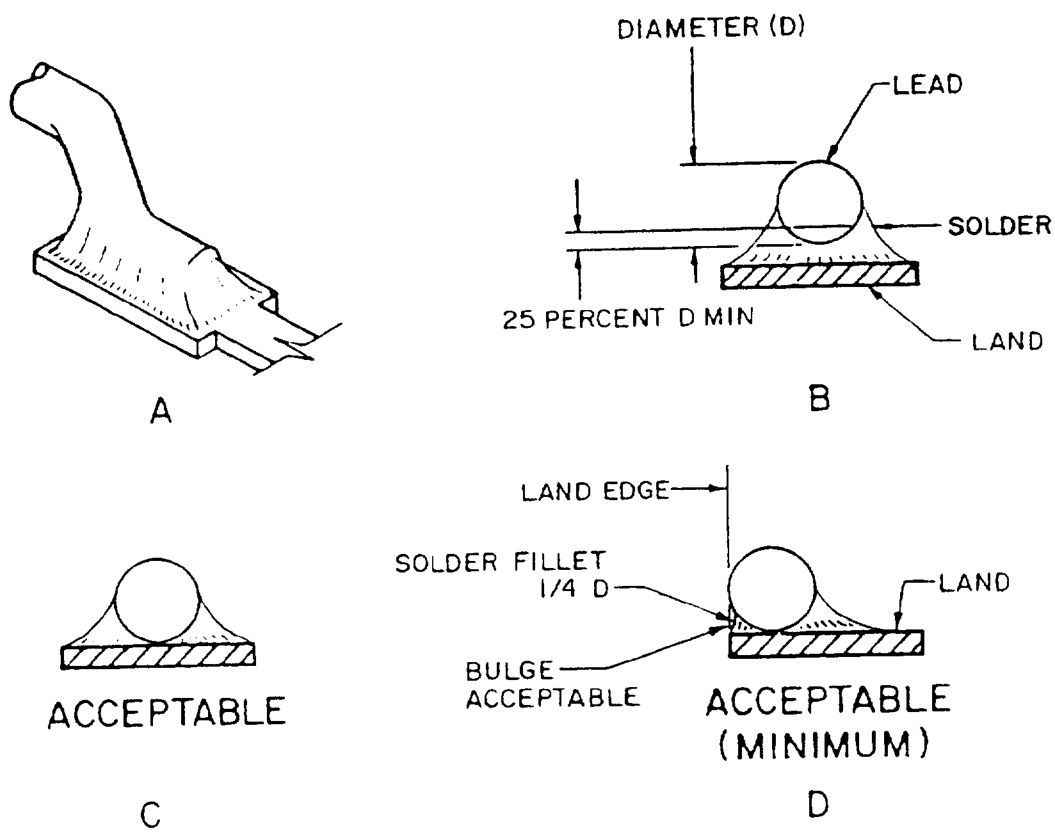
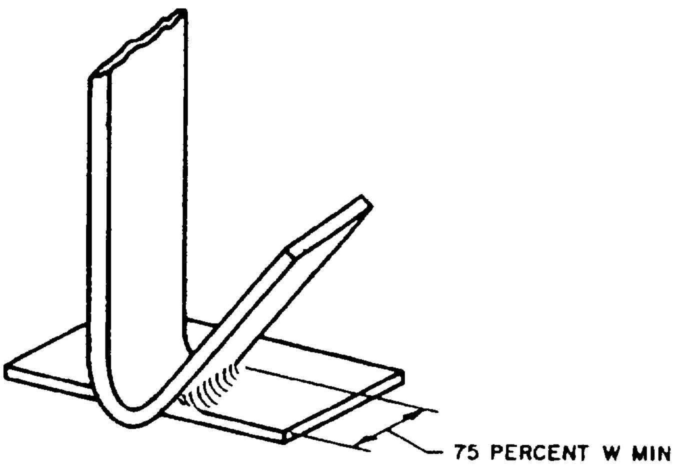


FIGURE 21. Surface mounted device round or coined lead solder fillet (see 4.23.7.4).



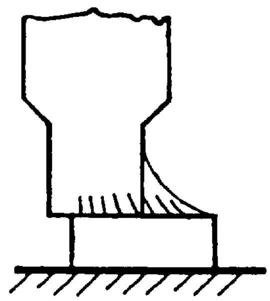


FIGURE 22. J-lead and V-lead solder fillet (see 4.23.7.7).

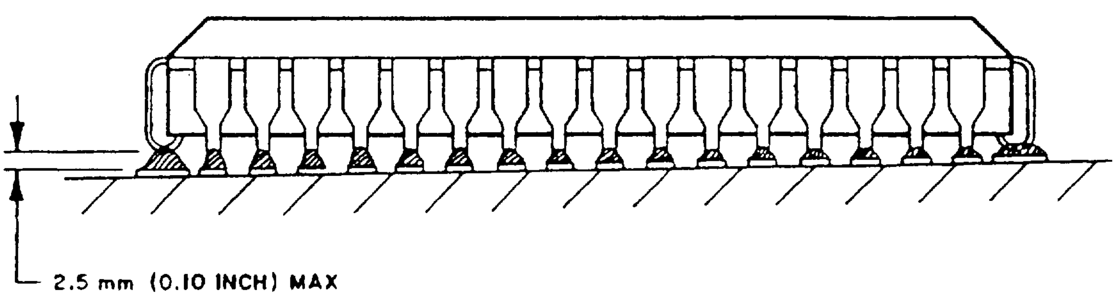


FIGURE 23. Maximum chip canting (see 4.23.7.8).

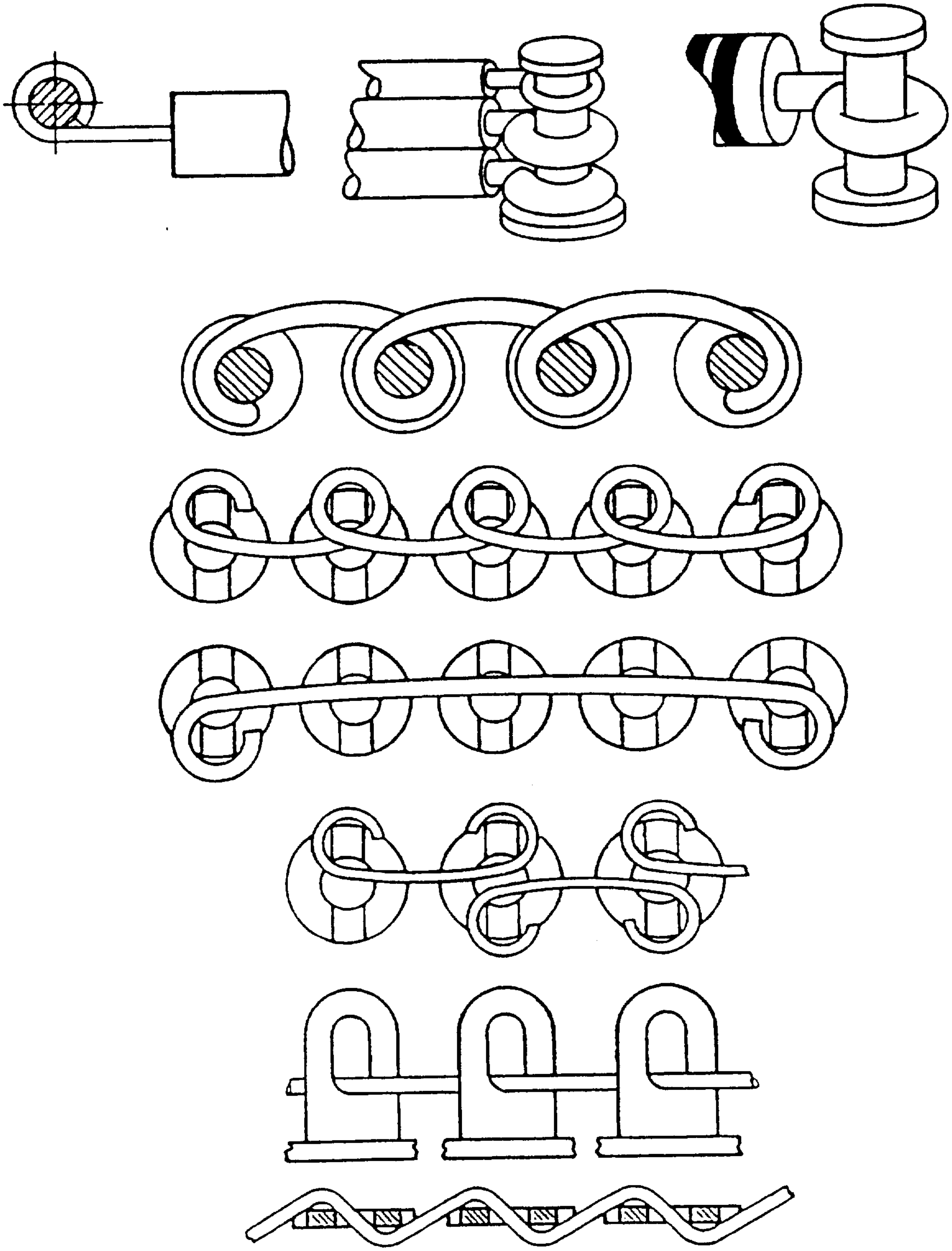
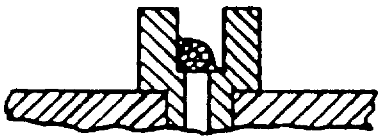


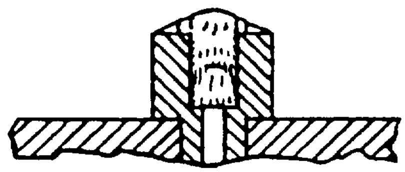
FIGURE 24. Wire and lead wrap/continuous runs (see 4.24.1).



MINIMUM AMOUNT OF SOLDER ALONG THE WIRE OR LEAD

WIRE OR LEAD END DISCERNIBLE IN TERMINAL

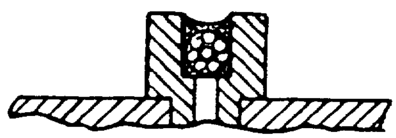
MINIMUM



SOLDER BUILDUP ON TOP OF TERMINAL

WIRE OR LEAD NOT DISCERNIBLE THROUGH TERMINAL

MAXIMUM



SOLDER COMPLETELY FILLS SLOT

WIRE OR LEAD DISCERNIBLE IN TERMINAL

PREFERRED

FIGURE 25. Wire and lead soldering to small slotted terminal (see 4.24.5).

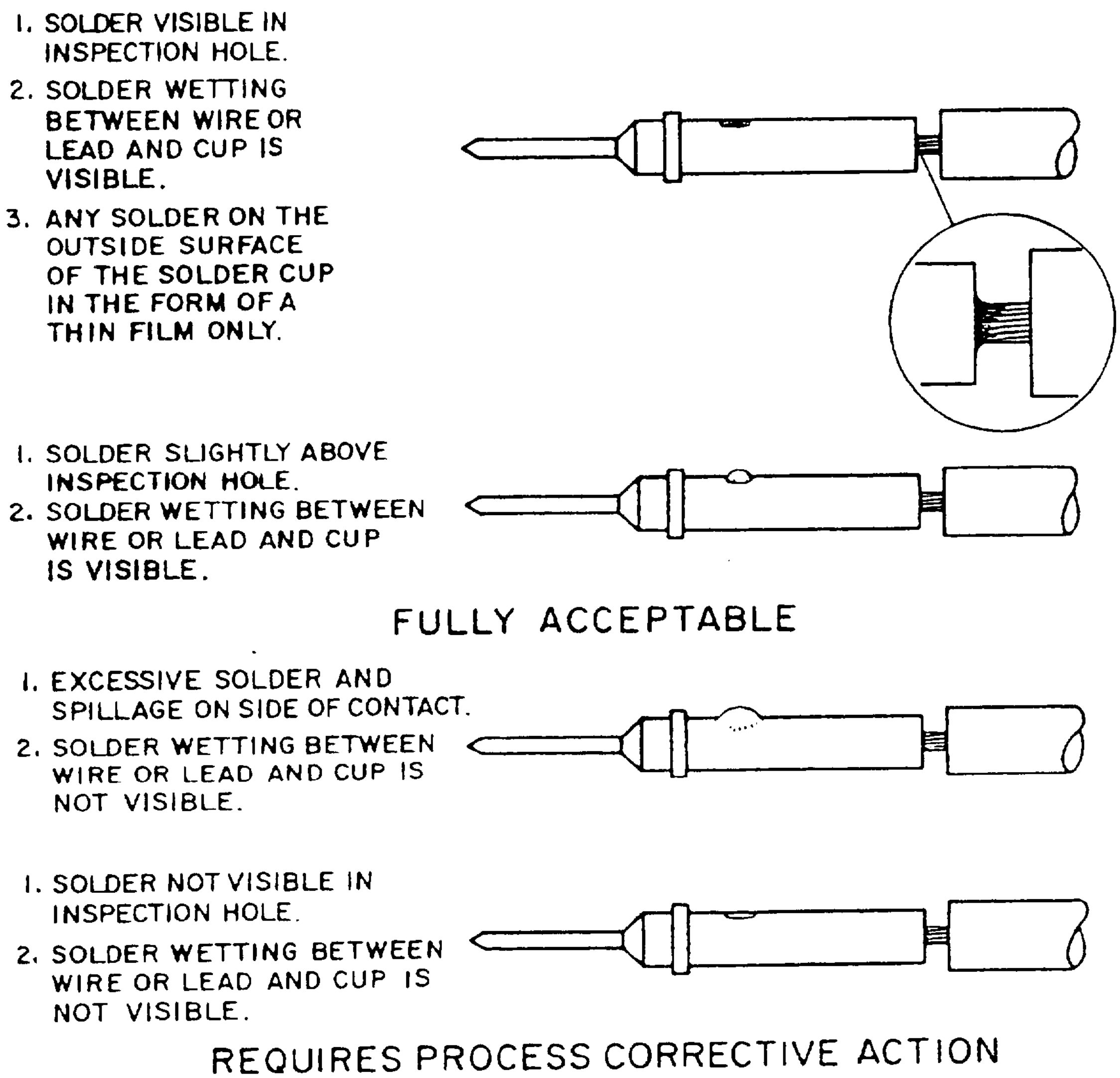


FIGURE 26. Wire and lead soldering to contacts (see 4.24.6).

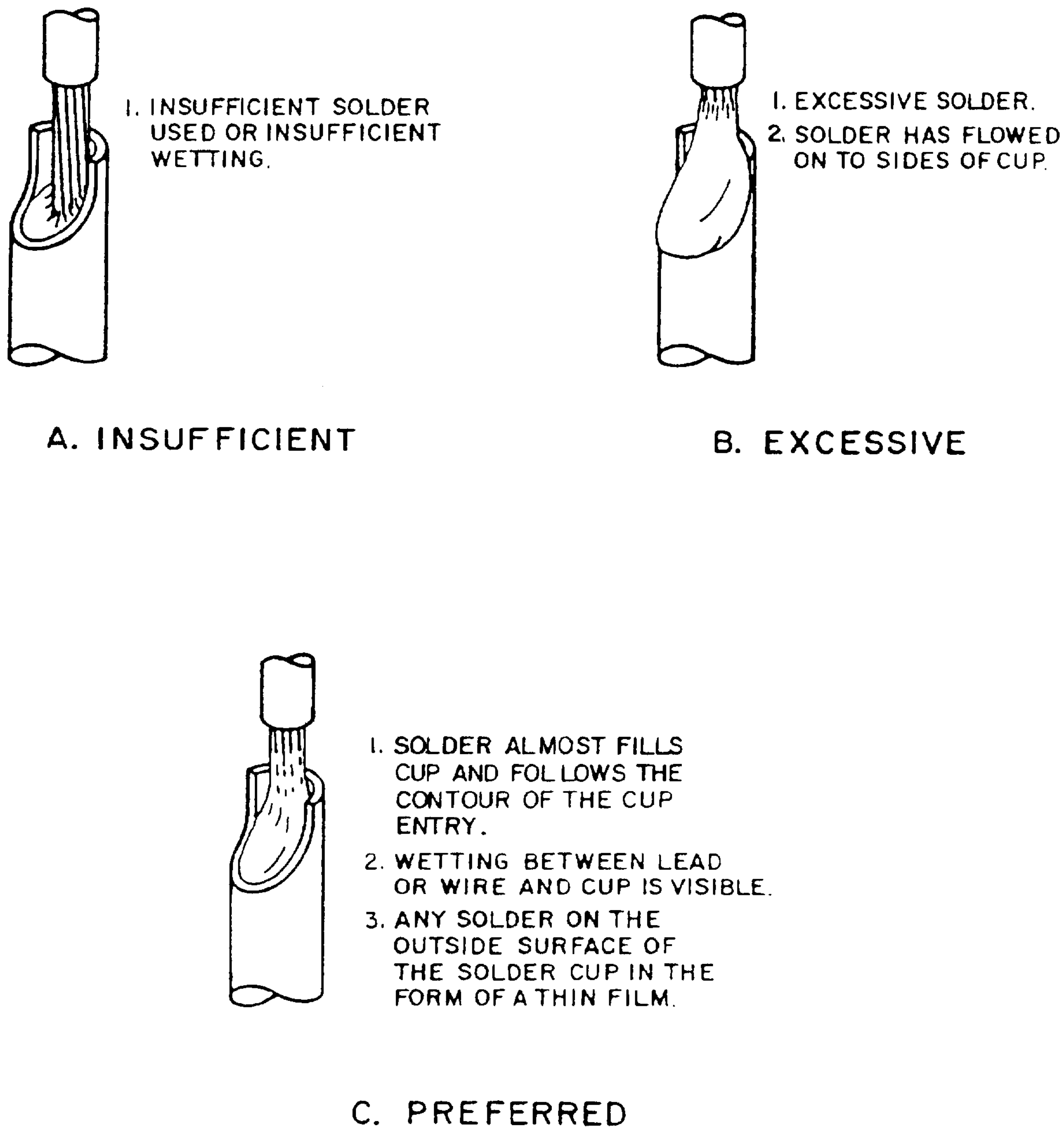
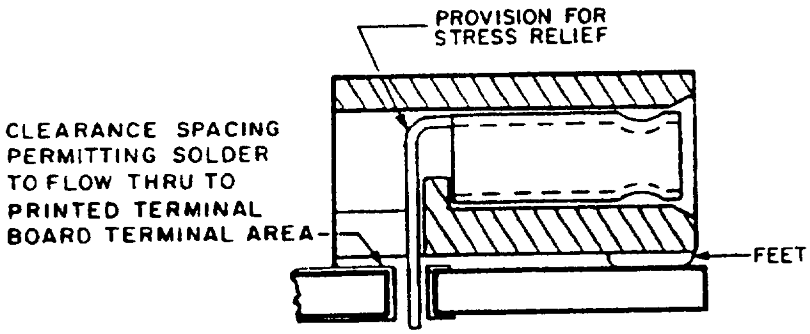
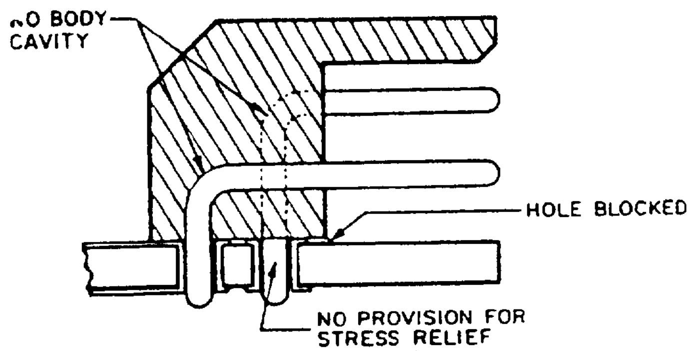


FIGURE 27. Wire and lead soldering to solder cups (see 4.24.6).



ACCEPTABLE



NOT ACCEPTABLE

FIGURE 28. Internal connector lead configurations (see 5.3.7.1.1).

APPENDIX A
CONTROL OF FLUXES

10. SCOPE.

10.1 Scope. When a contractor uses non-rosin fluxes, this appendix defines mandatory test requirements.

20. APPLICABLE DOCUMENTS.

20.1 Government documents.

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

SPECIFICATIONS

MILITARY

MIL-I-46058	Insulating Compound, Electrical for Coating Printed Circuit Assemblies

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building #4, Section D, Philadelphia, PA 19111-5094.

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

INSTITUTE FOR INTERCONNECTING AND PACKAGING ELECTRONIC CIRCUITS (IPC)

IPC-B-36	IPC CFC Benchmark test assembly

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

30. TERMS AND DEFINITIONS. Not Applicable.

40. GENERAL REQUIREMENTS.

40.1 Nonrosin based fluxes for component tinning. Other fluxes may be used for tinning component leads of sealed devices, epoxy bodied parts, solid bus wire, and terminals provided the following process information is available for review:

a. Chemical characterization of each flux to assure adequate incoming inspection control;

b. A detailed control system for procurement, receiving, testing, storage, usage, and application;

c. Detailed flux removal and cleaning process and monitoring requirements; and

d. Proof of cleanliness testing methods and results.

The system for controlling nonrosin based flux usage shall meet the requirements of 4.6.3 and 4.6.4.

40.2 Nonrosin based fluxes for soldering printed wiring assemblies. Other fluxes may be used for soldering component leads of sealed devices, epoxy bodied parts, solid bus wire, and terminals to printed wiring assemblies provided the following process information is available for review:

a. A minimum of 24 IPC-B-36 assemblies are fabricated using the proposed solder flux, soldering process and cleaning system using four 68 I/O LCCs for each printed wiring assembly. The conformal coating selected for the design shall be applied and cured in accordance with production requirements. If a manufacturer employs multiple conformal coatings, a sample set of at least 24 printed wiring assemblies shall be tested for each coating to be used. If a manufacturer will use the flux on uncoated assemblies, a sample set of at least 24 uncoated assemblies shall be tested.

b. These assemblies shall be tested in accordance with the moisture resistance test method of MIL-I-46058. The insulation resistance between adjacent pads of the 68 I/O chip carriers (i.e. daisy chain pattern) shall comply with the following requirements:

(1) Insulation resistance shall not be less than 100 megohms during the high humidity portion of the test.

(2) Insulation resistance shall not be less than 5000 megohms when tested within 24 hours of completion of the high humidity portion of the test.

(3) Within 24 hours of completion of the high humidity portion of the test, the assemblies shall comply with the visual inspection (appearance) requirements of MIL-I-46058.

APPENDIX B

PART MOUNTING REQUIREMENTS

10. SCOPE.

10.1 Scope. Unless the contractor elects to define alternate part mounting requirements on the government approved assembly drawing, this appendix defines mandatory requirements for part mounting.

20. APPLICABLE DOCUMENTS. Not Applicable.

30. TERMS AND DEFINITIONS. Not Applicable.

40. GENERAL REQUIREMENTS.

40.1 Lead terminations. The length of the clinched portion of wires and component leads shall be no less than one-half the largest dimension (usually the diameter) of the terminal area or 0.8 mm (0.03 inch), whichever is greater, and no more than the diameter (or length) of the termination area (see figure B-1A). The lead length shall be determined prior to soldering. The clinch of leads on opposite ends or sides of a component shall be directed in opposite directions (see figure B-1B).

40.1.1 Lead clinch restrictions. Fully clinched leads are not applicable for leads of dual-in-line packages (DIPS) or pins of other type modules. Fully clinched or partially clinched leads are not applicable for tempered pins or for leads over 1.3 mm (0.050 inch) in diameter.

40.1.2 Partial clinch of DIP leads. Bends shall be outward (away from the center of the part body). If manual clinching is used, only corner leads of DIPS may be clinched.

40.1.3 Straight-through lead terminations. Component leads terminated straight through shall be discernable and may extend a maximum of 1.5 mm (0.060 inch) above the termination area.

40.2 Unsupported hole lead terminations. When unsupported holes are used, leads shall be fully clinched.

40.3 Parts and components mounted to printed wiring boards. Axial and nonaxial-leaded components shall be mounted on only one side of a printed wiring assembly if the leads are dressed through holes. Surface mounted components may be mounted on either or both sides of a printed wiring assembly. On mixed technology assemblies with surface mounted components on both sides, through-hole components should be mounted on one side of the printed wiring board but may be mounted on both sides. As an exception, packaging and interconnect structures (P&IS) may contain through-hole mounted connector on each side of the

P&IS.

40.4 Hole obstruction. Parts and components shall be mounted such that they do not obstruct solder flow onto the topside termination areas of plated-through holes (see figure B-2).

40.5 One lead per hole. No more than one item, whether wire or component lead, shall be inserted in any one hole.

40.6 Lead attachment. Component leads shall be either surface mounted, mounted in through holes, or mounted to terminals. Lead and wire terminations shall be soldered.

40.7 Metal case component insulation. Metal cased components shall be insulated from adjacent electrically conductive elements. Insulation material shall be compatible with the circuit and printed wiring board material.

40.8 Moisture traps. Parts and components shall be mounted such that the formation of moisture traps is precluded.

40.9 Use of buffer material with conformally coated assemblies. When type ER conformal coating is applied to glass bodied components, buffer material is required.

NOTE: Board designers are cautioned to consider that buffer material may be needed when allocating space and location for components to be mounted on printed-wiring boards covered by this standard.

40.10 Detailed part mounting - through-hole mounted components.

40.10.1 Axial-leaded components.

40.10.1.1 Jumper wires. Jumper wires mounted and soldered in accordance with initial design requirements shall be treated as axial-leaded components and shall conform to the detail requirements herein stated for axial-leaded components.

40.10.1.2 Axial-leaded parts. Axial-leaded parts shall be mounted as specified on the approved assembly drawing and mounted approximately parallel so that the body is within 0.65 mm (0.025 inch) of the board surface.

40.10.1.3 Clinched wire interfacial connections. The wire connecting circuitry on opposite sides of the board or assembly which are not completed via a plated-through hole shall be uninsulated, solid, tinned, copper wire and shall be dressed through the unsupported (unplated) hole, clinched, and soldered to the terminal area on each side of the board or assembly. The clinched wire shall contact the terminal area on at least one side of the printed wiring board and shall approximate contact on the other side (normal spring back to one half the wire diameter is acceptable). The clinched portions of the wire shall meet the requirements for clinched component leads. Unless both clinched portions are soldered and cooled simultaneously, the two connections shall be step-soldered (see figure B-3).

40.10.2 Nonaxial-lead components with leads extending from a single surface. Nonaxial-leaded components shall be either mounted with the surface from which the leads egress (the base) parallel to the surface of the printed board within the spacing tolerances specified herein, or, side mounted.

40.10.2.1 Minimum lead extension. Leads shall extend straight from the base of the part and lead bends shall not extend to the part body or weld.

40.10.2.2 Meniscus trimming. Trimming of the lead coating meniscus is prohibited.

40.10.2.3 Meniscus spacing. There shall be a visible clearance between the coating meniscus on each lead and the solder connection (see figure B-4).

40.10.2.4 Freestanding components. When components are mounted freestanding, the spacing between the surface of the component and the surface of the board shall be a minimum of 0.75 mm (0.030 inch) and a maximum of 3.2 mm (0.125 inch) (see figure B-5). In no instance shall nonparallelism result in nonconformance within the minimum or maximum spacing limits.

40.10.2.5 Supported components. When components are supported, they shall be supported on:

a. Resilient feet or standoffs integral to the component body (see figure B-6A and B) which shall be mounted in contact with the board, or

b. A separate standoff (see figure B-6C), or a specially configured nonresilient footed standoff (see figure B-6D) which shall be mounted in contact with the component and the board (see figure B-7).

40.10.2.5.1 Footed standoffs. Footed standoffs shall have a minimum foot height of 0.25 mm (0.010 inch).

40.10.2.5.2 Standoff positioning. No standoff shall be inverted.

40.10.2.5.3 Nonresilient footed standoffs. When a specially configured non-resilient footed standoff is utilized, that portion of the lead in the lead bend cavity (see figure B-8) shall be formed to coincide with an angular line extending from the lead insertion hole in the standoff device to the lead attachment hole in the printed wiring board and seated in accordance with 40.10.2.5.b.

40.10.2.6 Side and end mounting. When components are side or end mounted, the part body shall either be bonded to the printed wiring or be constrained in a manner which prevents movement during shock and vibration.

40.10.2.7 In-line connectors. In-line printed wiring board connectors may be mounted in full contact with the printed wiring board. Connectors mounted in full contact with the board shall be designed so that there are both stress relief provisions internal to the connector body and cavities (either visible or hidden) which preclude blocking of plated-through holes.

40.10.2.8 Tall profile components. Tall profile transformers and other devices with center of gravity in the upper half of the component body shall be mounted in accordance with 40.10.2.5 through 40.10.2.5.3 regardless of lead diameter or weight per lead ratios.

40.10.2.9 Metal power packages. Components of the metal power package configuration shall not be mounted freestanding. These components shall be mounted:

a. in accordance with paragraph 40.10.2.5 through 40.10.2.5.3, or,

b. if the leads are neither tempered nor greater than 1.3 mm (0.050 in) in diameter, and stress relief is provided, they may be side-mounted, through-board mounted, or mounted on nonresilient standoffs.

The leads of all components of the metal power package configuration shall be stress relieved in accordance with a stress relief method corresponding to the mounting technique.

40.10.2.10 Mounting metal power packages to an assembly. Metal power packages, the standoffs, heat sink frames and resilient spacers on which metal power packages are mounted shall be of a configuration which does not block the plated-through holes, precludes excessive stresses (provides stress relief) and facilitates cleaning.

40.10.2.11 Insulating metal power packages from underlying circuitry. Lead holes shall not be plated-through if the component body is mounted in contact with the board or circuitry thereon. This requirement takes precedence over 4.12.5.

40.10.2.12 Potentiometers. As an exception to 4.12.2, potentiometers and other adjustment devices weighing less than 3.5 grams (1/8 ounce) per lead shall, unless the diameter of each lead is 1.0 mm (0.040 inch) or greater, be mounted in accordance with 40.10.2.5 through 40.10.2.5.3.

40.10.3 Nonaxial-leaded components with leads extending from more than a single surface. Leads shall not be truncated.

40.10.3.1 Dual in-line packages.

40.10.3.1.1 Base contact. The base of the device shall be spaced from the surface of the printed wiring board a maximum of either 1.1 mm (0.060 inch) or the lead shoulder, whichever is greater. The base of the device may be in contact with the board surface. The spacing shall be selected such that the part is not mounted directly on conductive circuitry. When placed over conductive circuitry, the part shall be spaced off of the board such that contaminants may be cleaned from underneath.

40.10.3.1.2 Use of standoffs with DIPs. When a separate resilient standoff is utilized in conjunction with a dual in-line package, mounting shall be in accordance with 40.10.2.5 through 40.10.2.5.3. Standoffs shall be mounted in contact with the component and the printed wiring board.

40.10.3.1.3 DIPs mounted to heat sinks. DIPs mounted directly to heat sink frames shall have special stress relief provisions included. The use of heat sink frames must comply with the hole obstruction requirements of 40.4.

NOTE: The inclusion of a pliable spacer material between the heat sink frame and the printed wiring board is an acceptable method for assuring stress relief provided the resilient added material is of sufficient thickness (0.5 mm (0.02 inch) typical) to compensate for forces imposed during temperature change.

40.10.3.1.4 Use of ceramic DIPs. The body of a semiconductor or microcircuit DIP device shall not be formed from epoxy, other resin, or plastic. CERDIPs and ceramic bodied DIPs with side brazed leads are acceptable provided they are proven reliable for intended environmental use.

40.10.4 Terminal shank discontinuities. The shank of the terminal shall not be perforated nor split, cracked, or otherwise discontinuous to the extent that oils, flux, inks, or other liquid substances utilized for processing the printed board are or can be entrapped within the mounting hole. Circumferential cracks or splits in the shank are not acceptable regardless of extent.

40.10.5 Terminal flange discontinuities. The terminal flange shall not be split, cracked, or otherwise discontinuous to the extent that flux, oils, inks, or other liquid substances utilized for processing the printed board can be entrapped within the mounting hole. After swaging, the flange shall be free of circumferential splits or cracks, but may have a maximum of three radial splits or cracks provided that the splits or cracks are separated by at least 90 degrees and do not extend beyond the rolled area of the terminal (see figure B-9).

40.10.6 Terminals used for mechanical mounting. Terminals not connected to printed wiring or printed ground planes shall be of the rolled flange configuration. A printed foil pad may be utilized as a seating surface for a rolled flange provided that the pad is isolated and not connected to active printed wiring or ground plane.

NOTE: When a rolled flange is used in conjunction with an electrically inactive pad, solder is neither necessary nor particularly desirable.

40.10.7 Terminals used for electrical mounting. The flared flange terminals configuration (figure 1) shall be utilized only in conjunction with terminal areas (isolated or active) or ground planes; they shall not be flared to the base material of the printed board. Terminals shall be mounted in accordance with 40.10.7.1 through 40.10.7.3.

40.10.7.1 Flange angles. Flared flanges shall be formed to an included angle between 35 and 120 degrees and shall extend between 0.4 mm (0.015 inch) and 1.5 mm (0.060 inch) beyond the surface of the terminal area provided minimum electrical spacing requirements are maintained (see figure B-10) and the flare diameter does not exceed the diameter of the terminal land area.

40.10.7.2 Hole support. Terminals shall only be mounted in unsupported holes. If it is essential that a terminal be utilized for interfacial connection, a dual hole configuration incorporating a supported plated-through hole shall be combined with an unsupported hole interconnected by a terminal area on the solder side of the printed wiring board (see figure B-11). As an exception, the terminal may be mounted in a plated through hole with a nonfunctional land on the component side (see figure B-12).

40.10.7.3 Unacceptable configuration. Terminals with a funnel shoulder on the component side shall not be used (see figure B-13).

40.10.8 Mounting to terminals. Whether terminals are mounted to printed boards, terminal boards or chassis members, components and wires shall be mounted in accordance with 40.10.8.1 through 40.10.8.6.

40.10.8.1 Service loops. Lead wires shall be dressed in the proper position with a slight loop or gradual bend as shown in figure B-14. The bend shall be sufficient to preclude tension on the connection when such is finished and to permit one field repair.

40.10.8.2 Orientation of wire wrap. Lead wires may be wrapped clockwise or counterclockwise but shall continue the curvature of the dress of the lead wires (see figure B-15) and shall not interfere with the wrapping of other wires on the terminal.

40.10.8.3 Stress relief. Unless mounted with the component body seated to a printed board, terminal board, or chassis with stress bends as shown in figure 3, components shall be mounted such that the body is displaced with respect to the terminal to which they are attached as shown in figure 3.

40.10.8.4 Bifurcated terminals. The order of preferred terminations of bifurcated terminals shall be as follows:

40.10.8.4.1 Side route connection. The wire or component lead shall be dressed through the slot and wrapped to either post of the terminal (see figure B-16A) and shall be in contact with the flat surfaces of two non-adjacent sides (see figure B-16B). The wire or lead shall also be in firm contact with the base of the terminal or the previously installed wire (see figure B-16C).

The number of attachments shall be limited to three per terminal post and shall be maintained such that:

a. There is no overlapping of wraps and wires.

b. Spacing between wires, and spacing between the wires and the terminal board or panel is a minimum consistent with the thickness of the wire insulation.

c. The wraps are dressed in alternate directions (see figure B-16D).

40.10.8.4.2 Bottom route connection. The wire shall be wrapped on the terminal post and shall be in contact with the flat surfaces of two non-adjacent sides. The wire lead shall also be in firm contact with the base of the terminal or the previously installed wire. When more than one wire is to be attached, they shall be inserted at the same time but shall be wrapped separately around alternate posts.

40.10.8.5 Hook terminals. The maximum wire fill shall not exceed the end of the hooks. There shall be no more than three conductors for each terminal.

40.10.8.6 Pierced or perforated terminals. For wiring to a single terminal, the wire shall pass through the eye and be wrapped around the terminal (see figure B-17). When a continuous run is used, the wire shall be attached to the end terminals (first and last) in the same manner that wires are attached to single terminals. The jumper wire shall contact at least two nonadjacent contact surfaces of each intermediate terminal.

40.11 Surface mounted assembly requirements.

40.11.1 External connections to packaging and interconnect structures (P&IS). Where P&IS are used to provide controlled thermal expansion, they shall not be connected to external system elements (i.e. chassis or heat sinks) which will degrade the thermal expansion control below design limits.

40.11.2 Body positioning. The body of a surface mounted axial-leaded component shall be spaced from the surface of the printed wiring board a maximum of 0.6 mm (0.025 inch) (see figure B-18). Leads on opposite sides of surface mounted axial-leaded components shall be formed such that component cant (nonparallelism between the base surface of the mounted component and the surface of the printed wiring board) is minimal and in no instance shall body cant result in nonconformance with the maximum spacing limits.

40.11.3 Vertical mounting. If the vertical (V) dimension of reflow configuration chips is greater than the thickness (T) dimension, then reflow configuration chips should not be used in assemblies subject to high vibration or shock loads, especially in airborne or missile systems. Vertical mounting shall be utilized for:

a. Low and tall-profile surface mount devices with reflow termination pads located on a single base surface;

b. Nonaxial-leaded devices with leads egressing from two or more sides of the device(s); and

c. Nonaxial leaded devices with leads egressing from a single base surface.

40.11.4 Leaded parts.

40.11.4.1 Perpendicular mounting. Under no circumstance shall surface mounting for perpendicular axial leaded components be used.

40.11.4.2 Flatpacks. Leads on opposite sides of surface mounted flatpacks shall be formed such that the nonparallelism between the base surface of the component and the surface of the printed wiring board (i.e. component cant) is minimal. Component cant is permissible provided the final configuration meets the maximum spacing requirement.

40.11.4.3 Lead forming to prevent deflection. Leads shall be formed such that they will contact the termination area upon mounting without the need to impart stress on the lead to accomplish soldering.

40.11.4.4 Parts not configured for surface mounting. Flatpacks of the through-hole configuration, dual in-line packages, transistors, metal power packages, and other nonaxial-leaded components shall not be surface mounted unless the leads are formed to meet the surface mounted device lead forming requirements.

40.11.4.5 Miniature axial-leaded components.

40.11.4.5.1 Rectangular leads. Components with axial-leads of rectangular cross section shall be mounted in accordance with the requirements for ribbon leads of flatpacks.

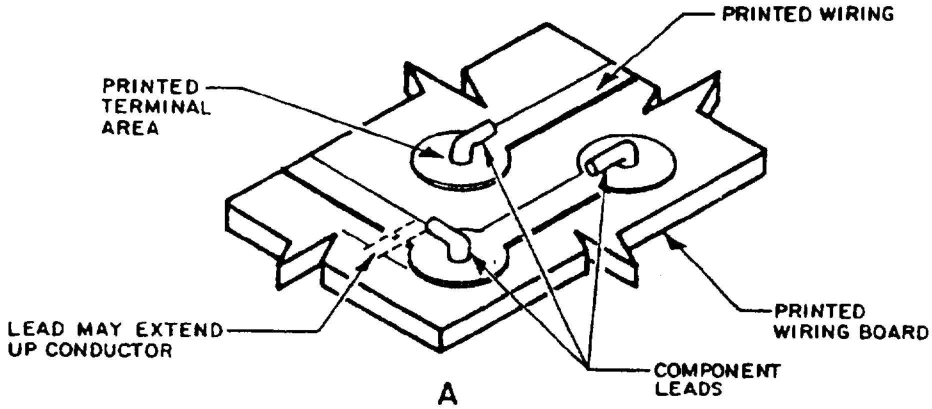
40.11.4.5.2 Coined leads. Components with axial-leads of round cross section may be coined or flattened for positive seating in surface mounting. If coining or flattening is used the flathead thickness shall be 50 $\pm$ 10% of the original diameter (see figure B-18). Flattened areas of leads coined for surface mounting shall be excluded from the 10 percent deformation requirement.

40.11.5 Dual in-line packages. Dual in-line packages may be surface mounted provided the leads are formed into a configuration which meets the mounting requirements for surface mounted leaded parts (i.e. flatpacks). The leads of DIPs shall be bent outward only. This lead forming operation shall be performed using die forming systems (hand forming is prohibited). The lead forming operation shall not cause lead seal cracks to exceed the limits imposed in the initial part specification. The use of butt mounted dual in-line packages is prohibited.

40.11.6 Other devices. TO-can devices, tall profile components (i.e., over 15 mm (0.60

inch)), transformers, and metal power package devices may be surface mounted provided the parts are bonded or otherwise permanently secured to the board in a manner which enables the part to withstand the end-item, shock, vibration, and environmental stresses.

40.11.7 Break-away tie bars. As an exception to the lead cutting requirements of this document, components (e.g. connectors and flexible circuits) which incorporate break-away tie bars in their design may be installed or soldered in place prior to removal of the tie bar. Exposed basis metal resulting from tie bar removal is permissible.



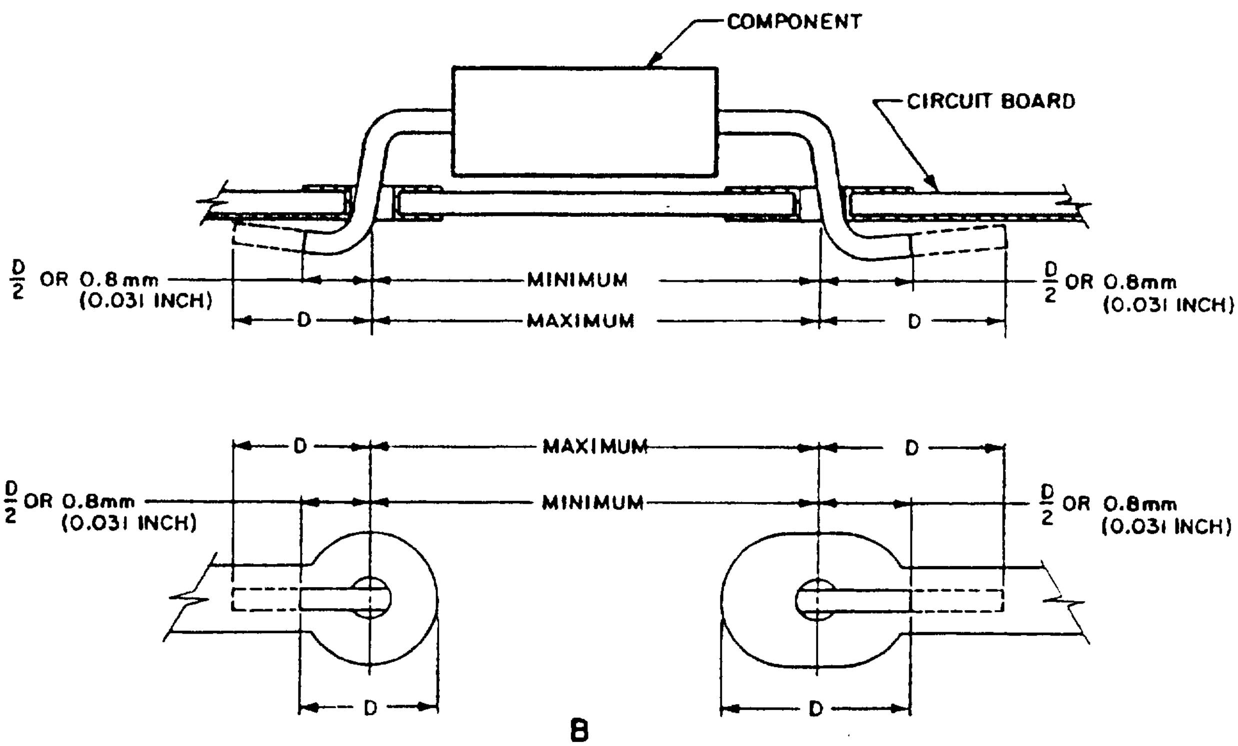


FIGURE B-1. Lead termination (clinched leads) (see 40.1).

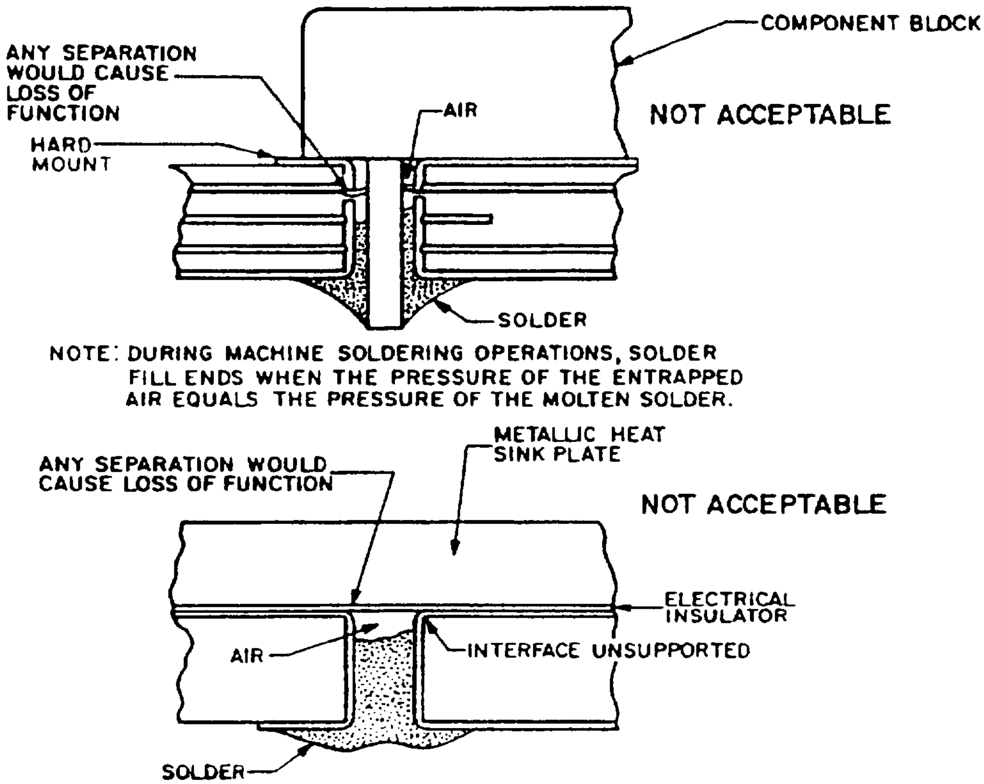


FIGURE B-2. Blocked plated-through holes (see 40.4).

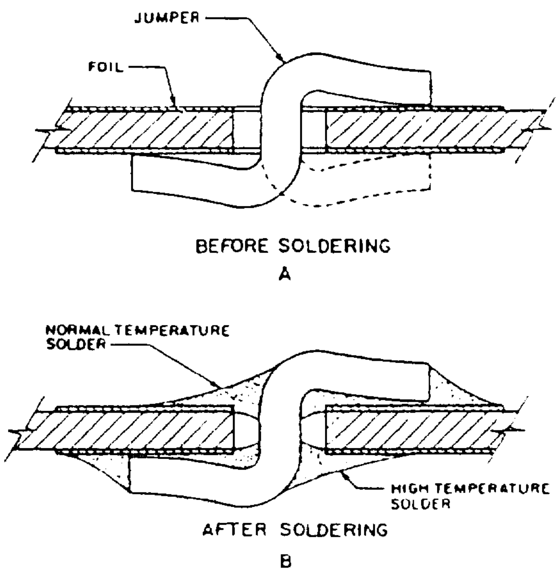


FIGURE B-3. Clinched wire interfacial connections (see 40.10.1.3).

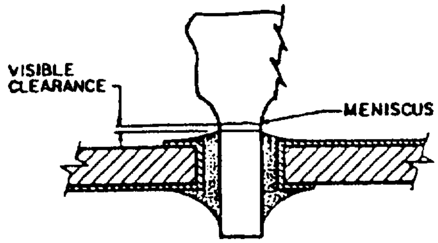


FIGURE B-4. Meniscus clearance (see 40.10.2.3).

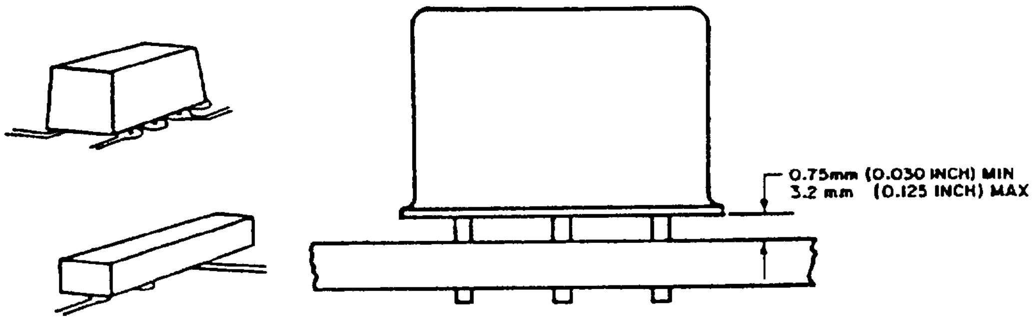


FIGURE B-5. Mounting of freestanding nonaxial-leaded components (see 40.10.2.4).

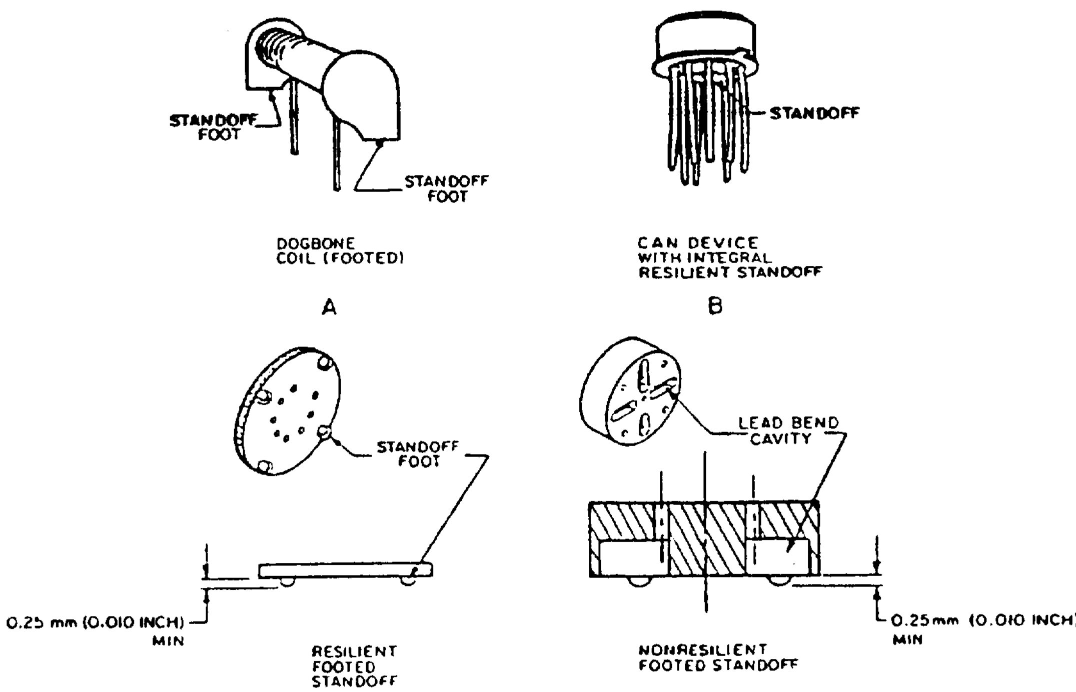
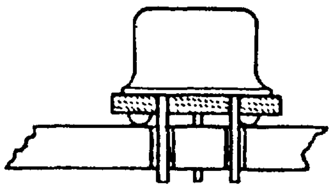


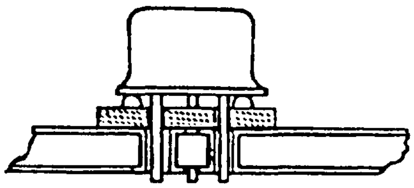
FIGURE B-6. Typical standoff devices (footed) (see 40.10.2.5).



COMPONENT SEATED FLAT TO STANDOFF.

FEET IN CONTACT WITH BOARD.

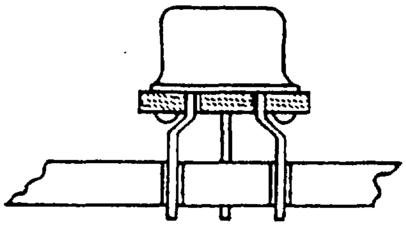
A



STANDOFF INVERTED.

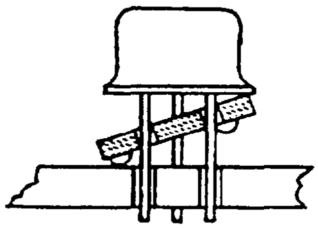
STANDOFF BLOCKS PLATED-THROUGH HOLE.

B



STANDOFF NOT IN CONTACT WITH BOARD.

C

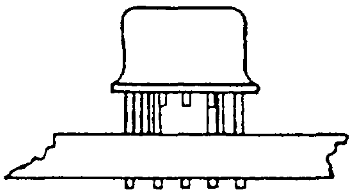


STANDOFF TILTED.

COMPONENT NOT SEATED FLAT TO STANDOFF.

FEET DO NOT CONTACT BOARD.

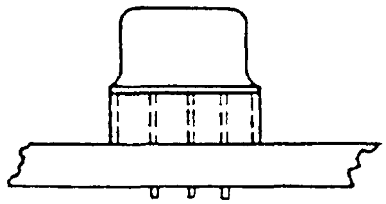
D



COMPONENT SEATED FLAT TO STANDOFF OF RESILIENT MATERIAL.

BASE OF STANDOFF FLAT ON BOARD.

E



ALTHOUGH OF RESILIENT MATERIAL, STANDOFF CONCEALS CONNECTION ON COMPONENT SIDE OF BOARD.

F

FIGURE B-7. Mounting components using standoffs (see 40.10.2.5).

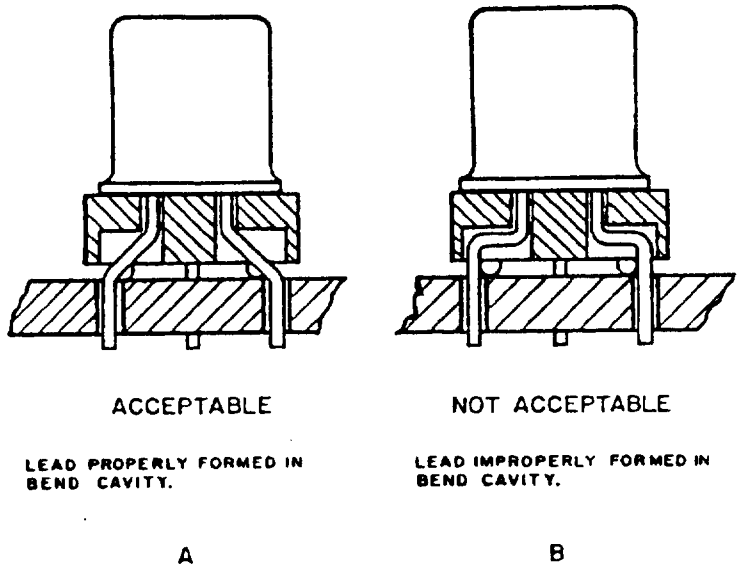


FIGURE B-8. Typical standoff devices (internal cavities) (see 40.10.2.5.3).

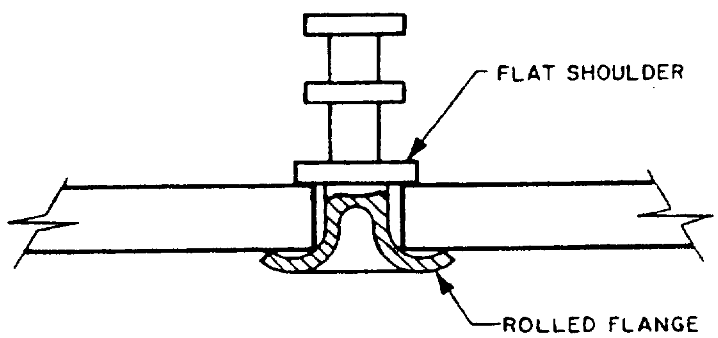


FIGURE B-9. Rolled flange terminals (see 40.10.5).

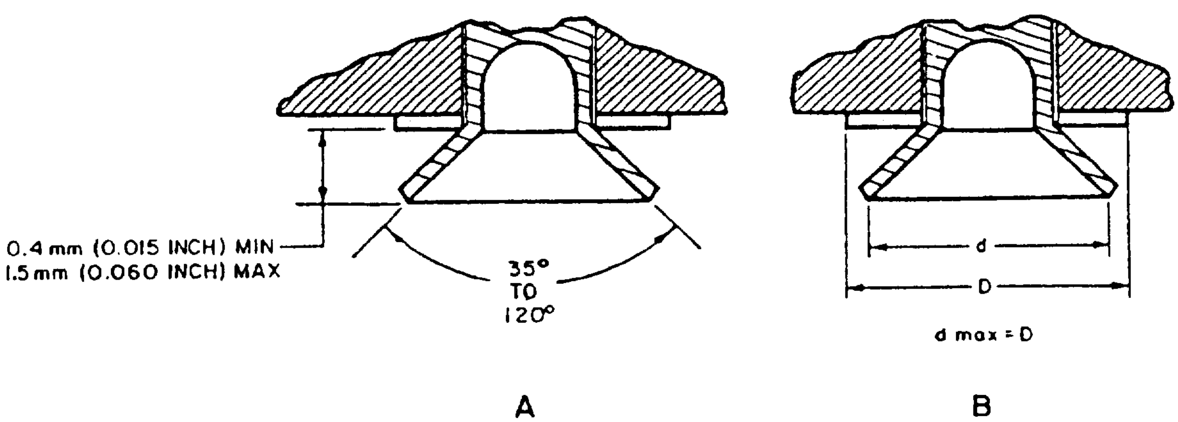


FIGURE B-10. Flare and extension of funnel flanges (see 40.10.7.1).

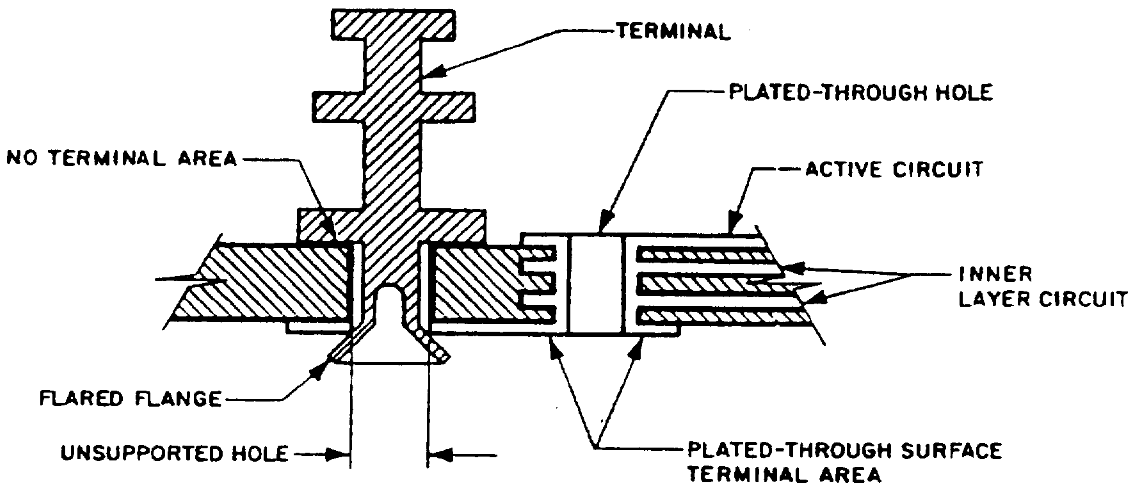


FIGURE B-11. Dual hole configuration for interfacial and interlayer terminal mountings (see 40.10.7.2).

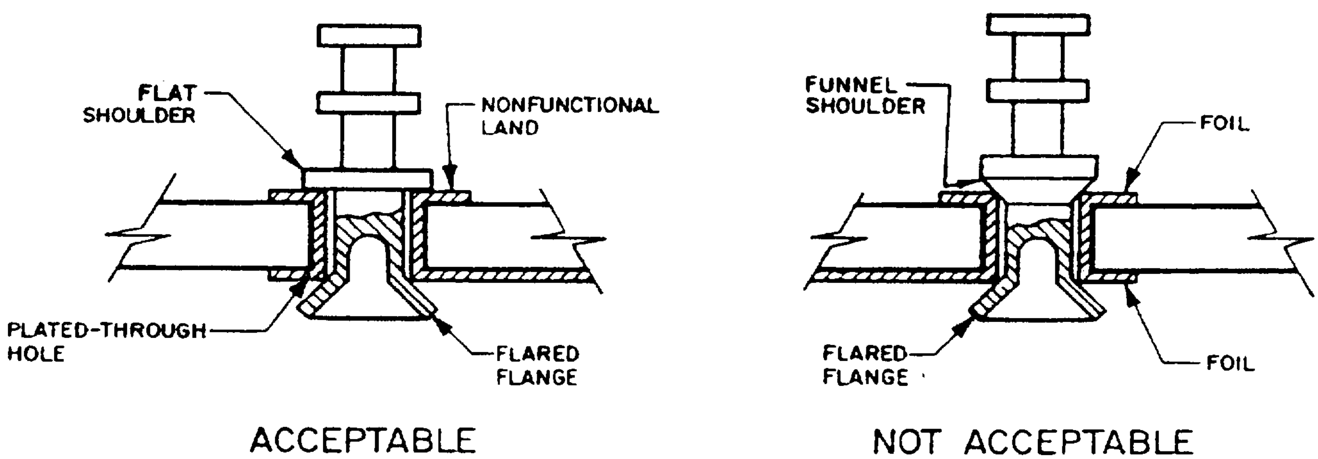


FIGURE B-12. Standoff terminal interfacial connection (see 40.10.7.2).

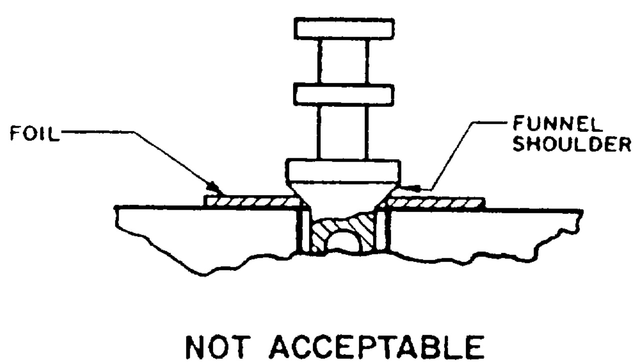


FIGURE B-13. Funnel shoulder terminal (see 40.10.7.3).

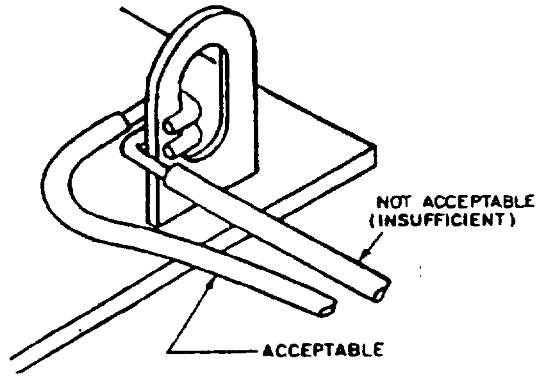


FIGURE B-14. Stress relief for lead wiring (see 40.10.8.1).

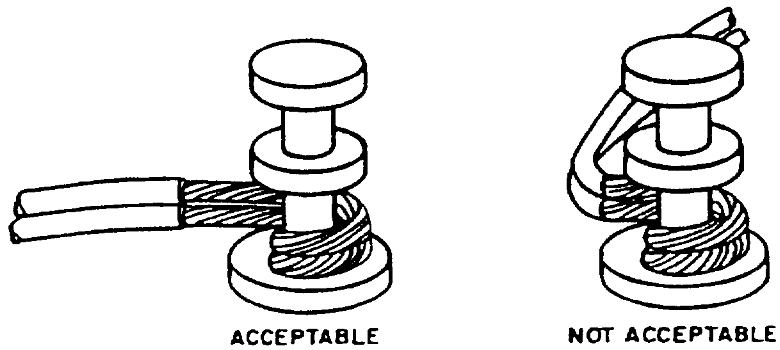


FIGURE B-15. Lead dress (see 40.10.8.2).

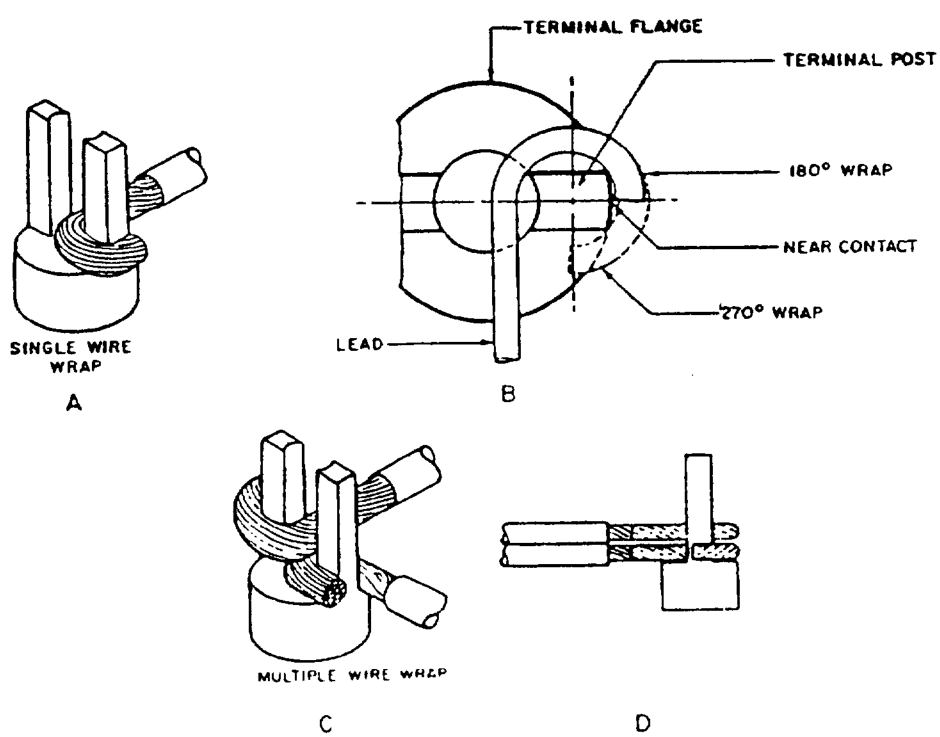


FIGURE B-16. Side route connections and wrap on bifurcated terminal (see 40.10.8.4.1).

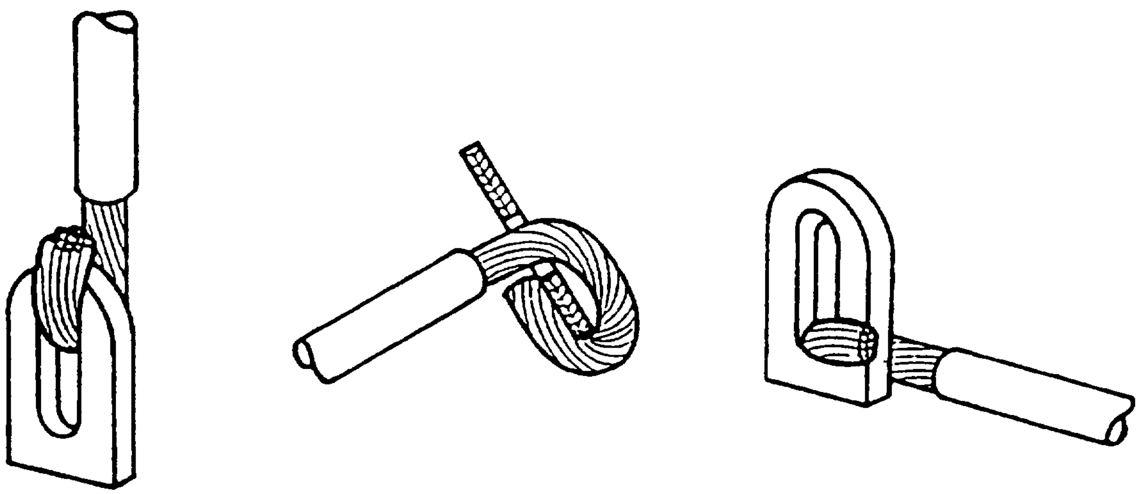


FIGURE B-17. Typical pierced or perforated terminal wire wrap (see 40.10.8.6).

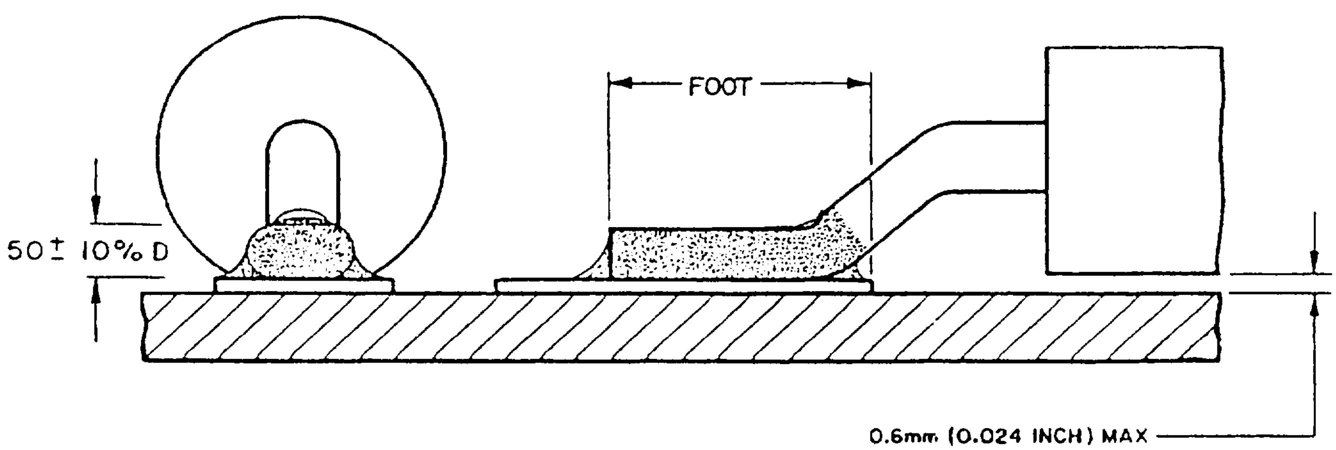


FIGURE B-18. Body positioning of part with coined lead (see 40.11.4.5.2).

APPENDIX C

CLEANLINESS TEST METHODS

10. SCOPE.

10.1 Scope. This appendix defines standard cleanliness test methods for determining printed wiring assembly cleanliness.

20. APPLICABLE DOCUMENTS.

20.1 Government documents.

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

SPECIFICATIONS

FEDERAL

MIL-P-28809 Printed Wiring Assemblies

30. TERMS AND DEFINITIONS. Not Applicable.

40. GENERAL REQUIREMENTS.

40.1 Resistivity of solvent extract. Solvent extract resistivity shall be measured as follows (see table C-I):

a. Prepare a test solution of 75 +0/-2 percent by volume of reagent grade isopropyl alcohol, with the remainder being deionized water. Pass this solution through a mixed bed deionizer cartridge. After passage through the cartridge, the sensitivity of the solution shall be greater than 6 megohm-centimeters (conductivity less than 0.166 micromhos/cm).

b. Clean a funnel, a bottle, and a container with a portion of this test solution. Measure 1.55 milliliters of fresh test solution for each square centimeter of assembly area into the wash bottle. Assembly area includes the areas of both sides of the board.

c. Slowly, direct the test solution, in a fine stream, onto both sides of the assembly until all of the measured solution has been used.

d. Collect the rinse solution and measure per 5.3.5.

40.2 Sodium chloride salt equivalent ionic contamination test. Sodium chloride salt equivalent ionic contamination shall be measured as follows (see table C-I):

a. The sodium chloride salt equivalent ionic contamination test shall use a solution of 75 +0/-2 percent by volume of reagent grade of isopropyl alcohol with the remainder being deionized water. The solution shall be verified for correct composition upon initial use and every four hours during a shift. The time limit may be extended when the results of data provide definite indications that such actions will not adversely affect the results of the test.

b. The equipment must be validated using a known amount of sodium chloride standard on the same schedule as the percentage composition verification.

c. The starting, or reference, purity of the solution shall be greater than 20,000,000 ohm-centimeters (0.05 micromhos/centimeter) before each sample is tested.

40.3 Alternate methods. Alternative equipment, with the appropriate equivalence values, may be used to verify cleanliness. This appendix is not intended to preclude use of other compatible equipment and equivalence values. The following equipment and associated methods of determining the cleanliness of printed wiring assemblies have been shown to be equivalent to the resistivity of the solvent extract method in paragraph 40.1.

a. The Kenco Alloy and Chemical Company, Inc., "Omega Meter™."

b. Alpha Metals, Inc. "Ionograph™."

c. E. I. Dupont Company, Inc. "Ion Chaser™."

d. Zero Systems, Inc. "Zero Ion™"

Test procedures and calibration techniques for these methods are documented in Materials Research Report 3-78 "Review of Data Generated With Instruments Used to Detect and Measure Ionic Contaminants on Printed-Wiring Assemblies." Application for copies of this report should be addressed to the Commander, Naval Avionics Center, Indianapolis, IN 46218. Table C-II lists the equivalence factors for these methods in terms of microgram equivalents of sodium chloride per unit area.

TABLE C-I. Cleanliness test values.

Test method	Starting resistivity	Ending value
Solvent Extract Resistivity	6×10^6 ohm-cm	Shall be greater than 2×10^6 ohm-cm
Sodium Chloride Salt Equivalent Ionic Contamination	20×10^6 ohm-cm	Shall be less than 1.55 micrograms/square centimeter

TABLE C-II. Equivalence factors for testing ionic contamination.

Method	$\bar{X}$ $\mu gNaCl/in^2$	Equivalence factor	Instrument "Acceptance limit" $\mu gNaCl/Cm^2$	Instrument "Acceptance limit" $\mu gNaCl/in^2$
MIL-P-28809 - Beckman	7.47	$\frac{7.545}{7.545}=1$	1.56	10
MIL-P-28809 - Markson	7.62	$\frac{7.545}{7.545}=1$	1.56	10
Omega Meter Model 200	10.51	$\frac{10.51}{7.545}=1.39$	2.2	14
Ionograph	15.20	$\frac{15.20}{7.545}=2.01$	3.1	20
Ion Chaser	24.50	$\frac{24.50}{7.545}=3.25$	5.1	32
Zero Ion Model ZI-100	25.17	$\frac{25.17}{6.578}$ 1/ $=3.83$	5.8	37

1/ Since alternative equipment was used to calculate this value, the MIL-P-28809 equivalence factor is 6.578 rather than 7.545.

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-STD-2000A	2. DOCUMENT DATE *(YYMMDD)* 91/02/14

3. DOCUMENT TITLE

STANDARD REQUIREMENTS FOR SOLDERED ELECTRICAL AND ELECTRONIC ASSEMBLIES

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) AUTOVON *(If applicable)*	7. DATE SUBMITTED *(YYMMDD)*

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE *(Include Area Code)* (1) Commercial	(2) AUTOVON
Commanding Officer NAEC, SESD Code 53	(201) 323-7475	624-7475
c. ADDRESS *(Include Zip Code)* Lakehurst, NJ 08733-5100	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466	