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MILITARY STANDARD

GENERAL PURPOSE SOLDERING REQUIREMENTS FOR ELECTRICAL AND ELECTRONIC EQUIPMENT

AMSC N/A

SOLD

DEPARTMENT OF DEFENSE
WASHINGTON, DC 20301

General Purpose Soldering Requirements for Electrical and Electronic Equipment

DOD-STD-2000-4A

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 5313, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this standard or by letter.

FOREWORD

1. This standard addresses that spectrum of solder connections normally defined as general purpose, and provides technical requirements essential to electric and electronic connections and wiring within equipment fabricated by or for the Department of Defense.

2. This standard provides for communication between designers, fabricating personnel and inspectors. The uniformity of soldering materials and processes applies to manual or mechanical soldering procedures. This standard is intended for use by any of the many organizations engaged in the production of military electronic equipment. Criteria of this standard are not directed to end item products per se but are instead directed to part and component solder connections and wiring essential to those end item products and should be implemented in conjunction with appropriate documents.

3. DOD-STD-2000-4 covers general purpose soldering only and will be invoked independently in situations which do not require soldering to the level covered by DOD-STD-2000-1 Soldering Technology, High Quality/High Reliability, DOD-STD-2000-2 Part and Component Mounting for High Quality/High Reliability Soldered Electrical and Electronic Assemblies, and DOD-STD-2000-3 Criteria for High Quality/High Reliability Soldering Technology.

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TABLES

1. SCOPE

1.1 Scope. This standard establishes general requirements for materials and procedures for making soldered electrical and electronic connections. In addition, component mounting requirements and acceptance criteria are provided to permit evaluation of complete assemblies.

2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation form a part of this standard to the extent specified herein.

SPECIFICATIONS

FEDERAL

O-E-760	Ethyl Alcohol (Ethanol) Denatured Alcohol, Proprietary Solvents and Special Industrial Solvents
O-M-232	Methanol (Methyl Alcohol)
QQ-S-571	Solder, Tin Alloy, Lead Tin Alloy and Lead Alloy
TT-B-848	Butyl Alcohol, Secondary (For Use in Organic Coatings)
TT-I-735	Isopropyl Alcohol

MILITARY

MIL-F-14256	Flux, Soldering, Liquid (Rosin Base)
MIL-P-28809	Printed Wiring Assemblies
MIL-P-55110	Printed Wiring Boards
MIL-C-81302	Cleaning Compound, Solvent Trichlorotrifluoroethane
MIL-T-81533	Trichloroethane 1, 1, 1 (Methyl Chloroform) Inhibited, Vapor Degreasing
MIL-P-81728	Plating, Tin Lead (Electrodeposited)
MIL-C-85447	Cleaning Compounds, Electrical and Electronic Components

STANDARDS

MILITARY

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-275	Printed Wiring for Electronic Equipment
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-1695	Environments, Working, Minimum Standards for
MIL-STD-2118	Flexible and Rigid-Flex Printed-Wiring for Electronic Equipment, Design Requirements for

FEDERAL

FED-STD-376	Preferred Metric Units for General Use by the Federal Government

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

2.2 Other publications. The following document(s) form a part of this standard to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. The issues of documents which have not been adopted shall be those in effect on the date of the cited DODISS.

ANSI/IPC-T-50	Terms and Definitions for Interconnecting and Packaging Electronic 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 standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 Terms and definitions. The definitions applicable to this standard shall be in accordance with ANSI/IPC-T-50.

4. GENERAL REQUIREMENTS

4.1 Conflict. In the event of any conflict between the requirements of this standard and the applicable assembly drawing(s), the government approved applicable assembly drawing(s) shall govern.

4.2 Materials. Materials used in the soldering process shall be compatible with each other, the printed wiring board and the components and shall not degrade the performance of these items or the soldered connection.

4.2.1 Solder. Solder alloy shall conform to Sn60, Sn62, or Sn63 of QQ-S-571. Sn62 solder shall only be used when specified on the engineering drawings. Other solders specified in QQ-S-571 may only be used when approved by the Government Contracting Officer, and shall be specified on the engineering drawing(s). The flux of flux-cored solder, solder paste, and solder preforms shall be type R or RMA of QQ-S-571.

4.2.2 Flux. Rosin flux conforming to types R or RMA of MIL-F-14256 shall be used for making electrical and electronic connections. For fluxing purposes, a soldered connection which functions as both a mechanical and an electrical connection (for example, in grounding applications through a chassis) shall be considered an electrical connection.

4.2.3 Cleaning agents. The cleaning agent used for the removal of grease, oil, wax, dirt, flux and other debris shall be selected for its ability to remove flux residue, ionic, ionizable nonpolar and particulate contaminants. The cleaning agent shall not degrade the materials and parts or degrade identification markings beyond legibility. Individually used cleaning agents shall conform to Federal specifications O-E-760, TT-I-735 and Military specifications MIL-C-81302, MIL-T-81533 and MIL-C-85447. Mixtures of these agents may be used provided the mixture is suitably stabilized or inhibited. Water or aqueous detergent solutions are exempt from this requirement and may be used. Mixtures which include Methanol (Methyl Alcohol) conforming to O-M-232 or secondary Butyl alcohol conforming to TT-B-848 shall be purchased preblended.

4.3 Work areas, tools and equipment.

4.3.1 Cleanliness of work areas and tools. Work areas and tools shall be maintained in a clean and orderly condition. There shall be no visible dirt, grime, grease, flux or solder spatter, nor other contaminating foreign materials at any work station (see MIL-STD-1695) and eating, smoking, or drinking at a work station shall be prohibited. Handcreams, ointments, perfumes, cosmetics, and other materials unessential to the fabrication operation are also prohibited at the work station.

4.3.2 Tool selection. Tools shall be suitable for the purpose intended and shall not cause damage to the parts, boards, or solder connections. The following tools are considered suitable for their application.

4.3.2.1 Thermal strippers. Thermal strippers utilized to remove insulation from stranded and solid conductor wires shall be of a design that can be regulated to prevent damage to the wire or unstripped insulation.

4.3.2.2 Mechanical strippers. Mechanical strippers utilized to remove insulation from stranded or solid conductor wires may be of the hand operated or automatic high volume machine type and shall not cause damage to the wire or unstripped insulation.

4.3.2.3 Wire and lead cutting tools. Cutters shall be designed to cut squarely without leaving burrs, excessive ridges or sharp points.

4.3.2.4 Holding devices. Tools, fixtures, and materials used to hold or restrain wires and components shall be of a design which will not damage or deform the wires, leads, wire insulation, or components. If toothed clips are utilized, the jaws of the clips shall be covered to provide the required protection.

4.3.2.5 Clinching tools. Clinching tools or clinching devices shall be of such design and made of a material which will not cause damage to printed wiring boards, printed circuitry, and component leads or components mounted thereon.

4.3.2.6 Bending tools. Bending tools shall be of a type designed to impart no damage to the component bodies or seals.

4.3.2.7 Soldering irons and equipment.

4.3.2.7.1 Soldering irons. Soldering irons and resistance heating elements shall be selected to meet the requirements of MIL-STD-454 Requirement 75 and shall heat the connection area rapidly and maintain proper soldering temperature at the connection throughout the soldering operation.

4.3.2.7.2 Solder pots. Solder pots shall be capable of maintaining the solder temperature at 500°F ± 10°F (260°C ± 5.5°C).

4.3.2.7.3 Heat sinks. Heat sinks shall be of such material, size, shape, and design as to facilitate rapid heat dissipation from the area being soldered with minimum interference to the soldering procedure.

4.3.3 Soldering guns. Soldering guns of the transformer type shall not be used.

4.3.4 Steel wool. Steel wool shall not be used.

4.4 Solderability. The solderability of parts shall meet the requirements of:

a. MIL-STD-750 Method 2026.4 for semiconductors.

b. MIL-STD-883 Method 2003.3 for microelectronics.

c. MIL-P-55110 for rigid printed wiring boards.

d. MIL-STD-2118 for flexible and rigid-flex printed wiring boards.

e. MIL-STD-202 Method 208 for all other parts not covered by (a) through (d) above.

4.5 Electrostatic discharge protection. Electrostatic discharge (ESD) control shall be in accordance with MIL-STD-454, Requirement 75.

4.6 Preparation for soldering.

4.6.1 Cleanliness. The cleanliness of terminals, component leads, conductors and printed wiring surfaces shall be sufficient to ensure solderability. When required, the surfaces shall be cleaned by either chemical methods or tinning. Cleaning shall not damage the component, component leads or conductors. Knives, emery cloth, sandpaper, sandblasting, braid, erasers and other abrasives shall not be used. Cleaning may be as follows:

a. Grease and oil shall be removed from conductors and terminals by applying a noncorrosive solvent such as: 1, 1, 1-trichloroethane conforming to MIL-T-81533; ethyl alcohol conforming to O-E-760, type III or isopropyl alcohol conforming to TT-I-735.

b. Oxides and varnishes shall be removed by methods which do not damage leads or parts, and which do not cause contamination or hinder solder wetting.

c. Dust or other loose matter shall be removed.

Note: When chemical compounds are used, caution should be exercised to protect personnel from toxic vapors that are emitted.

4.6.2 Stripping insulation. Sufficient insulation shall be stripped from the wire or leads to provide for insulation clearances as specified in 4.7.4. In stripping insulation, care should be taken to avoid nicking or otherwise damaging the wire or the remaining insulation. The number of damaged or severed strands in a single wire shall not exceed the limits given in table I. Wires used at a potential of 6kV or greater shall have no broken strands. Insulation discoloration resulting from thermal stripping is permissible.

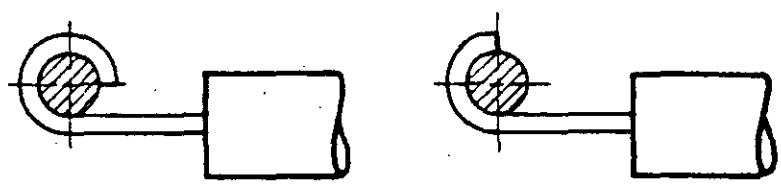
TABLE I. Limits.

Number of strands	Maximum allowable nicked or broken strands
Less than 7	0
7-15	1
16-18	2
19-25	3
26-36	4
37-40	5
41 or more	6

4.6.3 Tinning. At the time of soldering, component leads and terminations not meeting the designated solderability requirements shall be reworked by tinning or other methods as defined in paragraph 4.6.1. Where tinning is used, electroplated tin-lead shall be in accordance with MIL-P-81728 and hot dip solder tinning shall provide a minimum solder thickness of 0.0003 inch (0.00762 mm) on the surface of round leads and the crest of flat leads. Tinning of a stranded wire shall not obscure the wire contour at the termination end of the insulation to permit inspection of the wire for damage. Heat sinks shall be applied to leads of heat sensitive parts during the tinning operation. The preconditioning solder pot shall be maintained in accordance with 5.3.4.1 and 5.3.4.2. Wicking of solder under the insulation of stranded wire shall be minimized. Solder shall not obscure the contour of the conductor at the termination of the insulation. The leads of all devices to be planar mounted shall be tinned prior to installation.

4.7 Attachment of wires and leads. Unless otherwise specified herein attachment of wires and leads to terminals and to printed boards shall be in accordance with MIL-STD-275 for rigid printed wiring boards and MIL-STD-2118 for flex and rigid-flex printed wiring boards. Other attachments of wires and leads shall meet the requirements of the following paragraphs.

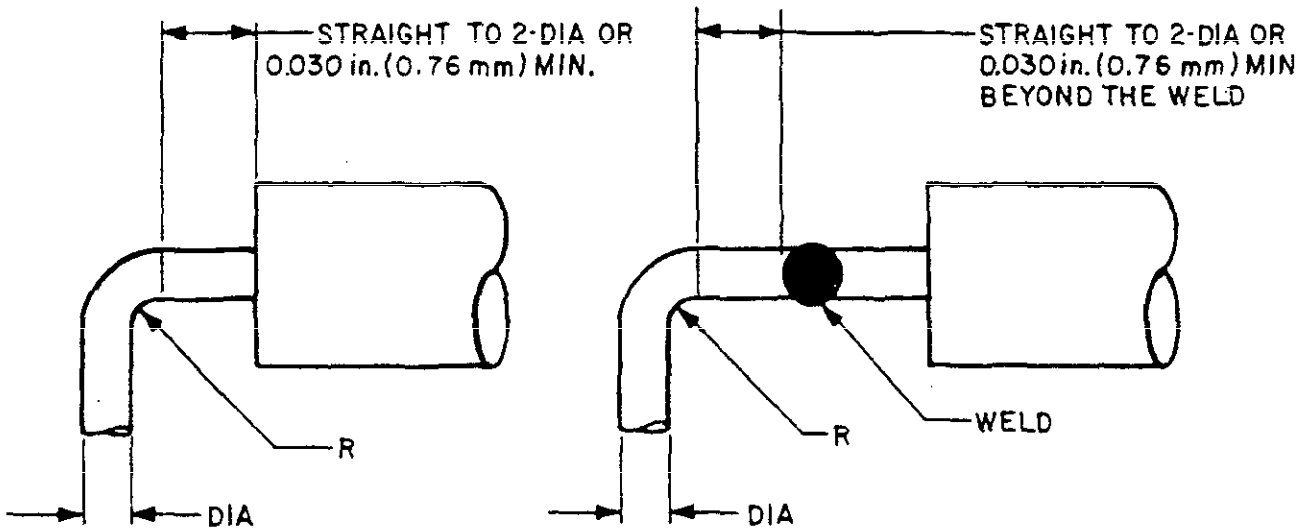
4.7.1 Wire and lead wrap around. Leads and wires shall be mechanically secured to their terminals before soldering. Such mechanical securing shall prevent motion between the parts of a connection during the soldering operation. Leads and wires shall be wrapped around terminals for a minimum of one-half and not more than three fourths turn (see figure 1). For AWG size 30 or smaller wire, a minimum of one turn and a maximum of 3 turns shall be used. Exception is made in the case of those small parts used for terminating conductors and to which such mechanical securing would be impracticable, such as connector solder cups, slotted terminal posts and heat shrinkable solder devices. Lead extension shall be restricted to the limits required by design to prevent equipment malfunction. In no case shall wires and leads be wrapped on or atop each other. In addition, the requirements of MIL-STD-454, Requirement 17, shall apply.



A. 3/4 TURN B. 1/2 TURN

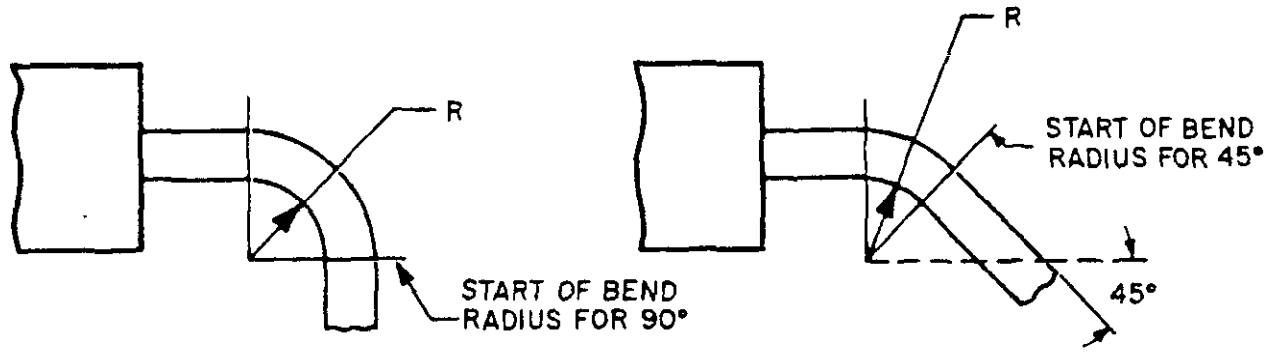
FIGURE 1. Wire and lead wrap around (see 4.7.1).

4.7.2 Lead bends. For parts other than planar mounted devices the distance between the body of the part or weld and the bent section of a lead shall be at least twice the diameter of the lead but not less than 0.030 inch (0.76 mm). The radius of bends shall conform to table II and figure 2. Planar mounted device lead forming requirements are located in paragraph 5.7 and its subparagraphs.



A. STANDARD BEND

B. WELDED BEND



C. 90° MAXIMUM

D. 45° MINIMUM

FIGURE 2. Lead bend (see 4.7.2).

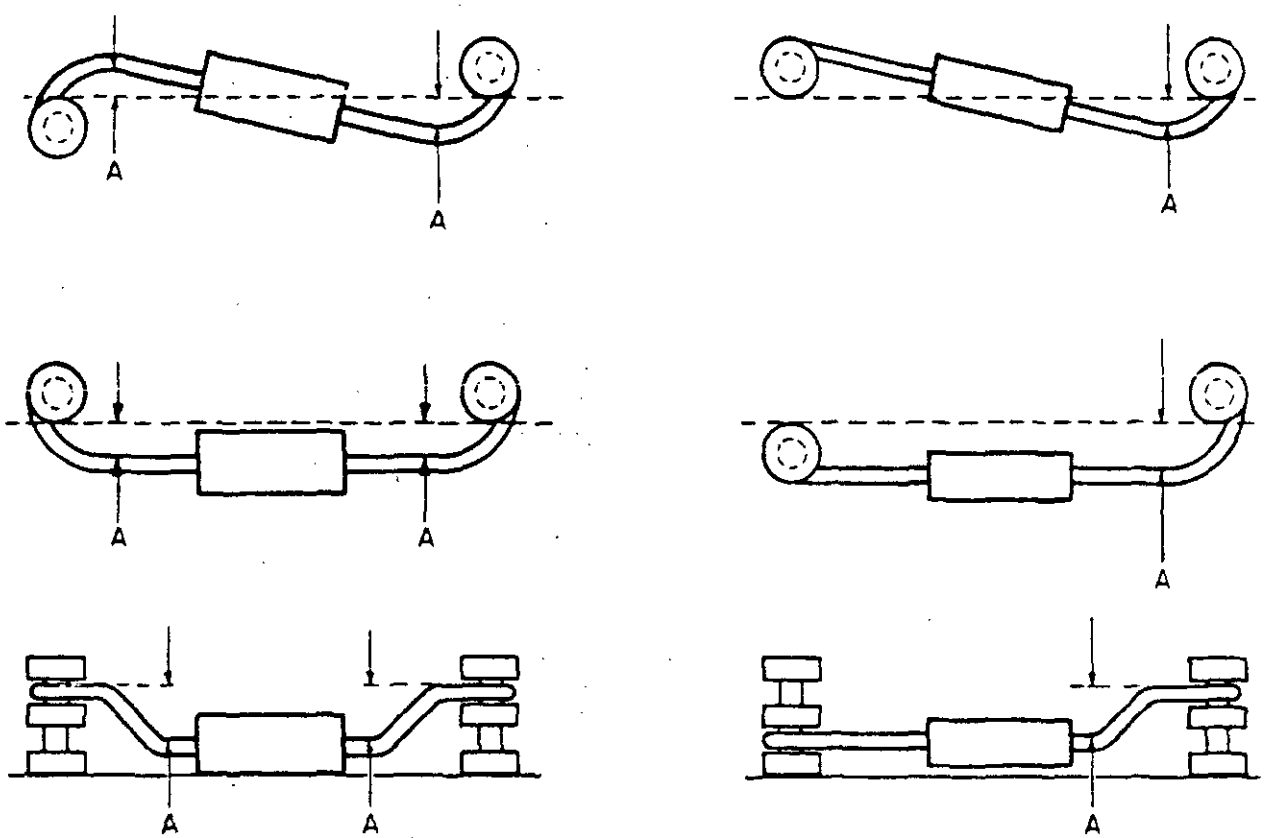
TABLE II. Bend radii.

Lead diameter (inch)	Minimum radius (R) (inch)
up to 0.027 inch (0.69 mm)	1 diameter
from 0.028 to 0.047 inch (0.71 to 1.19 mm)	1.5 diameter
0.048 inch (1.22 mm) and larger	2 diameter

4.7.3 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 0.030 inch (0.76 mm), as an allowance for stress relief to minimize tensile or shear stress to the soldered connection or part during thermal expansion. 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.

Devices with bodies either secured or unsecured mounting surface

Alternate method for devices with unsecured bodies



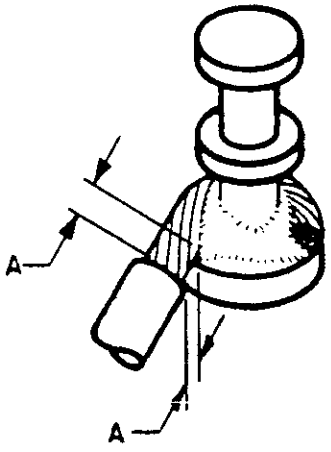
Measurement "A" is equal to or greater than two times lead diameter or thickness but not less than 0.030 inch (0.76 mm).

FIGURE 3. Typical stress relief bends (see 4.7.3).

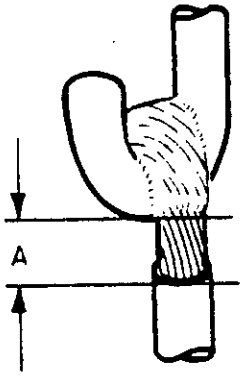
4.7.4 Insulation clearance. Clearance between the end of the insulation and the solder of the connection shall be as specified in 4.7.4.1 and 4.7.4.2 (see figure 4).

4.7.4.1 Minimum clearance. The insulation may abut but shall not be imbedded in the solder joint. The contour of the conductor shall not be obscured at the termination end of the insulation.

4.7.4.2 Maximum clearance. Clearance shall be less than two wire diameters (2D) (including insulation) or 0.060 inch (1.5 mm) whichever is larger, but shall not permit shorting between adjacent conductors.



A. TURRET TERMINAL



B. HOOK TERMINAL

Dimension "A" shall be zero (insulation abuts solder) or greater, and shall be less than two wire diameters (including insulation) or 0.060 inch (1.5 mm) whichever is larger.

FIGURE 4. Insulation clearance (see 4.7.4).

4.7.5 Hold down of planar mounted device leads. Except for lead compression during resistance reflow soldering, planar mounted device leads shall not be held down under stress during solder solidification.

4.8 Cooling. No liquid shall be used to cool a soldered connection. The connection shall be cooled at room temperature only. Heat sinks may be used to expedite cooling. The connection shall not be subjected to movement or stress at any time during the cooling and solidification of the solder.

4.9 Rework. The reworked connection shall conform to the requirements for the original connection. A cold solder or disturbed connection may require only reheating and reflowing of the solder.

4.10 Surface mounted devices. Unless otherwise specified herein, the mounting and soldering of leadless chip carriers, J-leaded devices and other surface mounted devices shall be in accordance with MIL-STD-275.

5. DETAIL REQUIREMENTS

5.1 Post soldering cleaning. Residues shall be removed within one hour after soldering by applying approved noncorrosive solvents as specified in 4.6.1a and drying. Mechanical means such as agitation or brushing may be used in conjunction with the solvents. The cleaning solvents and methods used shall have no deleterious effect on the parts, connections and materials being cleaned. Ultrasonic cleaning shall not be used for cleaning electrical or electronic assemblies or components or parts that contain electronic components. After cleaning, there shall be no visible evidence of flux residue or other contamination when examined in accordance with paragraph 5.6.1.

5.1.1 Cleanliness testing. Assemblies shall be subjected to a cleanliness test before the end of the production shift prior to conformal coating or encapsulation, before installation in the next assembly if not coated, or before packaging for shipment if the end product at contractor facility. The resistivity of solvent extract tests or the sodium chloride (NaCl) salt equivalent ionic contamination test, or a test approved by the Government Contracting Officer shall be used to test for ionic cleanliness. The resistivity of solvent extract tests must have a final value greater than 2,000,000 ohm-centimeters. The sodium chloride salt equivalent ionic contamination test must have a final value less than 10.0 micrograms per square inch of board surface area. Printed wiring assemblies shall be sampled, as a minimum, in accordance with MIL-STD-105.

5.1.2 Resistivity of solvent extract. Solvent extract resistivity shall be measured as follows (see table III):

a. Prepare a test solution of 75 percent by volume ACS reagent grade isopropyl alcohol and 25 percent by volume deionized water. Pass this solution through a mixed bed deionizer cartridge. After passage through the cartridge, the resistivity of the solution shall be greater than 6×10^6 ohm-cm (conductivity less than 0.166 micromhos/cm).

b. A clean funnel, a wash bottle, and a container with a portion of this test solution. Measure 10 milliliters of fresh test solution for each square inch of assembly area into the wash bottle. Assembly area includes the area 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.

5.1.3 Sodium chloride salt equivalent ionic contamination test. Sodium chloride salt equivalent ionic contamination shall be measured as follows (see table III):

a. The sodium chloride salt equivalent ionic contamination test must use a solution of 75 percent isopropyl alcohol/25 percent deionized water. This solution must be verified for correct composition upon initial use and every four hours during a shift.

b. The equipment must be calibrated 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 must be greater than 20 x 10^6 ohm-centimeters (0.05 micromhos/centimeter) before each sample is tested.

TABLE III. Cleanliness test values.

Test method	Starting resistivity	Ending value
Solvent Extract Resistivity	6 x 10^6 ohm-cm	shall be greater than 2 x 10^6 ohm-cm
Sodium Chloride Salt Equivalent Ionic Contamination	20 x 10^6 ohm-cm	shall be less than 10.0 micrograms/ square inch

5.1.4 Alternate methods. The following 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 5.1.2.

a. The Kenco Alloy and Chemical Company, Inc., "Omega Meter ™, Model 200."

b. Alpha Metals, Inc. "Ionograph ™."

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

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 IV lists the equivalence factors for these methods in terms of microgram equivalents of sodium chloride per unit area.

TABLE IV. Equivalence factors for testing ionic contamination.

Method	$\overline{X}$ μgNaCl/in^2	Equivalence factor	Instrument "Acceptance limit"	
			μgNaCl/Cm^2	μgNaCl/in^2
MIL-P-28809-Beckman	7.47 7.545	$\frac{7.545}{7.545} = 1$	1.56	10.06
MIL-P-28809-Markson	7.62	$\frac{7.545}{7.545} = 1$	1.56	10.06
Omega Meter	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

5.2 Manual soldering.

5.2.1 Applying flux. When used, liquid flux shall be applied in a thin, even coat to those surfaces being joined prior to application of heat. Cored solder wire shall be placed in such a position that the flux can flow and cover the connection as the solder melts. Flux shall be applied such that no damage will occur to surrounding parts and materials.

5.2.2 Applying heat. The areas to be joined shall be heated to cause melting of the solder and wetting of the surfaces. Excessive time (slow heating) and excessive temperature shall be avoided to prevent unreliable connections and damage to parts. Heat sinks shall be used as required for the protection of parts. Parts, wire insulation or printed wiring boards which have been charred, melted, or burned shall be replaced. When heat has caused part materials to discolor, further evaluation shall be performed to ascertain whether the essential properties have been adversely affected; if so, the item shall be replaced.

5.2.3 Applying solder. The areas to be joined shall be heated to the correct temperature, then the solder shall be applied to the connection and not the soldering iron; however, a very small quantity of solder may be applied at the place where the iron tip touches the connection to improve heat transfer. When solder-preform or solder paste methods are used, the solder shall be applied to the connection prior to heating.

5.3 Wave soldering for printed wiring assemblies.

5.3.1 Board condition. Prior to soldering, the assembly shall be adequately dried.

5.3.2 Flux application. Liquid flux shall be applied by the dip, spray, brush, roll, wave or foam method and shall form a thin coating on the surface. The flux shall be thinned as necessary to meet the requirements on flux application; however, the flux shall still meet the requirements of 4.2.2. The flux shall be dried to a tacky consistency before wave soldering to prevent solder splatter.

5.3.3 Preheating. Printed wiring assemblies shall be preheated prior to soldering. The preheat temperature shall not exceed the maximum temperature rating of parts.

5.3.4 Solder bath. The solder bath shall be maintained at a temperature of 450°F to 550°F (232°C to 288°C). The period of exposure of any printed wiring board to a solder bath shall be limited to a duration which will not cause damage to the board or parts mounted thereon. In no case shall the temperature or length of time be such as to cause damage to heat sensitive parts. Periodic inspections of the solder bath shall be made to insure that contamination levels meet the requirements of 5.3.4.1b.

NOTE: The temperature and the time of contact between the assembly and the solder is dependent upon such factors as preheating, thickness of board, number of contacts or conductors, and the type of parts.

5.3.4.1 Maintenance of solder purity. Solder purity shall be maintained as follows:

a. Before soldering a printed wiring board, all dross appearing on the surface shall be removed. Stainless steel or polytetrafluoroethylene (TFE) shall be used for stirring solder and removing dross. Dross blankets may be used provided the blankets do not contaminate the solder.

b. 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.

5.3.4.2 Inspection for solder purity. Solder in solder baths shall be chemically or spectrographically analyzed or renewed at the testing frequency levels shown in table V, 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 V, 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.

5.3.4.2.1 Guidelines. The information provided in the right hand column of table V is a guideline for monitoring of the soldering operation and may be used to indicate a need for increased frequency of testing, other than that shown in columns A, B and C, to ensure proper purity levels.

TABLE V. Contamination limits.

Contaminant 1/	Maximum Contamination Limits Percent by Weight		Interval Between Testing 8 Hr Operating Day 3/			Solder Joint Characteristic Guidlines (If Solder is Contaminated) 4/
	Preconditioning (Lead/Wire Tinning)	Assy Soldering 2/ (Pot, Wave, Etc.)	A	B	C	
Copper	.75	.30	15	30	30	Sluggish solder flow, solder hard and brittle
Gold	.50	.20	15	30	30	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	.20 ——► .50	.20 ——► .50	15	60	120	Not enough: Solder crumbles into white powder after low temperature aging Too much: Solder brittle
Iron	.02	.02	15	60	120	Iron tin compound $FeSn_2$ 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 from 59.5% to 63.5% tin 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 liquefied and used.

4/ See paragraph 5.3.4.2.1.

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

5.3.5 Touchup. Manual soldering as specified herein is permitted, if necessary, to remove solder projections, icicles, and bridges of solder, or to add solder to the part connection area. The quality standards for touchup shall be the same as for the original work.

5.4 Reflow soldering.

5.4.1 Solder application. Prior to component positioning, solder shall be applied to components or boards or both parts to be joined such that sufficient quantity is in place during reflow.

5.4.1.1 Solder paste drying (cure). Solder paste shall be dried (cured) before reflow. Thermal exposures employed shall not adversely affect the component, boards or solderability characteristics.

5.4.2 Flux application. Prior to the reflow process, a thin uniform coating of flux shall be applied to the land surfaces or connection area where the components leads are to be soldered. Where flux is a constituent of the solder paste or solder preform, additional flux need not be added.

5.4.3 Heat application. The component terminations to be soldered shall be heated above the flow temperature of the solder. The application of heat shall be controlled during the soldering operation to prevent damage to the assembly (e.g., base material, adjacent connections, electrical components). The process shall operate in a manner which precludes movement of the components relative to their respective terminal area as solder is solidifying.

5.4.3.1 Acceptable reflow soldering equipment. Reflow soldering equipment includes equipment which utilizes parallel gap resistance, shorted bar resistance, hot air, infrared, or thermal (condensation or vapor phase) soldering techniques. The laser reflow soldering process may be used with prior review and approval by the Government Contracting Officer or his designated technical activity. During reflow, the parts and printed wiring boards shall not be subjected to temperatures above which they are rated.

5.4.4 Touch-up. Manual soldering as specified herein is permitted, if necessary to remove solder projections, icicles and bridges or solder, or to add solder to the part connection area. The quality standards for touch-up shall be the same as for the original work.

5.4.5 Resoldering. The soldering operation may be repeated once provided that the reheating and resoldering does not introduce degradation of parts or printed wiring boards.

5.5 Additional soldering procedures. It is not the intention of this standard to exclude other acceptable procedures for applying flux and solder in making soldered electrical connections. However, the methods used must produce completed solder connections equivalent to those described as acceptable in this standard. The following requirements apply (see paragraphs 4 and 5 and appropriate subparagraphs):

a. Preparation and cleanliness of parts and wires.

b. Proper attachment of wires and leads.

c. Materials - fluxes, solders and cleaning solvents.

d. Application of fluxes and solders.

e. Temperature control.

f. Postsoldering cleaning. Terminations made with devices having premeasured amounts of solder and type R or RMA flux encapsulated in a preformed, transparent, heat shrinkable, self-sealing insulating material do not require flux removal.

5.5.1 Typical procedures. The following are typical additional acceptable soldering procedures:

a. Dip (solder bath).

b. Hot plate.

c. Induction.

d. Radiation.

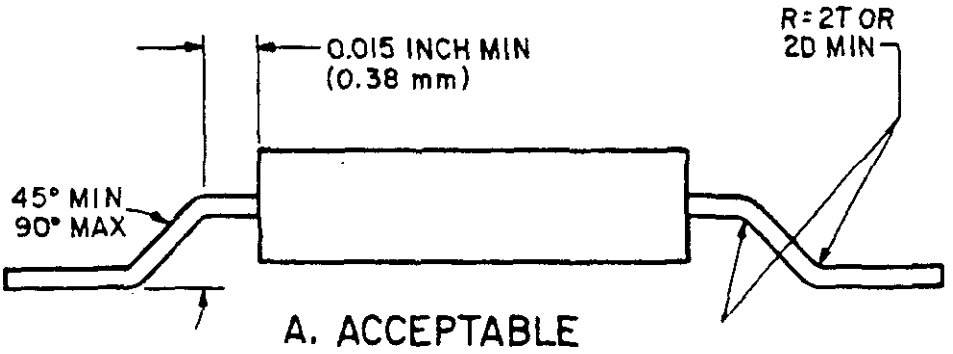
e. Hot-gas-blanket.

5.6 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 criteria delineated herein. Kovar or other iron based alloys leads shall be covered with solder. The cutting of component leads or wires after soldering shall be followed by the reflow of the solder connection.

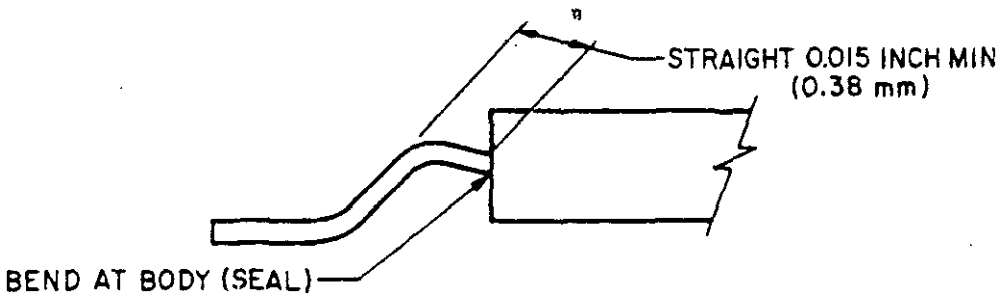
5.6.1 Inspection. Visual inspection of all soldered connections and assemblies shall be performed at a minimum magnification of 3 diopters (approximately 1.75X at a focal length of 10 inches (254 mm)) with a light source providing a shadowless illumination of the area being viewed. To determine conformance to the requirements specified herein 10X shall be used for referee examinations.

5.7 Characteristics of acceptable solder connections. The soldering, mounting and assembly requirements shall be in accordance with paragraphs 5.7 through 5.7.27 and the associated figures may be used as an aid in interpreting the requirements.

5.7.1 Planar mounted device lead forming. Leads shall be supported during forming to protect lead-to-body seal. Bends shall not extend into seal. The lead shall extend a minimum of 0.015 inch (0.38 mm) from the body before being bent. Lead bend radius shall be two thicknesses (2T) or two wire diameters (2D) minimum. 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 5).



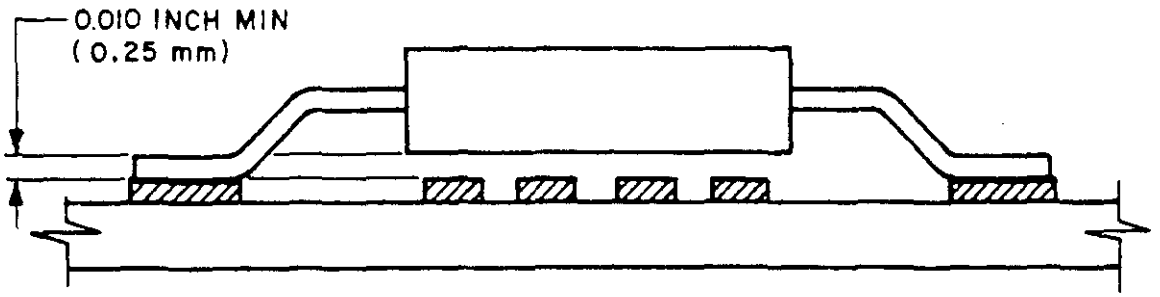
A. ACCEPTABLE



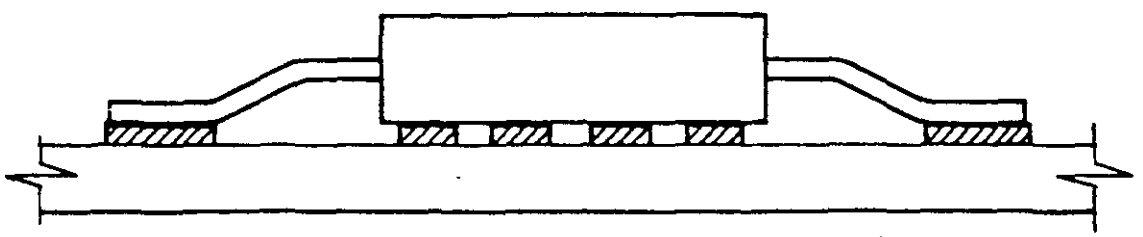
B. NOT ACCEPTABLE

FIGURE 5. Planar mounted device lead forming (see 5.7.1).

5.7.2 Planar mounted device lead forming over circuitry. Parts mounted over protected surfaces, or surfaces without exposed circuitry, may be mounted flush. Parts mounted over exposed circuitry shall have their leads formed to allow a minimum of .010 inch (0.25 mm) between the bottom of the component body and the exposed circuitry (see figure 6).



A. ACCEPTABLE



B. NOT ACCEPTABLE

FIGURE 6. Planar mounted device lead forming over circuitry (see 5.7.2).

5.7.3 Planar mounted device lead deformation. Minor lead deformation shall be allowed, provided none of the following conditions exist (see figure 7):

a. No evidence of a short or potential short exists.
b. Lead or body is not damaged by the deformation.
c. Top of lead does not extend beyond the top of body. Preformed stress loops may extend above the top of the body.
d. Toe curl, if present on bends, shall not exceed two times the thickness (2T).

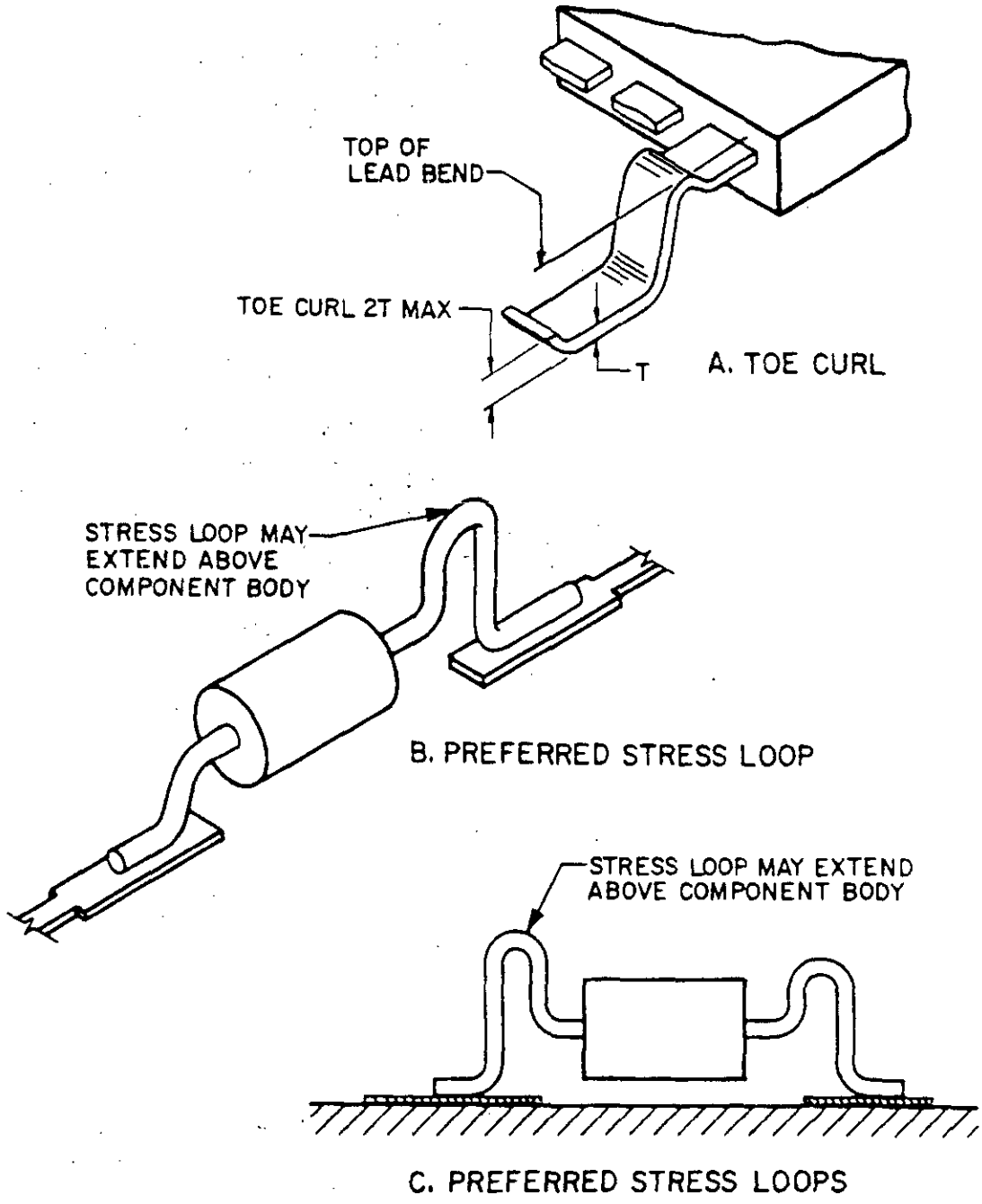


FIGURE 7. Planar mounted device lead deformation (see 5.7.3).

5.7.4 Planar mounted device lead and land contact. Minimum contact length shall be equal to the lead width for flat leads and two times the diameter (2D) for round leads (see figure 8).

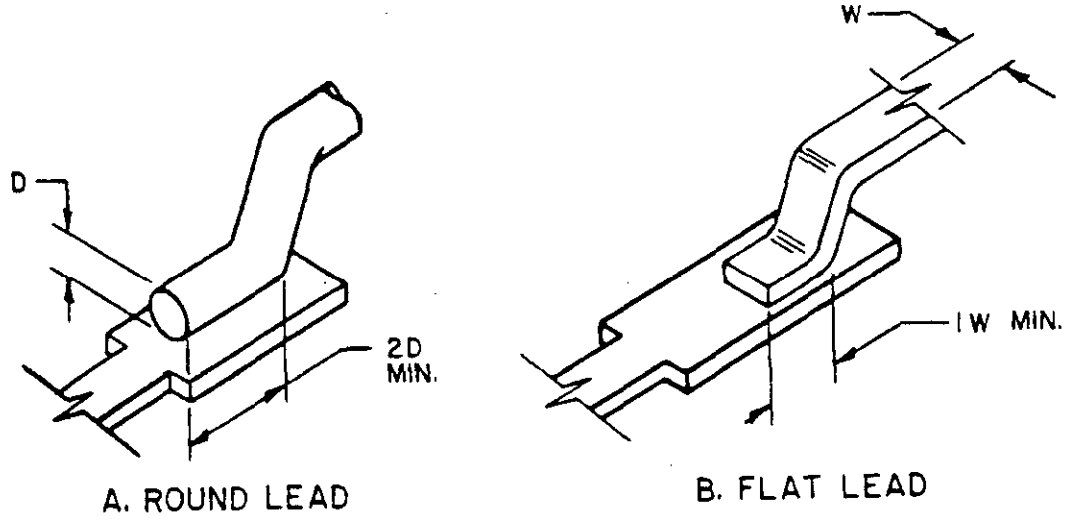


FIGURE 8. Planar mounted device lead and land contact (see 5.7.4).

5.7.5 Planar mounted device flat lead overhang. Flat leads may have side overhang, provided the overhang does not exceed 25 percent of the lead width or 0.020 inch (0.5 mm), whichever is less, and minimum conductor spacing is maintained (see figure 9).

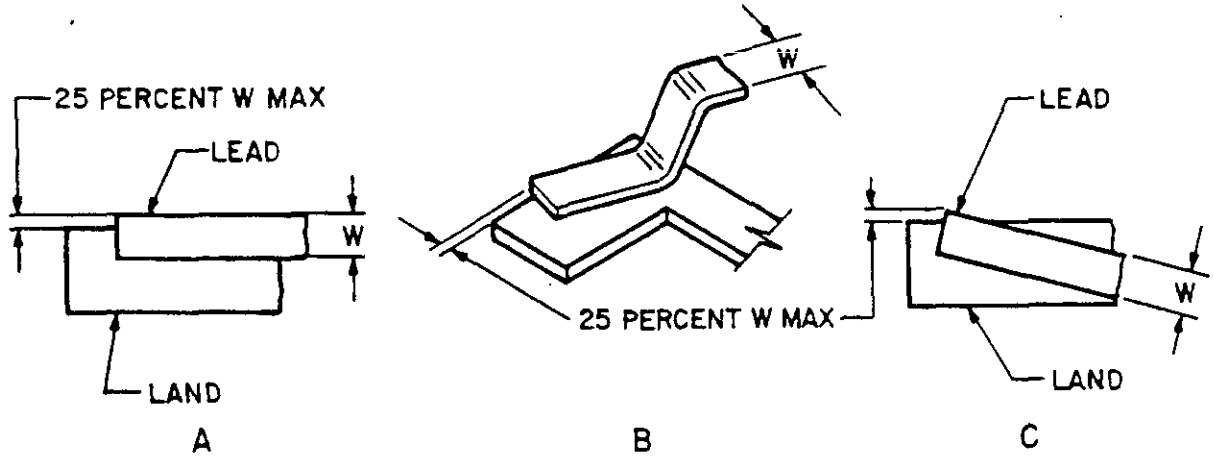


FIGURE 9. Planar mounted device flat lead overhang (see 5.7.5).

5.7.6 Planar mounted device round or coined lead side overhang. Round, flatted, or coined leads of planar mounted devices shall not exhibit any side overhang. Skewing is permissible provided there is no side overhang (see figure 10).

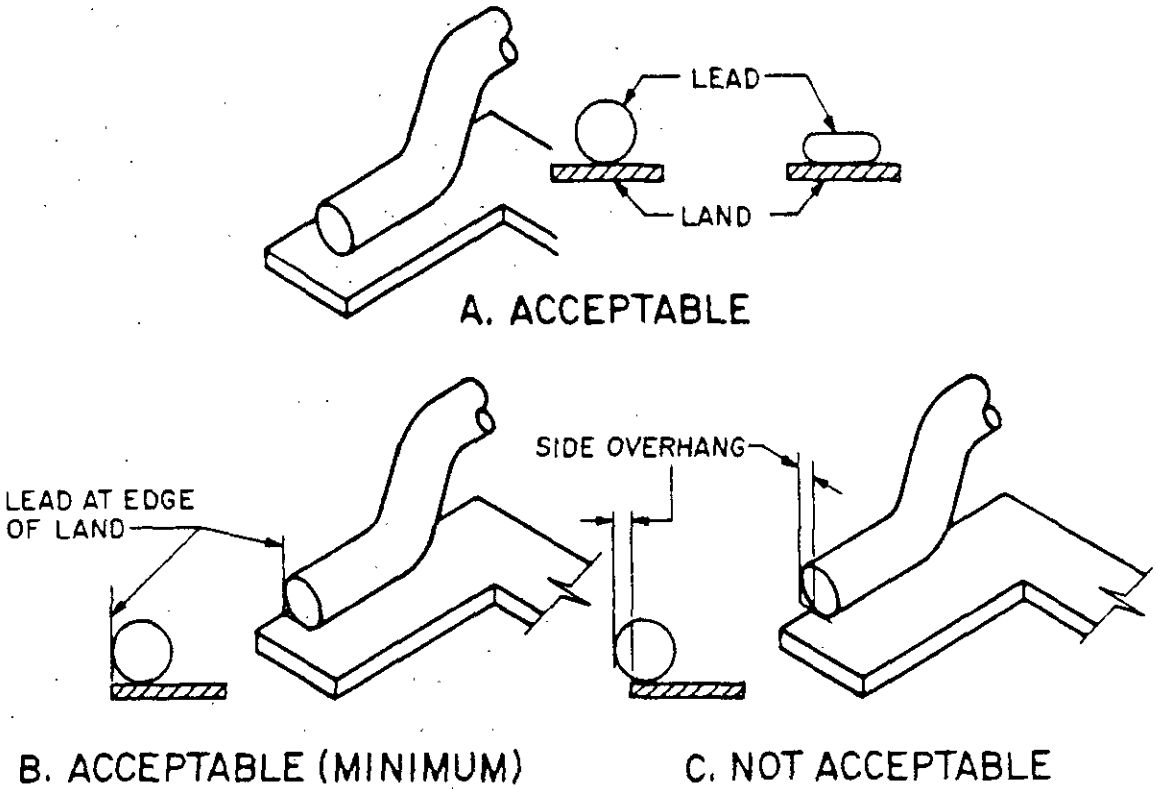


FIGURE 10. Planar mounted device round or coined lead side overhang (see 5.7.6).

5.7.7 Planar mounted device lead toe overhang. Toe end of leads of planar mounted devices may overhang the land, provided the minimum conductor spacing is maintained, the total overhang does not exceed 25 percent of the lead width or diameter (round leads) or 0.020 inch (0.5 mm), whichever is less, and the minimum contact length is maintained (see figure 11).

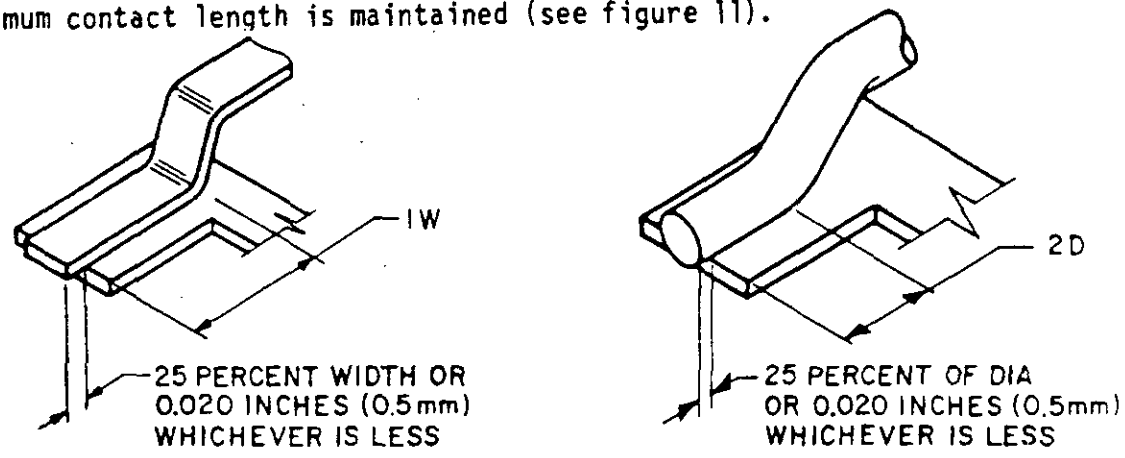


FIGURE 11. Planar mounted device lead toe overhang (see 5.7.7).

5.7.8 Planar mounted device lead heel clearance. Round and flat leads shall be placed so that the heel shall be a minimum of 2D or 1W from the edge of the land (see figure 12).

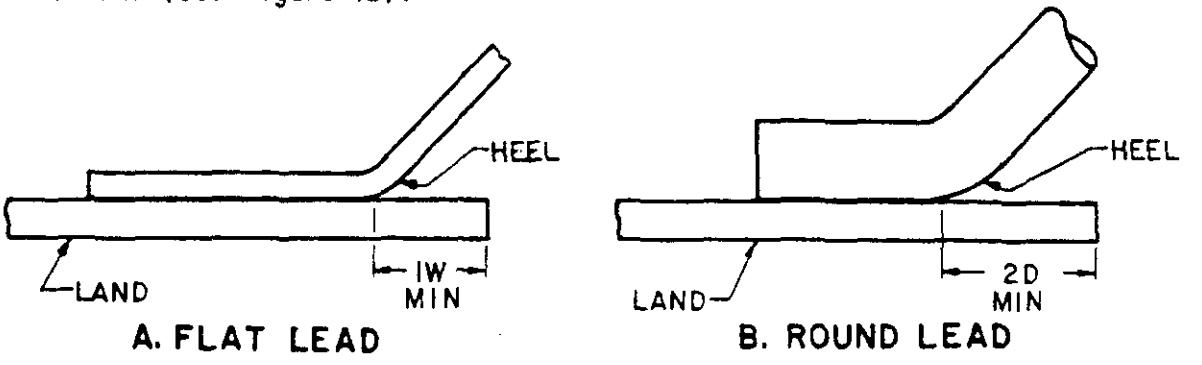


FIGURE 12. Planar mounted device lead heel clearance (see 5.7.8).

5.7.9 Planar mounted device lead height off land. Round or coined leads may be raised off the land surface a maximum of one-half of the original lead diameter. Flat or ribbon leads may be raised off the land surface a maximum of two times the lead thickness or 0.020 inches (0.5 mm), whichever is less (see figure 13). 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 1/2D limits.

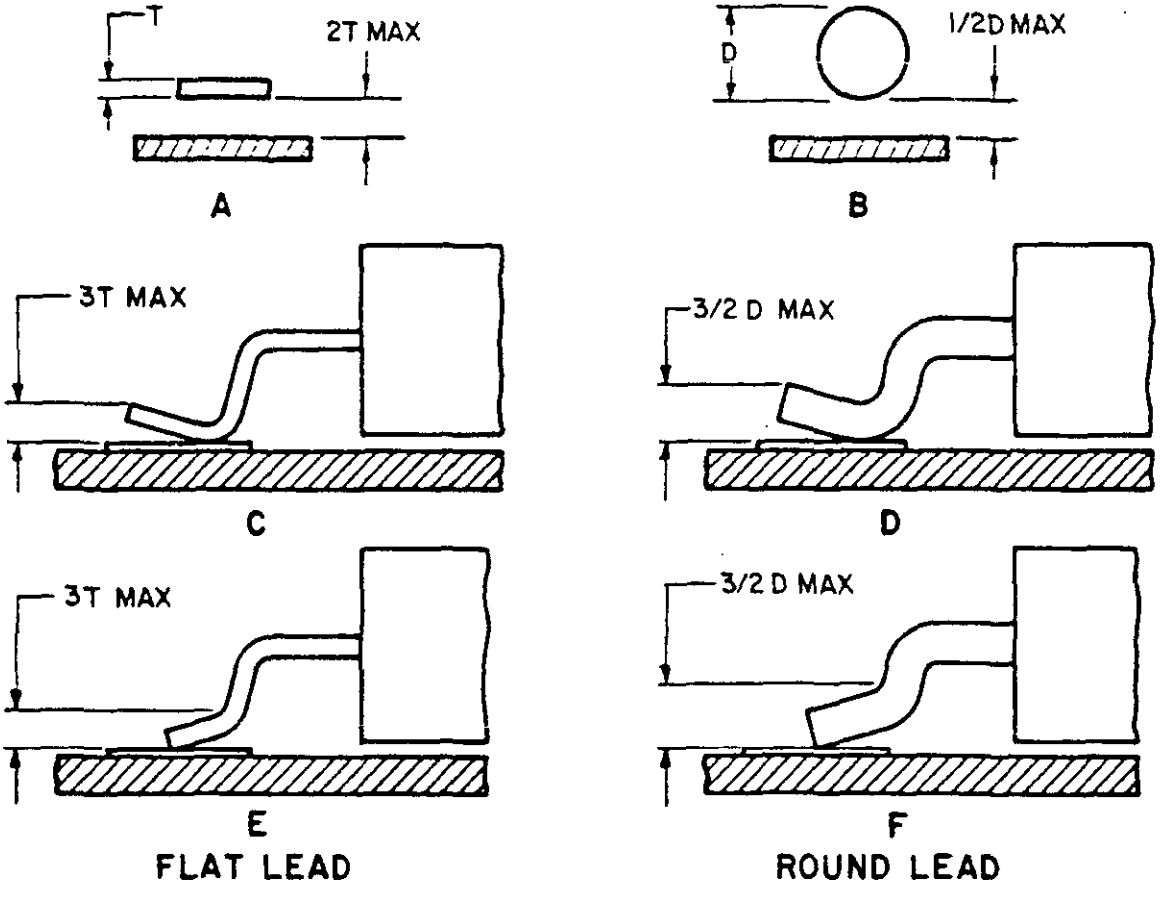


FIGURE 13. Planar mounted device lead height off land (see 5.7.9).

5.7.10 Planar mounted device round or coined lead solder fillet. Minimum solder fillet height on round or coined leads shall be 25 percent of the original lead diameter. The solder shall extend the length of the lead termination (see figure 14A). The solder shall not overhang the land. The outline of the lead must be discernible in the solder (see figure 14).

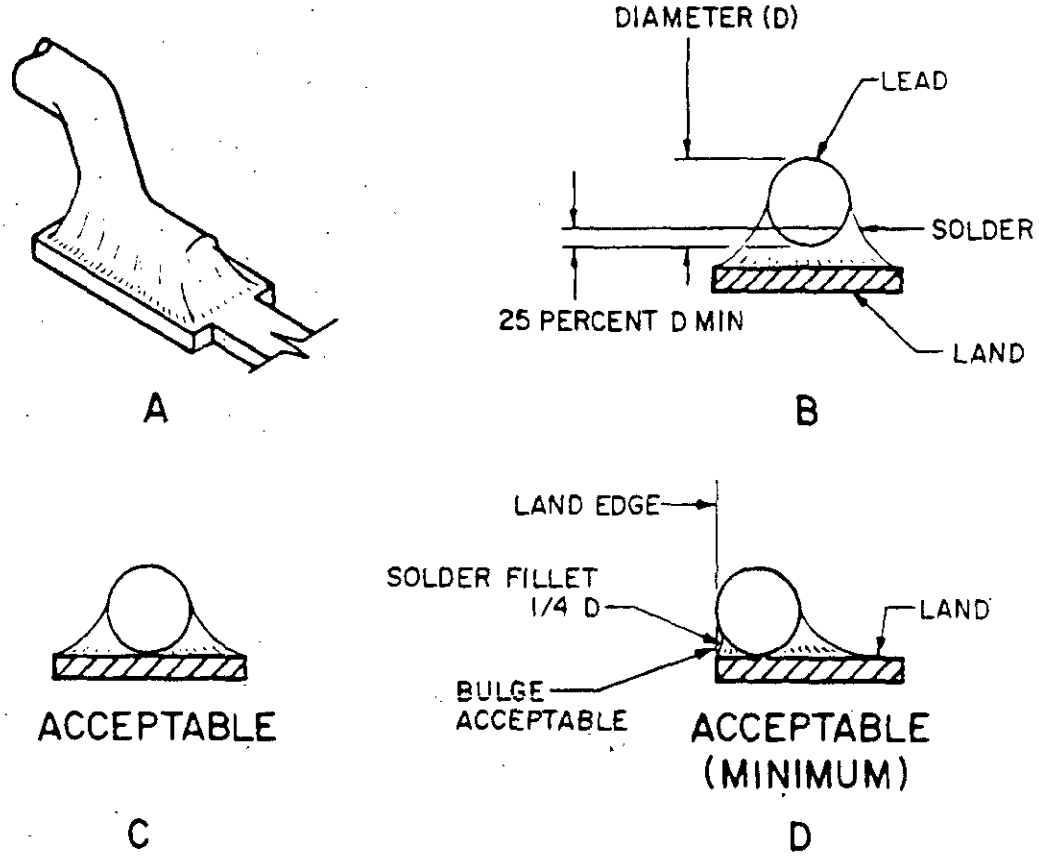


FIGURE 14. Planar mounted device round or coined lead solder fillet (see 5.7.10).

5.7.11 Planar mounted device flat lead solder fillet. Flat leads shall exhibit a visible fillet rising from the land to the top of the lead whenever the lead is over the land. The solder shall extend the length of the lead termination (see figure 15C). The solder shall not overhang the land. The outline of the lead must be discernible in the solder (see figure 15).

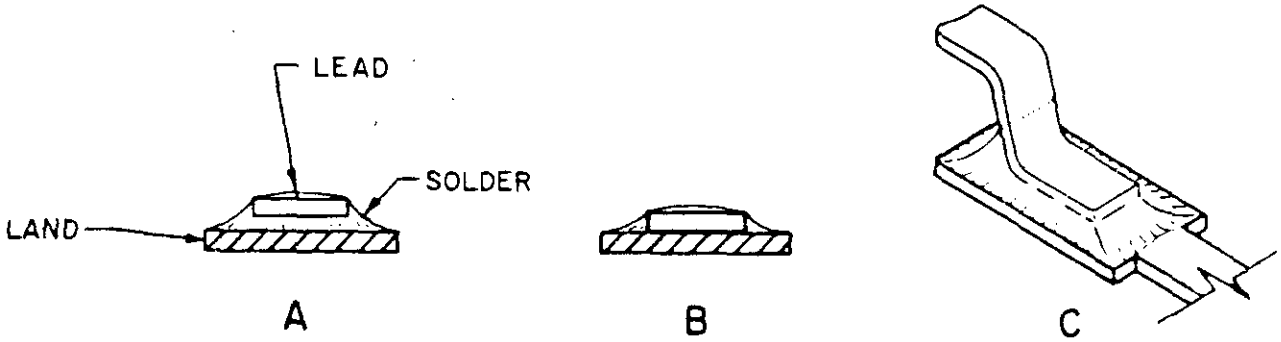


FIGURE 15. Planar mounted device flat lead solder fillet (5.7.11).

5.7.12 Planar mounted device lead heel fillet. The heel fillet shall be continuous between the heel of the lead and the circuit land. The heel fillet shall extend to the midpoint of the lower bend radius for flat leads. The heel fillet shall extend beyond the full bend radius for round leads. The solder fillet for any lead shall not extend into the start of the upper bend radius (see figure 16). The start of the bend radius between upper and lower bend points for flat and round leads shall be formed in accordance with 4.7.2.

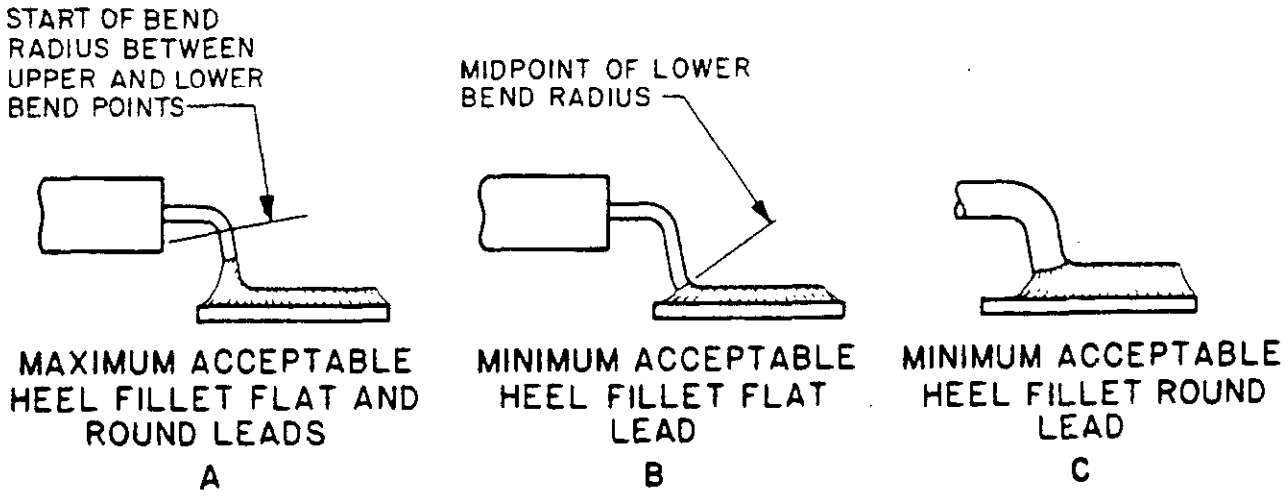


FIGURE 16. Planar mounted device lead heel fillet (see 5.7.12).

5.7.13 Tool marks on planar mounted device solder fillet. Tool marks resulting from heater bar or lead hold down during soldering operation shall not be cause for rejection (see figure 17).

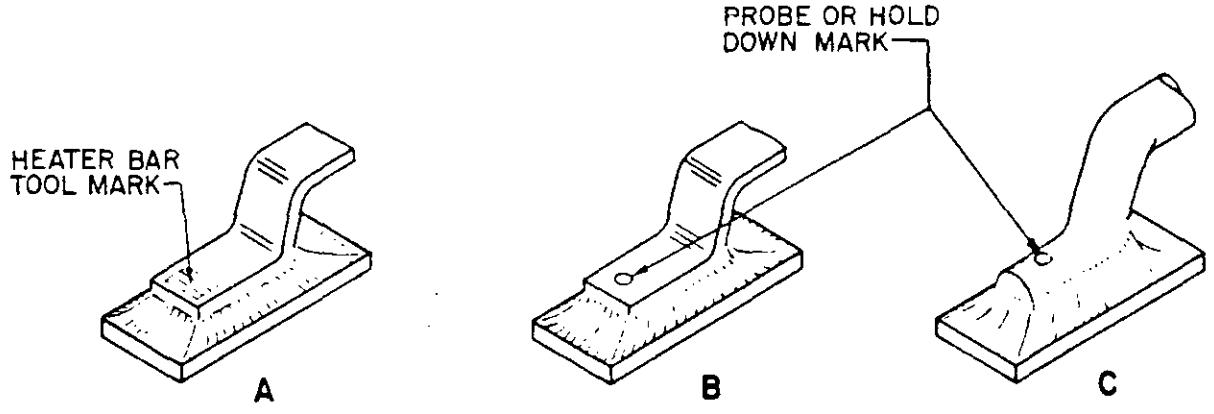


FIGURE 17. Planar mounted device tool marks (see 5.7.13).

5.7.14 Acceptable amount of solder on plated-through hole or unsupported hole. For leads or wires protruding through plated-through or unsupported holes, the length of the lead or wire shall be covered with solder, but if the lead or wire end is covered, the end shall be discernible. Solder connections shall cover at least 80 percent of the land and shall not overhang the land. There shall be no solder bridges or protrusions. Solder shall cover at least 80 percent of the land surface and the full 360° arc of the hole (see figure 18).

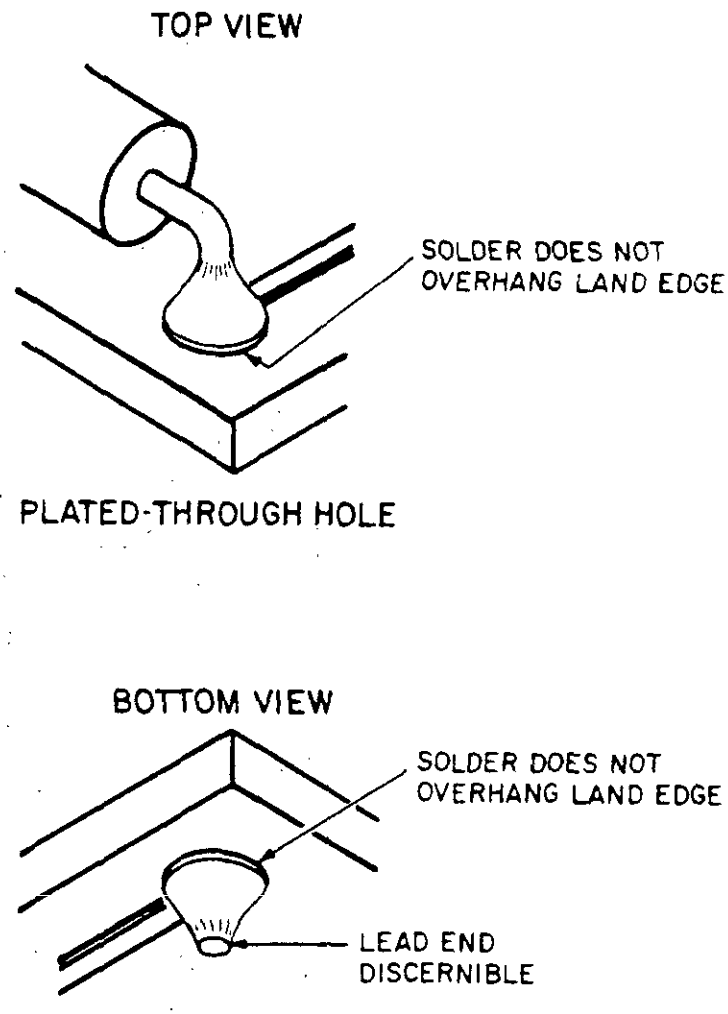
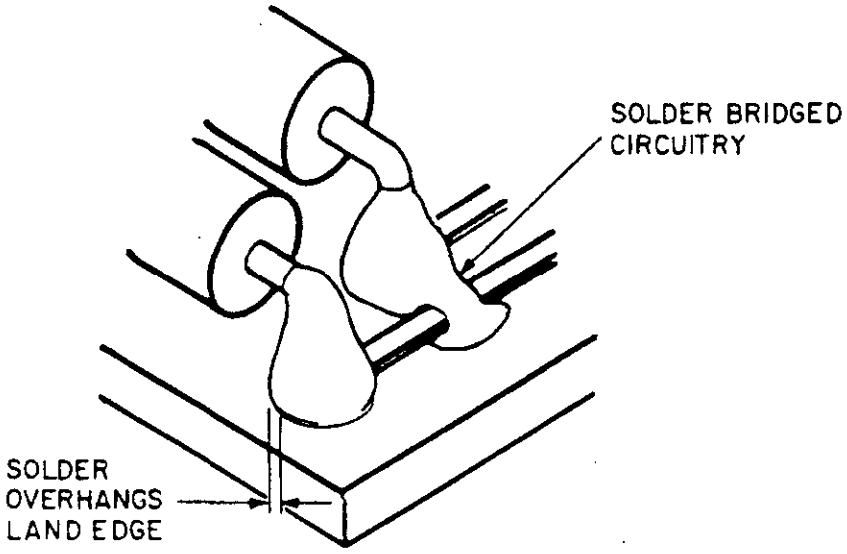


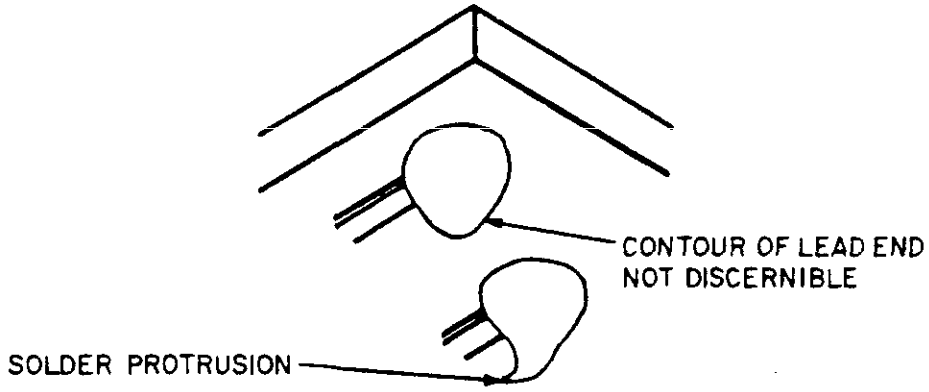
FIGURE 18. Maximum amount of solder (see 5.7.14).

TOP VIEW



PLATED-THROUGH HOLE

BOTTOM VIEW



PLATED-THROUGH HOLE
OR UNSUPPORTED HOLE

EXCESS SOLDER

B. NOT ACCEPTABLE

FIGURE 18. Maximum amount of solder (see 5.7.14) (continued).

5.7.15 Minimum amount of solder.

5.7.15.1 Minimum amount of solder on plated-through holes. For plated-through holes, total combined top and bottom solder recession shall be no more than 25 percent of the total thickness of the board including land on both sides. A concave fillet shall wet the upper edge of the complete 360° arc of the hole. The lower land shall also be wetted over the full 360° arc and at least 80 percent of the land shall be covered with solder (see figure 19).

5.7.15.2 Minimum amount of solder on unsupported hole. All lands of unsupported holes shall be wetted over the full 360° arc and the full area of the lands shall be covered with solder (see figure 19).

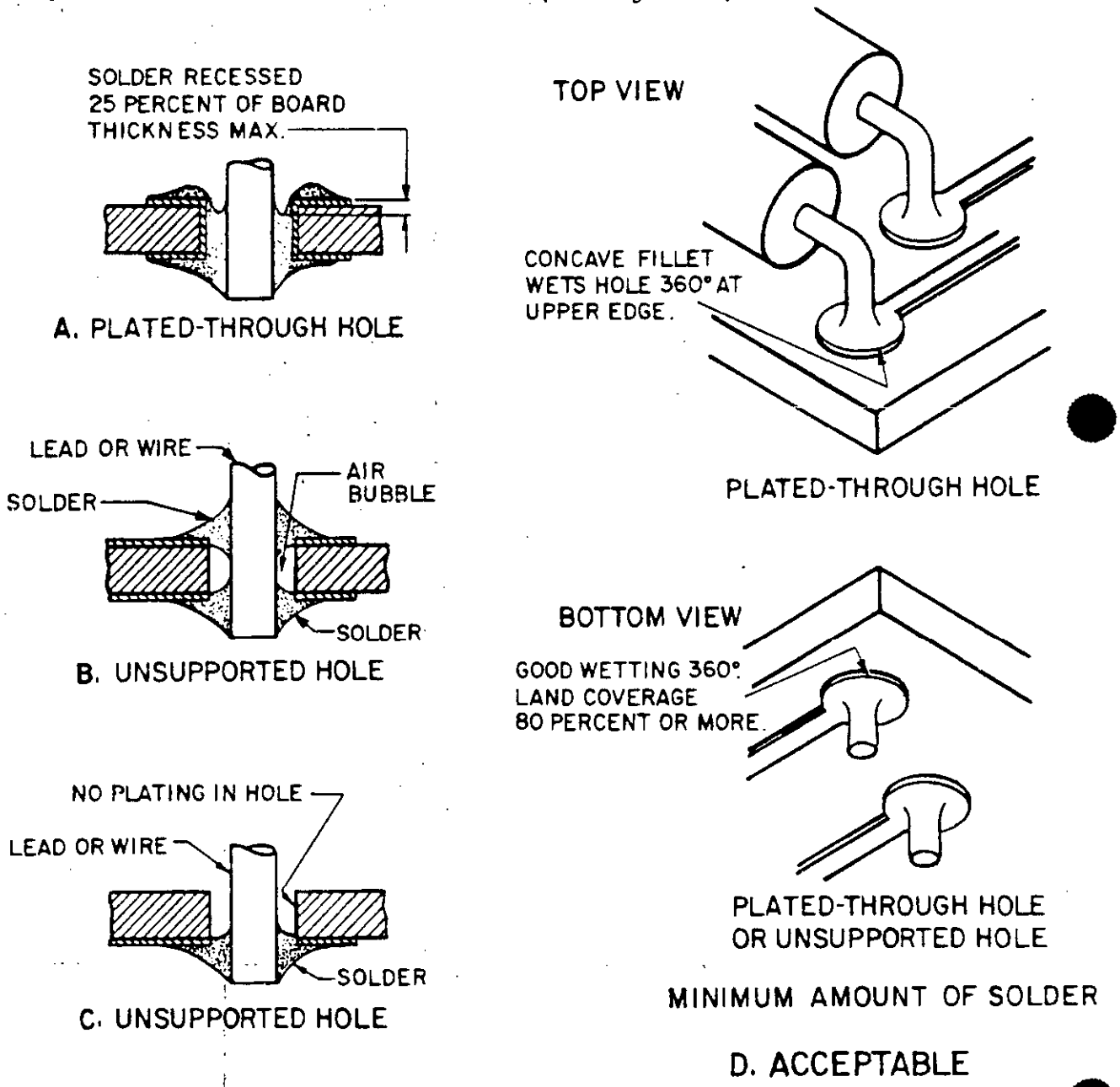
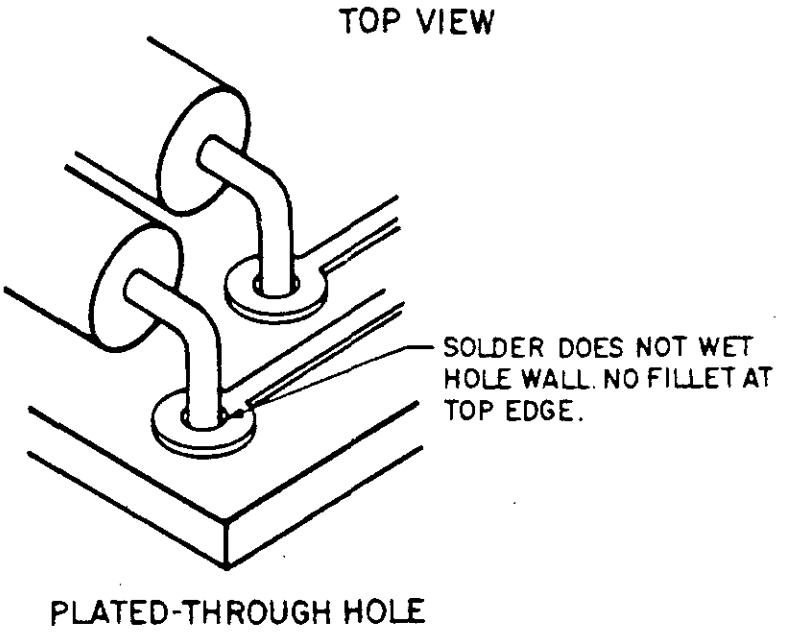


FIGURE 19. Minimum amount of solder (see 5.7.15).



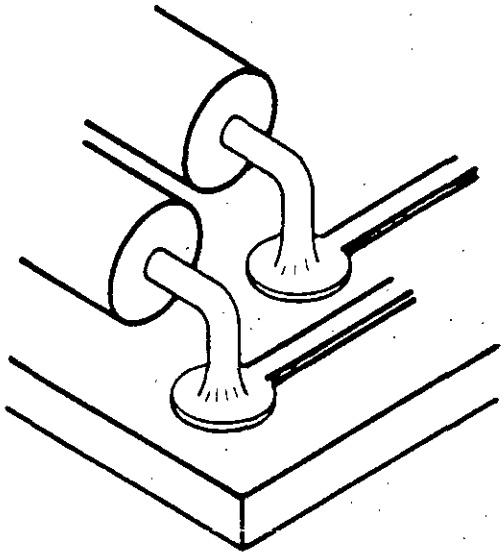
E. NOT ACCEPTABLE

FIGURE 19. Minimum amount of solder (see 5.7.15) (Continued).

5.7.16 Solder connection appearance and deformation. The appearance of the solder connection surface shall be smooth, nonporous, noncrystalline, bright and continuous. The solder connection shall be free of scratches, sharp edges, spikes, protrusions, blow holes, flux residue, inclusions of foreign material, and exposed basis metal. Pits and voids so located or of a size and shape that connection integrity is not degraded are permissible provided the bottom of the void cannot be seen. Solder shall be of sufficient amount to cover all elements of the connection but shall not be of such quantity that the outline of any included lead or lead wire is not discernible in the solder. Solder shall not appear as globules, peaks, strings and bridging between adjacent conductor paths. Insufficient solder shall not be acceptable.

5.7.17 Solder wetting. Solder shall wet the surfaces of all connection elements and form a fillet between elements over the complete periphery of the connection. The solder shall have a small contact angle between the surfaces being joined. A small inclusion in the fillet does not constitute dewetting. Solder shall not gather in droplets or balls (see figure 20).

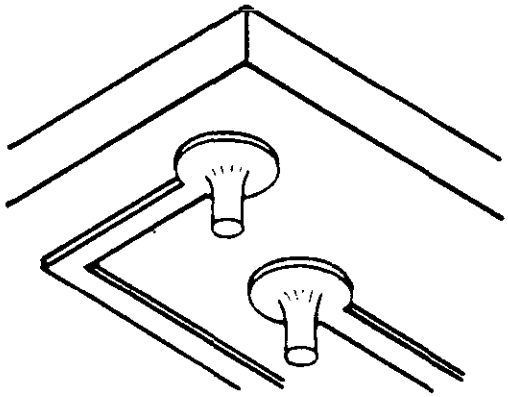
TOP VIEW



PLATED-THROUGH HOLE

1. SMALL INCLUSION IN FILLET DOES NOT CONSTITUTE DEWETTING.
2. SURROUNDING AREAS WELL WETTED.
3. FILLET MAY BE CONCENTRATED ON ONE SIDE OF LAND.
4. NO DEWETTING IN EVIDENCE.

BOTTOM VIEW

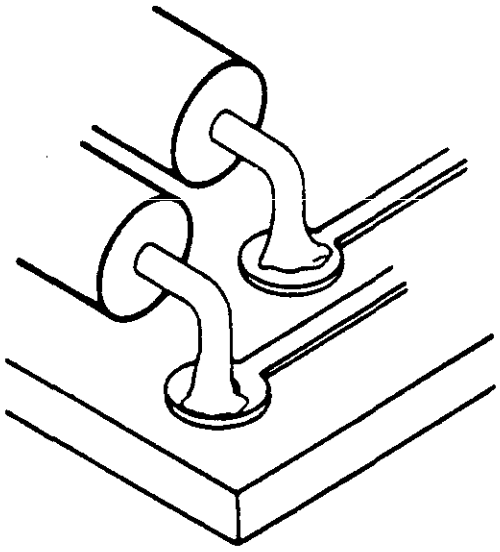


PLATED-THROUGH HOLE
OR UNSUPPORTED HOLE

A. ACCEPTABLE

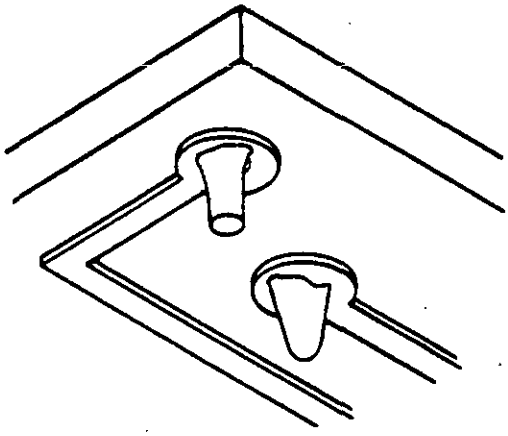
FIGURE 20. Plated-through holes straight-through lead-solder wetting (see 5.7.17).

TOP VIEW



PLATED-THROUGH HOLE

BOTTOM VIEW



PLATED-THROUGH HOLE
OR UNSUPPORTED HOLE

1. SOLDER DOES NOT COMPLETELY COVER SURFACES OR DOES NOT FEATHER TO LEAD OR LAND SURFACES.

2. SOLDER GATHERS INTO DROPLETS OR BALLS.

B. NOT ACCEPTABLE

FIGURE 20. Plated-through holes straight-through lead-solder wetting (see 5.7.17) (Continued).

5.7.18 Voids. A void whose surface is less than 5 percent of the surface area of the solder connection is acceptable provided the inner surface of the void is totally visible when viewed with the magnification specified herein (see figure 21).

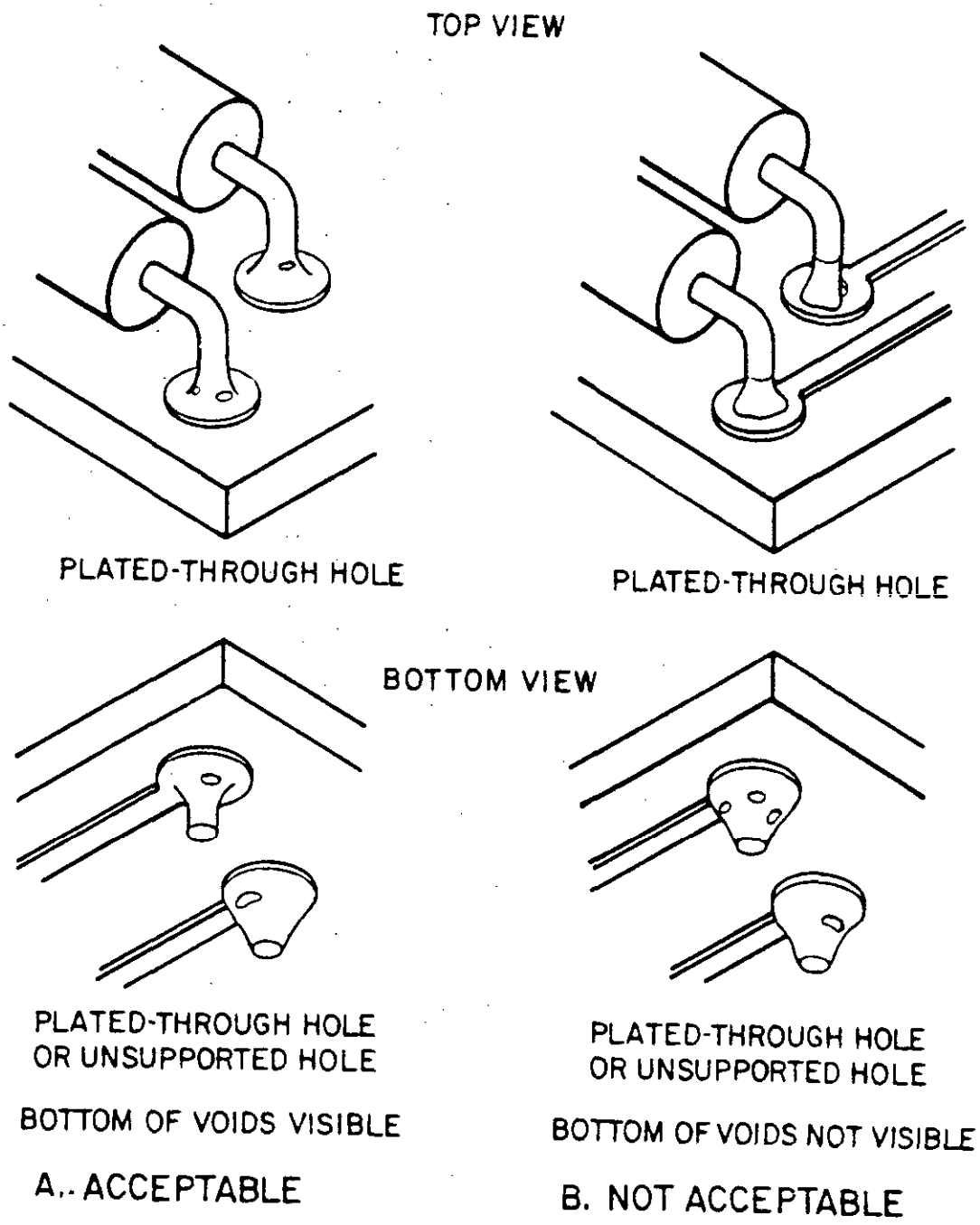
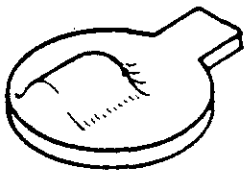
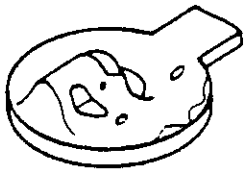


FIGURE 21. Plated-through holes-voids (see 5.7.18).

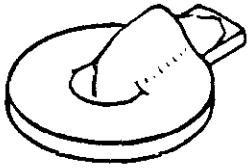
5.7.19 Visual characteristics of acceptable solder connections. Solder shall wet the surfaces of all connection elements and shall form a fillet between connection elements over the complete periphery of the connection. The solder shall have a small contact angle between the surfaces being joined. As a minimum, solder shall fill a plated-through hole 75 percent of the board thickness. A nonplated through hole need not be covered with solder (see figures 22 and 23).



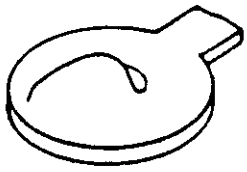
1. SOLDER FILLET 100 PERCENT COMPLETE.
2. CONTOUR OF LEAD IS DISCERNIBLE.
3. HEEL OF LEAD IS WETTED WITH SOLDER.



1. SOLDER FILLET NOT COMPLETE.
2. NUMEROUS VOIDS.
3. EVIDENCE OF DEWETTING.



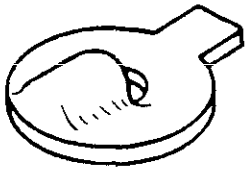
A. ACCEPTABLE (MINIMUM)



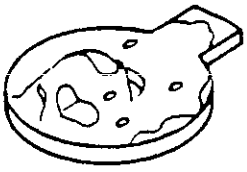
EXCESS SOLDER.
LEAD NOT VISIBLE

B. NOT ACCEPTABLE

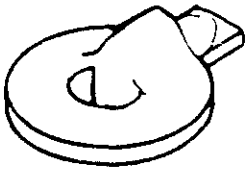
FIGURE 22. Plated-through holes - clinched lead and wires (see 5.7.19).



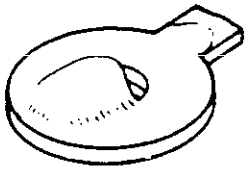
1. SOLDER FILLET 100 PERCENT COMPLETE.
2. CONTOUR OF LEAD IS DISCERNIBLE.
3. HEEL OF LEAD IS WETTED WITH SOLDER.
4. NONPLATED THRU HOLE NEED NOT BE COVERED WITH SOLDER.



1. SOLDER FILLET NOT COMPLETE.
2. NUMEROUS VOIDS.
3. EVIDENCE OF DEWETTING.



A. ACCEPTABLE (MINIMUM)

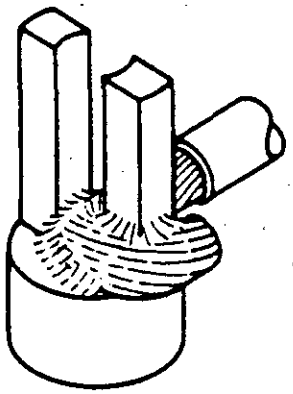


EXCESS SOLDER.
LEAD NOT VISIBLE.

B. NOT ACCEPTABLE

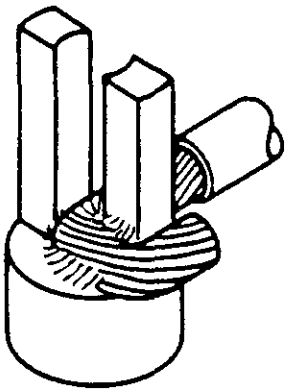
FIGURE 23. Nonplated-through hole - clinched leads and wires (see 5.7.19).

5.7.20 Soldering of wires and leads to bifurcated terminals. Solder shall cover the wire or lead over the extent of the wrap but shall not obscure the extent of the wrap. The solder shall wet the terminal and wire or lead and form a visible fillet (see figure 24).



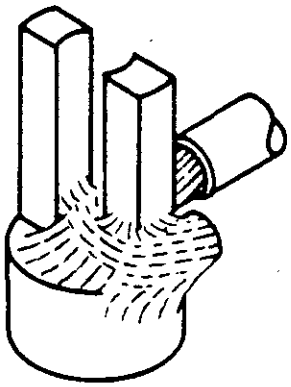
1. SOLDER JUST COVERS THE WIRE OR LEAD OVER THE EXTENT OF THE WRAP.
2. SOLDER WETS THE TERMINAL AND WIRE OR LEAD AND FORMS A VISIBLE FILLET.

A. ACCEPTABLE (MINIMUM)



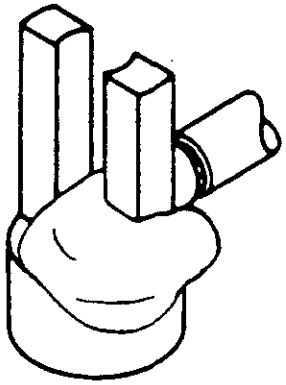
1. SOLDER DOES NOT COVER THE WIRE OR LEAD OVER EXTENT OF THE WRAP.
2. FILLETING IS INCOMPLETE.

B. NOT ACCEPTABLE (INSUFFICIENT)



1. SOLDER DOES NOT COMPLETELY OBSCURE THE EXTENT OF THE WRAP.
2. SOLDER WETS THE TERMINAL AND WIRE OR LEAD.

C. ACCEPTABLE (MAXIMUM)

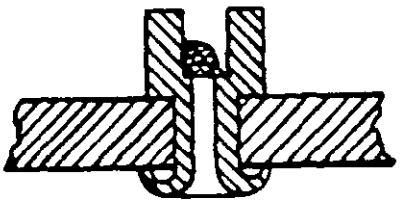


1. A BUILDUP OF SOLDER COMPLETELY OBSCURES THE CONTOUR OF THE WIRE OR LEAD OVER EXTENT OF THE WRAP.

D. NOT ACCEPTABLE (EXCESSIVE)

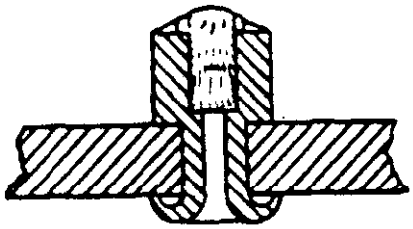
FIGURE 24. Wire and lead soldering to bifurcated terminals (see 5.7.20).

5.7.21 Soldering of wires and leads to slotted terminals. As a minimum solder shall form a fillet with that portion of the wire or lead that is in contact with the terminal. Solder may completely fill the slot but shall not be built up on top of the terminal. The wire or lead shall be discernible in the terminal (see figure 25).



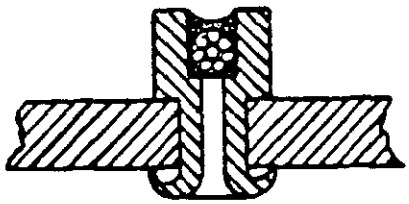
1. MINIMUM AMOUNT OF SOLDER ALONG THE WIRE OR LEAD.
2. WIRE OR LEAD END DISCERNIBLE IN TERMINAL.

A. ACCEPTABLE (MINIMUM)



1. SOLDER BUILDUP ON TOP OF TERMINAL.
2. WIRE OR LEAD NOT DISCERNIBLE THROUGH TERMINAL.

B. NOT ACCEPTABLE

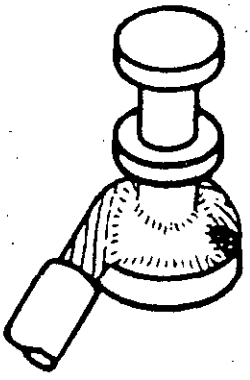


1. MAXIMUM AMOUNT OF SOLDER COMPLETELY FILLS SLOT.
2. WIRE OR LEAD END DISCERNIBLE IN TERMINAL.

C. ACCEPTABLE (MAXIMUM)

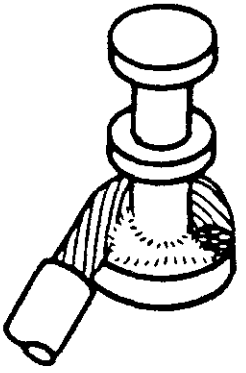
FIGURE 25. Wire and lead soldering to small slotted terminal (see 5.7.21).

5.7.22 Soldering of wires and leads to turret terminals. Solder shall wet the terminal and wire or lead and form a visible fillet between all areas of contact between the terminal and wire or lead. The solder shall cover the wire or lead over the extent of the wrap but shall not obscure the contour of the wire or lead (see figure 26).



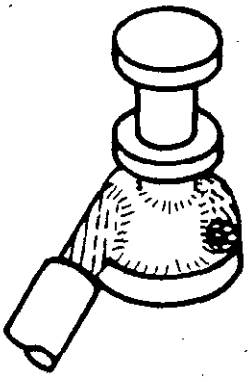
1. SOLDER JUST COVERS THE WIRE OR LEAD OVER THE EXTENT OF THE WRAP.
2. SOLDER WETS THE TERMINAL AND WIRE OR LEAD AND FORMS A VISIBLE FILLET.

A. ACCEPTABLE (MINIMUM)



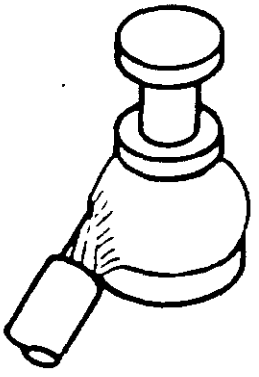
1. SOLDER DOES NOT COVER THE WIRE OR LEAD OVER EXTENT OF THE WRAP.
2. FILLETING IS INCOMPLETE.

B. NOT ACCEPTABLE (INSUFFICIENT)



1. SOLDER DOES NOT COMPLETELY OBSCURE THE EXTENT OF THE WRAP.
2. SOLDER WETS THE TERMINAL AND WIRE OR LEAD AND FORMS A VISIBLE FILLET.

C. ACCEPTABLE (MAXIMUM)

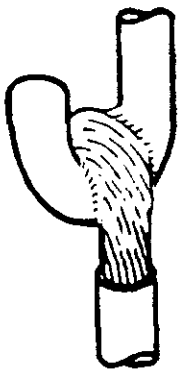


1. BUILDUP OF SOLDER COMPLETELY OBSCURES THE CONTOUR OF THE WIRE OR LEAD OVER EXTENT OF THE WRAP.

D. NOT ACCEPTABLE (EXCESSIVE)

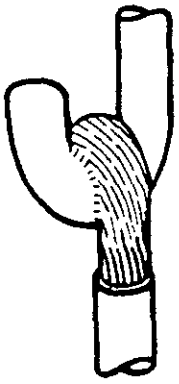
FIGURE 26. Wire and lead soldering to turret terminals (see 5.7.22).

5.7.23 Soldering of wires and leads to hook terminals. Solder shall wet the terminal and wire or lead and form a visible fillet between all areas of contact between the terminal and wire or lead. The solder shall cover the wire or lead over the extent of the wrap but shall not obscure the contour of the wire or lead (see figure 27).



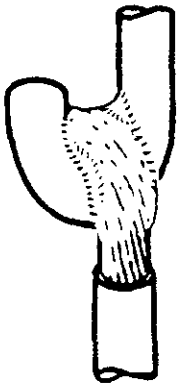
1. SOLDER JUST COVERS THE WIRE OR LEAD OVER THE EXTENT OF THE WRAP.
2. SOLDER WETS THE TERMINAL AND WIRE OR LEAD AND FORMS A VISIBLE FILLET.

A. ACCEPTABLE (MINIMUM)



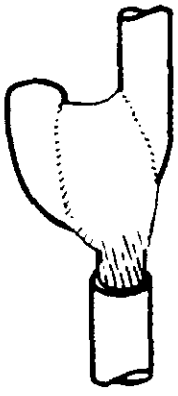
1. SOLDER DOES NOT COVER THE WIRE OR LEAD OVER EXTENT OF THE WRAP.
2. FILLETING IS INCOMPLETE.

B. NOT ACCEPTABLE (INSUFFICIENT)



1. SOLDER DOES NOT COMPLETELY OBSCURE THE EXTENT OF THE WRAP.
2. SOLDER WETS THE TERMINAL AND WIRE OR LEAD.

C. ACCEPTABLE (MAXIMUM)



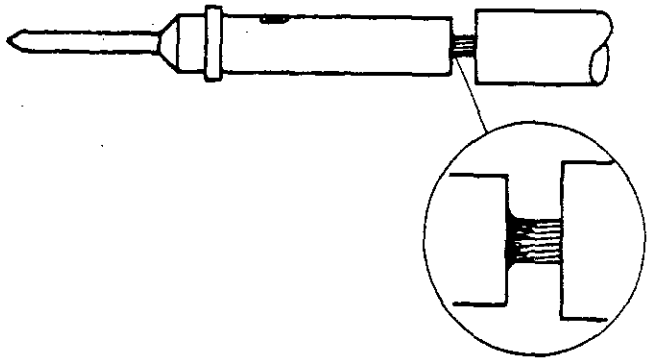
1. BUILDUP OF SOLDER COMPLETELY OBSCURES THE CONTOUR OF THE WIRE OR LEAD OVER EXTENT OF THE WRAP.

D. NOT ACCEPTABLE (EXCESSIVE)

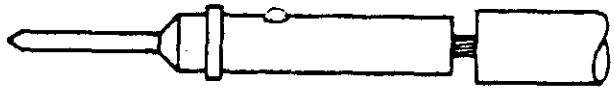
FIGURE 27. Wire and lead soldering to hook terminals (see 5.7.23).

5.7.24 Soldering of wires and leads to contacts. Solder shall visibly wet between the cup and wire or lead. Any solder on the outside surface of the solder cup shall be in the form of a thin film only. Solder shall be visible in the inspection hole, may rise slightly above it, but shall not spill onto the side of the contact (see figure 28).

1. SOLDER VISIBLE IN INSPECTION HOLE.
2. SOLDER WETTING BETWEEN WIRE OR LEAD AND CUP IS VISIBLE.
3. ANY SOLDER ON THE OUTSIDE SURFACE OF THE SOLDER CUP IN THE FORM OF A THIN FILM ONLY.

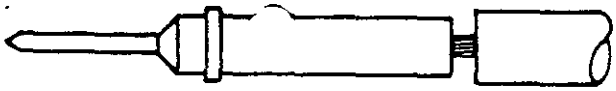


1. SOLDER SLIGHTLY ABOVE INSPECTION HOLE.
2. SOLDER WETTING BETWEEN WIRE OR LEAD AND CUP IS VISIBLE.

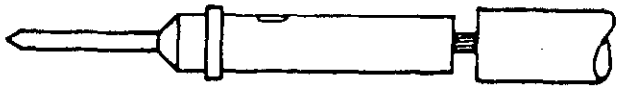


A. ACCEPTABLE

1. EXCESSIVE SOLDER AND SPILLAGE ON SIDE OF CONTACT.
2. SOLDER WETTING BETWEEN WIRE OR LEAD AND CUP IS NOT VISIBLE.



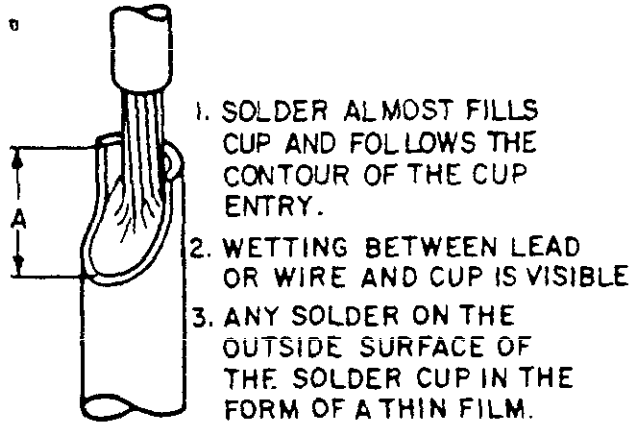
1. SOLDER NOT VISIBLE IN INSPECTION HOLE.
2. SOLDER WETTING BETWEEN WIRE OR LEAD AND CUP IS NOT VISIBLE.



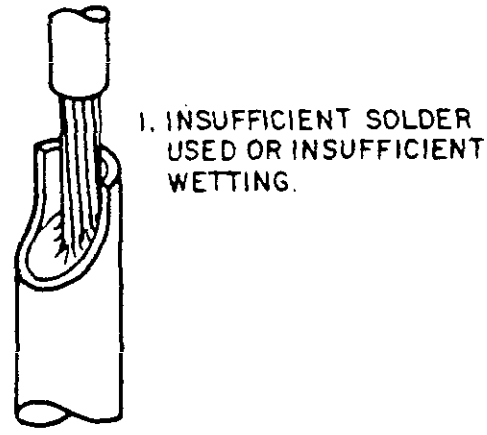
B. NOT ACCEPTABLE

FIGURE 28. Wire and lead soldering to contacts (see 5.7.24).

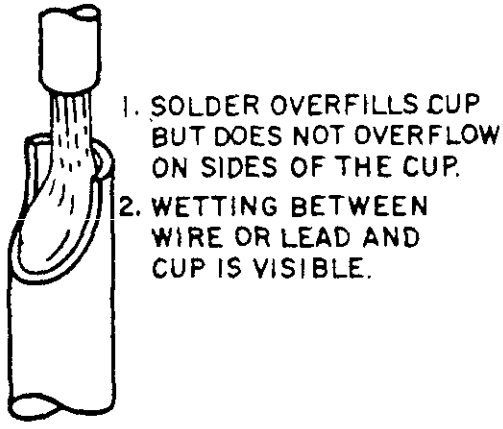
5.7.25 Soldering of wires and leads to solder cups. Solder shall wet between the cup and wire or lead. The wire or wires shall be in contact with the back wall of the cup for the full depth of the cup and a fillet shall be formed along the surfaces of contact. Solder shall wet the entire inside of the cup. Solder shall follow the contour of the cup and shall fill the cup at least 75 percent of the mouth of the cup (see figure 29). Solder may overfill the cup but shall not overflow on the sides of the cup. Tinning (thin solder film) of the outside of the cup is permissible (see figure 29).



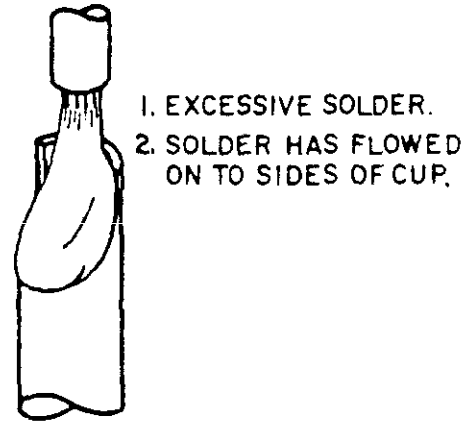
A. ACCEPTABLE (MINIMUM)



B. NOT ACCEPTABLE (INSUFFICIENT)



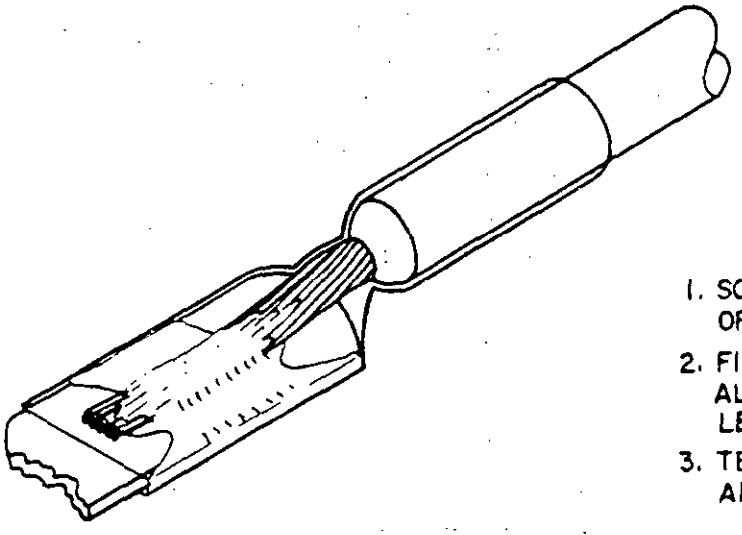
C. ACCEPTABLE (MAXIMUM)



D. NOT ACCEPTABLE (EXCESSIVE)

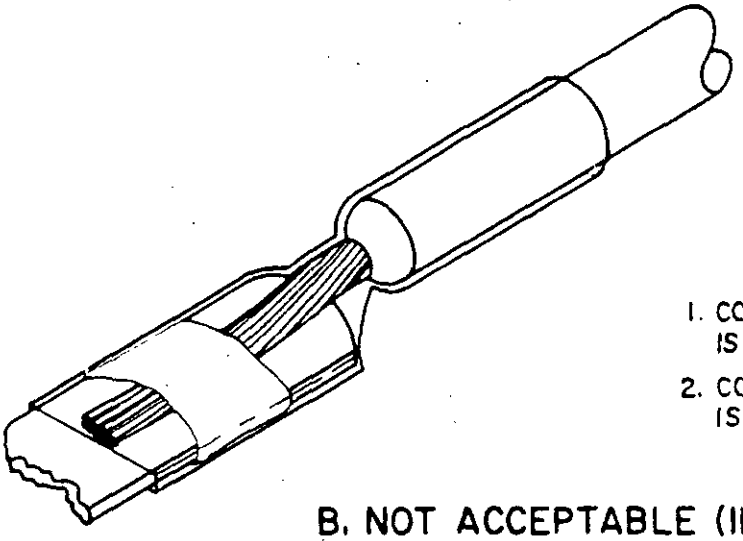
FIGURE 29. Wire and lead soldering to solder cups (see 5.7.25).

5.7.26 Connector terminations for heat shrinkable solder devices. The terminal and lead contours shall be visible and shall not be obscured by solder. Solder fillet and connection area shall be clearly discernible along the terminal and lead interface. The solder shall lose all appearance of a ring shape and the contour of the solder preform shall not be visible. With the exception of minor "browning," the wire insulation shall not be damaged outside of the sleeve (see figures 30 and 31).



1. SOLDER HAS LOST ALL APPEARANCE OF RING SHAPE.
2. FILLET IS CLEARLY DISCERNIBLE ALONG THE TERMINAL AND LEAD INTERFACE.
3. TERMINAL AND LEAD CONTOURS ARE VISIBLE.

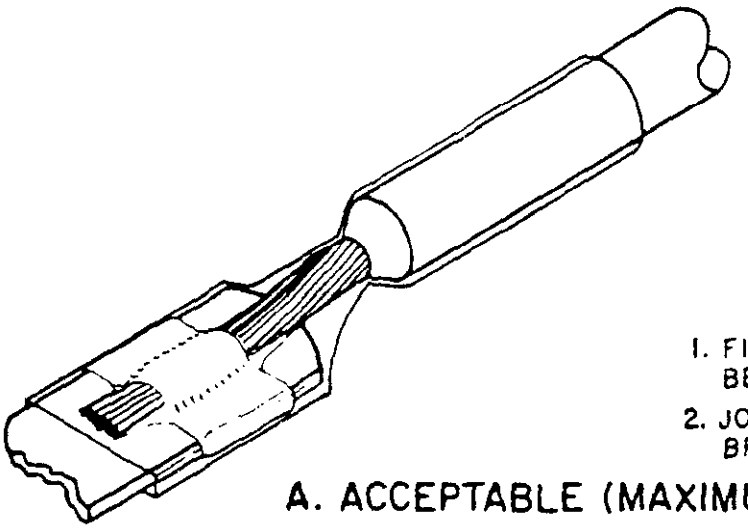
A. ACCEPTABLE (MINIMUM SOLDER FLOW)



1. CONTOUR OF SOLDER PREFORM IS DISCERNIBLE.
2. CONTOUR OF TERMINAL OR LEAD IS OBSCURED BY SOLDER.

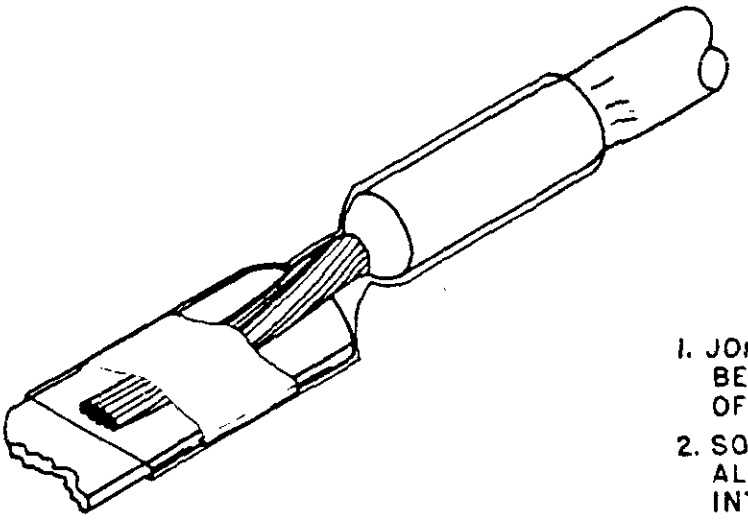
B. NOT ACCEPTABLE (INSUFFICIENT HEAT)

FIGURE 30. Heat shrinkable solder devices-connector terminations (see 5.7.26).



1. FILLET IS CLEARLY DISCERNIBLE BETWEEN TERMINAL AND LEAD.
2. JOINT AREA IS VISIBLE DESPITE BROWNING OF SLEEVE.

A. ACCEPTABLE (MAXIMUM SOLDER FLOW)

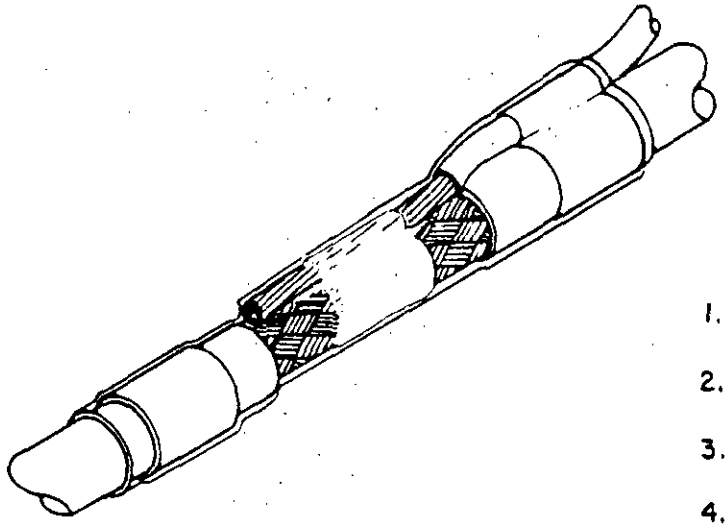


1. JOINT AREA IS NOT VISIBLE BECAUSE OF SEVERE DARKENING OF THE OUTER SLEEVE.
2. SOLDER FILLET IS NOT DISCERNIBLE ALONG TERMINAL AND LEAD INTERFACE.
3. WIRE INSULATION DAMAGED (BROWNING ACCEPTABLE) OUTSIDE OF SLEEVE.

B. NOT ACCEPTABLE (OVERHEATED)

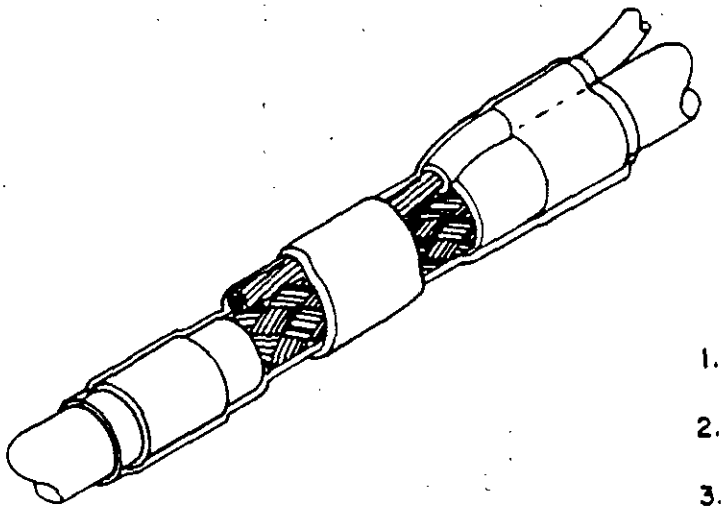
FIGURE 31. Heat shrinkable solder devices-connector terminations (see 5.7.26).

5.7.27 Shield terminations for heat shrinkable solder devices. A fillet shall be clearly discernible along the lead and shield interface. 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 shield and lead contours shall be visible and the contour of the braid or lead shall not be obscured by solder. 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 (see figures 32 and 33).



1. SOLDER HAS LOST ALL APPEARANCE OF RING SHAPE.
2. INSERTS HAVE MELTED AND FLOWED ALONG WIRES.
3. SHIELD AND LEAD CONTOURS ARE DISCERNIBLE.
4. FILLET IS CLEARLY DISCERNIBLE ALONG THE LEAD AND SHIELD INTERFACE.

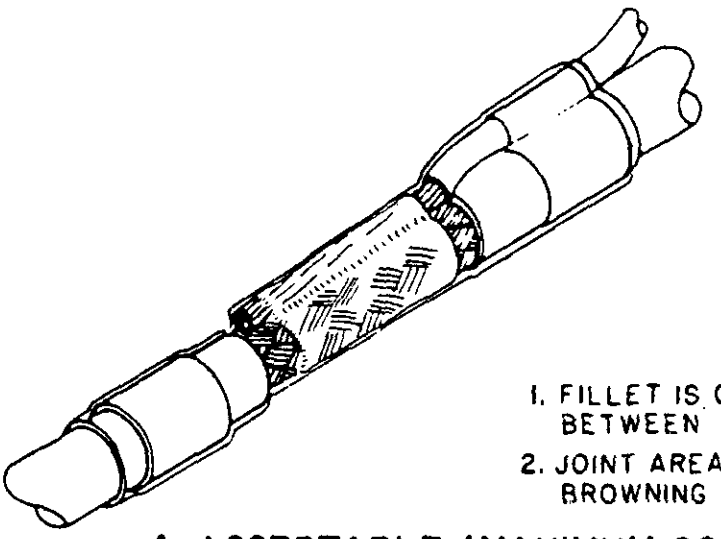
A. ACCEPTABLE (MINIMUM SOLDER FLOW)



1. CONTOUR OF SOLDER PREFORM IS DISCERNIBLE.
2. MELTABLE INSERTS HAVE NOT FLOWED.
3. CONTOUR OF BRAID OR LEAD IS OBSCURED BY SOLDER.

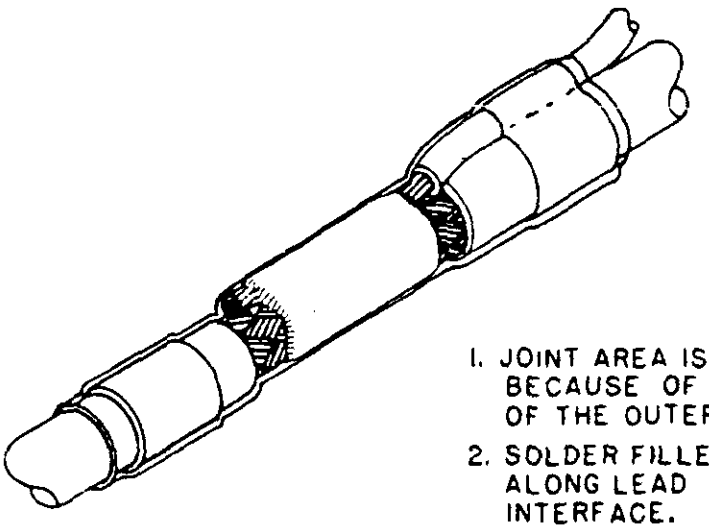
B. NOT ACCEPTABLE (INSUFFICIENT HEAT)

FIGURE 32. Heat shrinkable solder devices-shield terminations (see 5.7.27).



1. FILLET IS CLEARLY DISCERNIBLE BETWEEN LEAD AND SHIELD.
2. JOINT AREA IS DISCERNIBLE DESPITE BROWNING OF SLEEVE.

A. ACCEPTABLE (MAXIMUM SOLDER FLOW)



1. JOINT AREA IS NOT VISIBLE BECAUSE OF SEVERE DARKENING OF THE OUTER SLEEVE.
2. SOLDER FILLET IS NOT DISCERNIBLE ALONG LEAD AND SHIELD INTERFACE.
3. WIRE INSULATION DAMAGED (BROWNING ACCEPTABLE) OUTSIDE OF SLEEVE.

B. NOT ACCEPTABLE (OVERHEATED)

FIGURE 33. Heat shrinkable solder devices-shield terminations (see 5.7.27).

6. NOTES

6.1 Supersession note. This standard is intended to supersede Requirement 5, Soldering, of MIL-STD-454. Requirement 5 will remain in effect until it is cancelled by separate notice.

6.2 Changes from previous issue. The margins of this standard are marked with vertical lines to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

6.3 Subject term (key word) listing.

Connector
Flux, soldering
Insulation sleeving, electrical
Printed circuit board
Printed wiring, flexible
Printed wiring board
Solder
Solderability
Soldering iron
Terminal
Wire
Wire lead

6.4 Use of metric units. English units (inches, pounds, Fahrenheit) are the primary units used by the United States Industry for manufacturing electronic assemblies. In this document, measurements are provided in English units followed by the metric equivalent. The conversions from English to metric are made in accordance with FED-STD-376. The metric equivalents provided in this document are rounded to sensible values. Direct conversions which are mathematically correct but reflect unreasonable degrees of precision in metric units have been avoided (i.e., 5.002 mm is considered unreasonable; this should be rounded to 5.0 mm). In the event of conflict, the primary English measurement shall take precedence.

Custodian:
Air Force - 20
Army - MI
Navy - AS
NSA - NS

Reviewers:
AF - 11, 15, 17, 19, 84, 99
Army - AR, AT, AV, CR, ER, GL, MR
Navy - EC, OS, SH
DLA - ES

Users:
Army - AV
Navy - MC
DLA - DH

Preparing Activity:
Navy - AS
(Project No. SOLD-0019)

INDEX

INDEX (Continued)

INDEX (Continued)

INDEX OF REFERENCED DOCUMENTS

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions - Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
DOD-STD-2000-4A	General Purpose Soldering Requirements For Electrical And Electronic Equipment

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ USER
	☐ MANUFACTURER
	☐ OTHER *(Specify)*:

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 82 MAR 1426 PREVIOUS EDITION IS OBSOLETE.