

DOD-STD-2000-1B

10 June 1986

SUPERSEDING

DOD-STD-2000-1A

29 MARCH 1985

SUPERSESSON NOTE

(SEE 6.1)

MILITARY STANDARD

**SOLDERING TECHNOLOGY,
HIGH QUALITY/HIGH RELIABILITY**



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DOD-STD-2000-1B
10 JUNE 1986

DEPARTMENT OF DEFENSE
WASHINGTON, DC 20301

Soldering Technology, High Quality/High Reliability

DOD-STD-2000-1B

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 standard should be addressed to: Commanding Officer, Naval Air Engineering Center, Code 9313, 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.

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FOREWORD

1. Electrical and electronic equipment and systems used in military applications are continuously becoming more diverse, complex, and sophisticated yet smaller, lighter, denser in internal packaging, sturdier with respect to environment, and more reliable with respect to both function and service life. Such changes in technological posture mandate both definition and standardization of connections and wiring in military electrical and electronic equipment.

2. This standard provides for communication between designers, fabricating personnel and inspectors. The uniformity of soldering materials and processes applies to manual or automated 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 the said end item products and should be implemented in conjunction with appropriate documents.

3. This standard addresses that spectrum of solder connections normally defined as standard and miniature, and provides technical criteria essential to electrical connections and wiring within equipment fabricated by or for the Department of Defense. Requirements for microminiature soldering applicable to connections in thin and thick film microelectronic assemblies are not specifically defined but are imposed through callout of MIL-M-38510.

4. It is recognized that solder processes other than specified herein exist or may exist in the future but it is intended that the requirements of this standard be extrapolated to such noncovered processes insofar as practicable.

5. DOD-STD-2000-1, DOD-STD-2000-2, and DOD-STD-2000-3 are standards concerning the requirements for High Quality/High Reliability soldered electrical and electronic connections. They are intended to be invoked only for this level of "Quality". The three documents are also intended to be used as a set. The requirements in each consider and complement the others.

6. These three documents are not to be confused with DOD-STD-2000-4 General Purpose Soldering Requirements for Electrical and Electronic Equipment. DOD-STD-2000-4 covers general purpose soldering only, and will be invoked independently in situations which do not require soldering at the level covered by DOD-STD-2000-1, DOD-STD-2000-2, and DOD-STD-2000-3.

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1. SCOPE

1.1 Applicability. This standard is applicable to soldering processes for high quality/high reliability electrical and electronic connections on guided missiles, aircraft, avionics systems, communication equipment, satellites, shipboard weapons systems, ammunition and weapon systems, ground vehicle equipment, and program critical ground support equipment.

1.2 Classification. The soldering processes specified herein are of the following classes:

Class 1. Manual Soldering (5.1)

Class 2. Automated Soldering (5.2)

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-I-7444	Insulation Sleeving, Electrical Flexible
MIL-F-14256	Flux, Soldering, Liquid (Rosin Base)
MIL-I-22076	Insulation Tubing, Electrical Nonrigid, Vinyl, Very Low Temperature Grade
MIL-I-23053	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for

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SPECIFICATIONS (Continued)

MILITARY (Continued)

MIL-M-38510	Microcircuit, 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-C-81302	Cleaning Compound, Solvent, Trichlorotrifluoroethane
MIL-T-81533	Trichloroethane 1, 1, 1 (Methyl Chloroform) Inhibited, Vapor Degreasing
MIL-S-83519	Splice, Shield Termination, Solder Style, Insulation, Heat Shrinkable, Environment Resistant, General Specification for
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-1389	Design Requirements for Standard Electronic Modules
DOD-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically-Initiated Explosive Devices) (Metric)
DOD-STD-1866	Soldering Process, General (Non-Electrical) (Metric)
DOD-STD-2000-2	Part and Component Mounting For High Quality/High Reliability Soldered Electrical and Electronic Assemblies

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STANDARDS (Continued)

MILITARY (Continued)

DOD-STD-2000-3 Criteria for High Quality/High Reliability Soldering
Technology

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

HANDBOOKS

MILITARY

MIL-HDBK-141 Optical Design

DOD-HDBK-263 Electrostatic Discharge Control Handbook for Protec-
tion of Electrical and Electronic Parts, Assemblies
and Equipment (Excluding Electrically Initiated
Explosive Devices) Metric

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

2.2 Other publications. The following document(s) form a part of this
standard to the extent specified herein. The issues of the documents which
are indicated as DOD adopted shall be the issue in the DODISS and the supple-
ment thereto, if applicable.

ANSI/IPC-T-50 Terms and Definitions for Interconnecting and
Packaging Electronic Circuits

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

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

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 1193 Reagent Water

ASTM D 3295 Polytetrafluoroethylene Tubing

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

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CFR, Title 29, Code of Federal Regulations,
Part 1900 to 1919, Occupational Safety and Health Administration,
Chapter XVII Department of Labor

(Application for copies should be addressed to the American Conference of Industrial Hygienists, 6500 Glenway, Building D-7, Cincinnati, OH 45211.)

Industrial Ventilations, Manual of Recommended Practices

(Application for copies should be addressed to: Committee of Industrial Ventilation, P.O. Box 16153, Lansing, MI 48902.)

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), differences shall be referred to the Government Contracting Officer or his designated technical activity and a request for deviation with supporting data shall be submitted for approval prior to proceeding. Upon such approval, the provisions shall be officially documented (by notice of revision or equivalent) on the assembly drawing(s) which shall then govern.

4.2 Requirements flowdown. The requirements of the DOD-STD-2000 series of standards shall be imposed by each contractor on all applicable subcontractors requirements and purchase orders. The contractor shall not impose or allow any variations from these standards on subcontractors or purchase orders other than those which have been approved by the Government Contracting Officer for the applicable prime contract.

4.3 Visual aids. Line drawings, illustrations and photographs depicted either herein, DOD-STD-2000-2, or DOD-STD-2000-3, and any additional provisions approved by the procuring Government Contracting Officer are provided as aids for determining compliance with the written requirements of this standard and shall not take precedence over the written requirements.

4.4 Visual inspection. One hundred percent visual inspection of all soldered connections and assemblies shall be performed using the magnification aids of paragraph 4.11.3.5. The soldered connections and assemblies shall conform to the requirements specified herein.

4.5 Hybrid microelectronic modules and assemblies. Hybrid microelectronic processing, modules, and assemblies shall be in accordance with MIL-M-38510.

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4.6 Specialized technologies. Mounting and soldering requirements for specialized technologies (such as multiple terminations modules) not specified herein shall be considered peculiar and must be identified on the drawing and performed in accordance with processes reviewed and approved by the Government Contracting Officer.

4.7 Harness and cable assemblies. Harnesses and cable assemblies shall conform to the requirements of MIL-C-45224 except that soldering processes and acceptance criteria shall be as stated herein. Wax-impregnated lacing tape shall be utilized only for harnesses which will not be subjected to cleaning solvents subsequent to lacing operations.

4.8 Electrostatic discharge. Electrostatic discharge control for the protection of electrical and electronic parts, components, assemblies and equipment shall be in accordance with DOD-STD-1686. Class III static sensitive devices, as defined in DOD-HDBK-263, shall be protected from damage in accordance with the requirements for Class II devices of DOD-STD-1686.

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

4.10 Vapors control. Areas used for cleaning parts and areas where toxic or volatile vapors are generated shall include a local exhaust system utilized for removing air contaminants from the area in which they are generated. As a minimum, the exhaust unit utilized shall be in accordance with the recommendations or guidelines of the Industrial Ventilation Manual of Recommended Practices and applicable CFR, Title 29, Part 1900 to 1919, Chapter XVII Occupational Safety and Health Administration (OSHA) requirements.

4.11 Facilities, tools and equipment.

4.11.1 The soldering facility.

4.11.1.1 Environmental controls. An enclosed soldering facility, maintained at a slight positive pressure, shall be required if the soldering area is not air conditioned.

4.11.1.2 Temperature and humidity. The temperature shall be maintained at $75^{\circ}\text{F} + 9^{\circ}\text{F}$ ($24^{\circ}\text{C} + 5^{\circ}\text{C}$) and the relative humidity shall not exceed 65 percent. When humidity decreases to a level of 30 percent or lower, electrostatic discharge sensitive devices and assemblies shall be processed only if extraordinary controls for the protection of electrostatic sensitive devices, including grounding, are previously approved by the Government Contracting Officer and are utilized. (See also paragraph 4.8.) The requirements of this paragraph shall also apply to areas where components to be soldered or printed wiring assemblies are stored.

4.11.1.3 Cleanliness. Work areas shall be maintained in a clean and orderly condition. All visible dirt, grease, flux, solder spatter, chips and other contaminating foreign material shall be promptly removed. Eating, smoking or drinking at the soldering work station shall not be permitted.

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4.11.1.4 Lighting. Illumination at the working surface of soldering stations shall be 100 foot-candles minimum (1077 Lm/m²).

4.11.2 Soldering and related tools.

4.11.2.1 Thermal strippers. Thermal strippers utilized to remove insulation from stranded and solid conductor wires shall be of a type that can be regulated to provide the required temperature. Temperature controls shall be sufficient to prevent damage to the wire or unstripped insulation.

4.11.2.1.1 Solder for thermal solder stripping. If applicable, thermal solder stripping of solder strippable magnet wire (with polyurethane or similar insulation) may be performed by hot solder application in compliance with the wire manufacturer's recommendations.

4.11.2.2 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. Hand operated strippers shall be of a fixed die configuration (see figure 1). Automatic high volume machine strippers shall be of a type utilizing either fixed dies, dies adjustable to calibrated stops, or roller cutters adjustable to calibrated stops. Dies, whether adjustable or fixed, shall be properly maintained to assure consistently sharp and even cuts without damage to the wires or unstripped insulation.

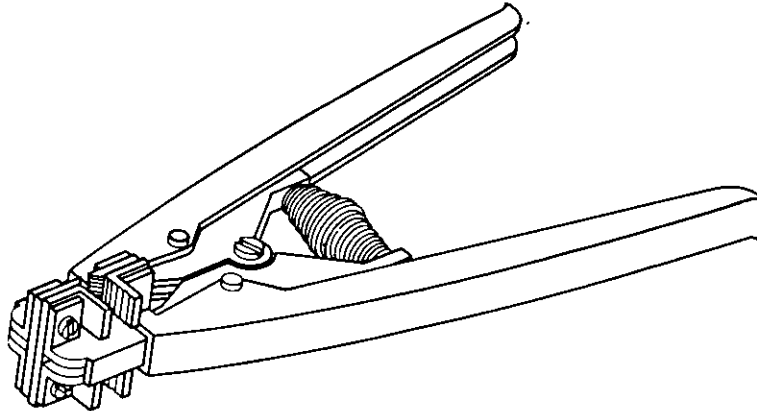


FIGURE 1. Mechanical hand wire stripper (see 4.11.2.2).

4.11.2.3 Chemical strippers. Chemical solutions, pastes, and creams used to strip hookup and magnet wires shall be suitable for removal of the insulation to be stripped and shall be limited to those that:

- a. Cause no degradation of the base metal of the wire.
- b. Allow wires or conductors to be neutralized and cleaned of both ionic and nonionic contaminants.

4.11.2.4 Wire and lead cutting tools. Cutters shall be of a full flush cut or rotary blade type, designed to cut squarely without leaving burrs, excessive ridges, or sharp points.

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4.11.2.5 Holding devices. Tools, fixtures, and materials used to hold or restrain wires and components shall be of a type 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 plastic covered.

4.11.2.6 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.

4.11.2.7 Antiwicking tools. Antiwicking tools shall be of a design which fits only a specific conductor gage size and shall be marked with that conductor gage size.

4.11.2.8 Bending tools. Bending tools used for wire or lead bending may be automatic or hand implements and shall be of a material that will not cut, nick, or otherwise damage solid or stranded wires, leads, integral insulation, or any other insulation or insulators added prior to the bending operation. Bending tools shall be of a type that imparts no stress to the component bodies or seals.

4.11.2.9 Heat source. Devices used for shrinking heat shrinkable tubing shall be temperature controlled to prevent damage to components, wiring or boards.

4.11.2.10 Storage containers. Containers shall be of a material that does not introduce gases or chemicals that could be detrimental to the solderability of the printed wiring board or its components. Bags or containers shall not be made of silicones, sulphur compounds, polysulphides, or be processed with these or other detrimental compounds. Bags and containers for electrostatic sensitive devices shall conform to DOD-STD-1686.

4.11.2.11 Wiping pads. Sponge pads for wipe cleaning the soldering iron tip shall be finely textured and sulphur free.

4.11.3 Soldering equipment. Soldering irons, soldering machines and systems, and associated process equipment (including fluxers, preheaters, solder pots, cleaning systems, and cleanliness test equipment) shall be of a type that does not inject electrical energy to the item(s) being soldered or cleaned to the extent that functional integrity of the item(s) is compromised. Resistance between items processed and earth ground shall be no greater than 20 ohms measured from the tip of hot soldering irons and from the carrier of any soldering or cleaning equipment. Soldering irons and machines and cleaning and cleanliness test equipment shall be in accordance with DOD-STD-1686 for electrostatic discharge protection. Potential differences between earth ground and items being machine soldered or cleaned and between earth ground and the tip of hot soldering irons shall be no greater than 2 mV RMS measured as detailed in Appendix A or equivalent method. Magnetic fields of soldering irons, soldering machines, and associated process equipment shall be no greater than two gauss measured at any surface of a component or part of items processed.

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4.11.3.1 Soldering irons. Soldering irons shall be of the temperature controlled type, controllable within $+11^{\circ}\text{F}$ ($+6^{\circ}\text{C}$) of the preselected idling temperature unless it can be demonstrated to the procuring activity that uncontrollable irons are essential for a particular application. The size and shape of the soldering iron and tip shall permit soldering with maximum ease and control without causing damage to adjacent areas or connections. The soldering iron or resistance heating element shall heat the connection area rapidly and maintain proper soldering temperature at the connection throughout the soldering operation. Three-wire cords and tip grounding to prevent potential greater than two millivolts at the tip shall be used when voltage sensitive devices are soldered. The soldering iron shall be of such design as to provide zero voltage switching. Transformer type soldering guns shall not be used.

4.11.3.2 Soldering iron tips. The soldering iron tips or resistance soldering element shall be sized to the operations involved. Soldering iron tips shall be made of commercially pure copper, tellurium copper, or lead copper and shall be plated or coated with another metal that prevents degradation of the tip in molten solder.

4.11.3.3 Soldering iron holders. A soldering iron holder shall be of a type satisfactory for the soldering iron utilized. The holder shall leave the soldering iron element and tip unsupported without applied excess physical stress or heat sinking and shall protect personnel from burns.

4.11.3.4 Solder pots. Solder pots shall be capable of maintaining the solder temperature within $+11^{\circ}\text{F}$ ($+6^{\circ}\text{C}$) of the preselected temperature specified in 5.1.2. Solder pots shall be grounded.

4.11.3.5 Magnification aids and lighting. Magnification aids and lighting used for assembly and inspection shall be commensurate with the size of the item being processed and conform to the following:

- a. Magnification aid of 2X to 4X for use during the assembly and inspection of other than solder connections.
- b. Magnification aids for inspection of solder connections other than miniature (MIL-STD-1389) or microminiature (MIL-M-38510) shall be 4X to 10X. Magnification aids for inspection of miniature and microminiature connections shall as a minimum be capable of 30X and 70X, respectively. Binocular aids shall be used for soldered connections on printed wiring assemblies.
- c. Light sources shall provide shadowless illumination of the area being viewed. A clear incandescent light (operated at 3000 to 3400 Kelvin (K)) shall be used for detection of nontinned copper.
- d. Optical systems utilized shall provide a field of view suitable to permit inspection of each solder connection in its entirety but shall in no case be less than 10 degrees apparent field of view angle, measured with the image centered in the field, as defined in MIL-HDBK-141.

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- e. Utilize optical elements which not only render true color and proportional dimensions but also provide resolution characteristics permitting the viewer to clearly discriminate 68 line pairs per millimeter (1 lp/mm) at 10 power magnification.
- f. Magnification aids used shall be of a type that permit simultaneous viewing with both eyes by users except where a monocular type magnification aid is approved by the Government Contracting Officer, as essential to meet the requirements of a, b, and d above.
- g. Fixed power single-eyed devices, when allowed, shall have an eye-to-object distance not less than 2.25 inches (57.2 mm) and an object-to-lens working distance not less than 55 percent of the focal length of the magnifier.
- h. The magnification power (MP) of optical aids shall be determined using the equation $MP = \frac{V}{f'}$ in accordance with MIL-HDBK-141.
The eye-to-object distance (V) shall be 10 inches (254 mm) and the effective focal length (f') of the magnification device shall be measured in inches.

4.11.3.6 Thermal shunts. Thermal shunts shall be of such material, size, shape, and design as to permit rapid application and removal with minimum interference to the soldering procedure and to facilitate rapid heat dissipation from the area being soldered.

4.12 Machine soldering systems. Machine soldering systems shall be of the automatic or automated type of such design to provide:

- a. A capability for preheating printed wiring assemblies to within 212°F (118°C) of the soldering temperature immediately prior to contact with the molten solder.
- b. The capacity to maintain the solder temperature at the printed wiring assembly within +10°F (+5.5°C) of the established bath temperature throughout the span of any continuous soldering run.
- c. An exhaust system, either integral or separate, adequate to assure conformance with applicable OSHA health and safety requirements (see 4.10).
- d. Drag soldering and other soldering equipment not specified herein shall be approved by the Government Contracting Officer prior to use.

4.13 Carriers. Devices used for the transport of printed boards through preheat, soldering, and cooling stages shall be of such material, design, and configuration that they shall not contaminate, mar, or otherwise damage the printed board. Carriers shall not transmit vibrational or shock stress from the conveyors or other such mechanisms to cause board, part, or component degradation and shall also be of such design to prevent electrostatic discharge damage to components.

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4.14 Soldering equipment for reflow soldering of planar mounted components. The soldering device and machine used shall be of such design to rapidly heat the surfaces to be joined and shall have the capacity to re-attain the preset temperature within $+11^{\circ}\text{F}$ ($+6^{\circ}\text{C}$) during repetitive soldering operations. The heat source shall not cause damage to the board or components or contaminate the solder when direct contact is made between the heat source and the metals to be joined. Reflow soldering equipment (including equipment which utilizes parallel gap resistance, shorted bar resistance, hot air, infrared, laser powered devices or thermal transfer soldering techniques other than soldering irons) shall be approved by the Government Contracting Officer prior to use.

4.15 Condensation reflow system. The condensation reflow system shall be mechanized to provide for smooth transition of the work piece and of such design to prevent electrostatic discharge damage to components. The nonflammable, inert, chemically and thermally stable liquid used to produce the vapors shall be maintained to produce consistent high quality metallurgical bonds. The level of vapor in the equipment shall be controlled so that the dwell time of the work piece is minimal while insuring that the solder and work piece have reached a temperature sufficient to produce the metallurgical bonds. Condensation reflow systems shall be approved by the Government Contracting Officer prior to use.

4.16 Materials. Materials used in the soldering processes stipulated in this standard shall be as specified herein. It is possible that the materials and processes specified may in some combinations be incompatible. It shall be the responsibility of the manufacturer to select those materials and processes that will produce acceptable high quality/high reliability products.

4.16.1 Solder. Solder composition Sn60, Sn62, or Sn63, solder form optional, conforming to QQ-S-571 shall be used. Sn5, Sn10, or Sn96 solder, conforming to QQ-S-571, may be used for high temperature soldering when specified on the government approved assembly drawing. Flux of cored solder shall be type R or RMA. Core conditions and flux percentages are optional. When procured, type BS solder shall contain no more than 0.01 percent phosphorus and no more than 0.001 percent sulphur.

4.16.2 Flux. Rosin based fluxes conforming to types R or RMA of MIL-F-14256 shall be used for making soldered connections. Other types of flux may be used during component lead tinning provided they have been approved by the Government Contracting Officer prior to use.

4.16.3 Solder creams (paste) and solder preforms. Solder creams (paste) and solder preforms shall meet the requirements of 4.16.1 and 4.16.2. Flux solvents used in solder creams (paste) shall not be harmful to the work piece or solder joint and shall be easily removed after the soldering operation.

4.16.4 Solvents and cleaners. The solvents or aqueous cleaners used for removal of grease, oil, dirt, flux, and other debris, shall be selected for the ability to remove both ionic and nonionic contamination. The solvents or cleaners used shall not degrade the materials or parts being cleaned. A list of approved solvents and cleaners are shown in tables I and II. Other solvents and cleaners shall be approved by the Government Contracting Officer prior to use.

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TABLE I. Solvents.

Solvent (see 4.16.4.1 and 4.16.4.2)	Specification
Ethyl Alcohol	O-E-760, Types III, IV or V
Isopropyl Alcohol	TT-I-735
Methyl Alcohol (see 4.16.4.5)	O-M-232, Grade A
Butyl Alcohol, Secondary (For Use In Organic Coatings) (see 4.16.4.5)	TT-B-848
1, 1, 1-Trichloroethane (see NOTE)	MIL-T-81533
Trichlorotrifluoroethane (see 4.16.4.3 and 4.16.4.4)	MIL-C-81302
Trichlorotrifluoroethane (see 4.16.4.3 and 4.16.4.4)	MIL-C-85447, Type II
Solvent Petroleum Distillate (Stoddard) (see 4.16.4.6)	Use Appendix B

TABLE II. Cleaners.

Cleaners	Specification/Note
Reagent water (Type II)	ASTM D 1193
Detergent cleaners and saponifiers	As approved by the Government Contracting Officer prior to use

4.16.4.1 Mixtures of the approved solvents may be used. Solvents used shall be selected for compatibility with the materials being cleaned and for the capability of removing both ionic and nonionic contamination.

4.16.4.2 To prevent contamination of parts and to provide for personnel safety, areas for cleaning parts and areas where toxic or volatile vapors are generated shall have an exhaust system to remove the vapors as they are generated.

4.16.4.3 Solvents in which a nitromethane stabilizer is blended with trichlorotrifluoroethane conforming to either MIL-C-81302 or MIL-C-85447 (Type II) are also acceptable provided such mixtures are preblended by the supplier.

4.16.4.4 Trichlorotrifluoroethane blends which include chlorocarbons are unacceptable. Mixtures of trichlorotrifluoroethane and water shall not be used.

4.16.4.5 Methyl alcohol and secondary butyl alcohol shall be used only when purchased as a constituent of an already blended solvent. Pure methyl alcohol or secondary butyl alcohol shall not be used alone as a solvent.

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4.16.4.6 Solvent in accordance with Appendix B shall be used only as a constituent of an already blended solvent. The pure solvent shall not be used unblended. The blended solvent shall not be used as a final cleaner.

NOTE: 1, 1, 1-Trichloroethane may attack plastics commonly used in electronic assemblies, including acrylics, polycarbonates and may also attack rubber, neoprene and silicone; consequently, use of this solvent should be restricted or carefully controlled. (Do not mix with water.)

4.16.5 Tubing. Polytetrafluoroethylene tubing shall conform to ASTM-D-3295.

4.16.6 Heat shrinkable tubing. Heat shrinkable tubing shall conform to MIL-I-23053 except that use of polyvinylchloride tubing is prohibited.

4.16.7 Extruded vinyl plastic tubing. Extruded vinyl plastic tubing shall conform to MIL-I-7444, type I, or MIL-I-22076.

4.16.8 Rigid printed wiring boards. Rigid printed wiring boards (PWB) shall be designed to MIL-STD-275 and fabricated to MIL-P-55110 except as modified herein (DOD-STD-2000-1, -2, and -3) (see 4.18.10).

4.16.8.1 Copper plating. Copper plating of the plated-through-holes shall be accomplished utilizing solutions that will not affect quality of plated-through-holes before, during and after exposure to solder reflow or wave soldering temperature. The copper plating process shall meet the following requirements:

- a. Purity: 99.8 minimum (copper sulfate type bath)
99.5 minimum (pyrophosphate type bath)
- b. Elongation: 6 percent minimum
- c. Tensile strength: 36,000 pounds per square inch (psi) minimum
(250 MPa)

4.16.8.2 Finish plate. Immersion-tin or electroless-tin plating shall not be used as a finishing process. As an exception, immersion and electroless-tin plating may be used on special R.F. circuitry applications with prior approval of the Government Contracting Officer.

4.16.8.3 Surface finish (coating). The fused tin-lead plating or solder coating shall be continuous. There shall be no dewetting or exposed basis metal in plated-through holes or on the top surface of conductors and terminal areas.

4.16.9 Flexible and rigid-flex printed wiring. Flexible and rigid-flex printed wiring shall be designed to MIL-STD-2118 and fabricated to MIL-P-50884 except as specified herein (DOD-STD-2000-1, DOD-STD-2000-2 and DOD-STD-2000-3) (see 4.18.10).

4.16.10 Solder masks and localized maskants. Polymer solder mask coatings shall conform to IPC-SM-840, Class 3 and shall be applied only to surfaces which are not coated with solder or other material which will become

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semi or totally liquid during subsequent assembly operations. Dry film polymer mask shall be applied by a vacuum laminant process. Polymer solder mask coatings and localized maskants shall also be of a material that:

- a. Does not degrade the substrate material or printed wiring;
- b. Precludes solder flow to the masked area;
- c. Is compatible, if left in place, with printed wiring board basis material, solder, printed wiring, and subsequently applied conformal coatings; and
- d. Can be readily removed without post-removal residual contamination harmful to board integrity if removal is essential.

4.17 Solderability.

4.17.1 Solderability of leads and terminations. Within 30 days of receipt, component leads, terminations and end caps to be soldered shall be tested to and conform to the solderability tests specified in MIL-STD-202, Method 208 using as a minimum, a sampling plan in accordance with MIL-STD-105, Inspection level S-2, Acceptable Quality Level (AQL) 1.0 percent defective. If more than 120 days elapse before use, the items shall be retested to and conform to MIL-STD-202, Method 208 or shall be hot solder dipped to provide a fused coating with a minimum thickness of 0.0001 inch (0.0025 mm). Solderability shall be tested after tinning using the same Method and sampling plan. If the items meet solderability requirements, they may be used immediately or stored for one year without further testing, provided issuance to production is in accordance with a first-in first-out (FIFO) system. If these items are stored more than one year after tinning, solderability testing, using same inspection level and AQL, shall be performed prior to use.

4.17.2 Solderability of boards. The solderability of printed wiring boards shall conform to the requirements of MIL-P-55110 for rigid printed wiring and MIL-P-50884 for flexible and rigid-flex printed wiring. The solderability of printed wiring stored for more than one year shall be re-verified in the same manner prior to use in accordance with MIL-STD-105 inspection level S-2, AQL 1.0 percent defective.

4.18 Preparation for soldering.

4.18.1 Insulation removal. Insulation shall be removed from wire conductors by one of the following methods, using the tools specified in 4.11.2. After insulation removal, insulation deformation shall not exceed 20 percent of the insulation thickness. The insulation shall not have gouges, ragged edges nor be loose or frayed. Slight discoloration of the insulation from thermal stripping is acceptable. At no time during the soldering process shall insulation that is degraded from the use of solvents or chemical stripping agents be acceptable. Wires or strands shall not be broken, severed, nor show evidence of nicks, cuts, scrapes, stretching, or other observable damage exceeding 5 percent of the original diameter of any wire strand when viewed under 4X magnification. There shall be no birdcaging of

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the wire strands. No basis metal shall be exposed. Discoloration of the wires or strands that shows evidence of overheating shall be cause for rejection.

4.18.1.1 Thermal. When extruded insulation is removed using a thermal stripping tool, the lay of the wire shall be restored, if disturbed, without using bare finger contact. Thermal type insulation strippers are preferred for wires of size 20 AWG and smaller.

4.18.1.2 Mechanical. When extruded insulation is removed using a mechanical stripping tool, the lay of the wire strands shall be restored, if disturbed, without using bare finger contact. A device that utilizes fiber-glass stripping wheels may be used for magnet wire.

4.18.1.3 Chemical. Insulation removal from magnet wire shall be accomplished by the use of chemical stripping agents, in accordance with the manufacturer's recommendation. Chemical stripping agents shall be neutralized or removed prior to soldering.

4.18.1.4 Solder dip. Polyurethane or similar type coatings may be removed by dipping the insulated wire to the required depth into a solder pot (see 4.11.3.4) at the temperature recommended by the manufacturer. Stripping of solder strippable magnet wire (with polyurethane or similar insulation) on the termination of coils and windings wound with such wire may be performed by hot solder application in compliance with the wire manufacturers recommendations.

4.18.2 Preparation of gold plated areas. Gold plated areas of connectors and component leads shall not be utilized when thickness of the plating is less than 0.000050 inch (.00127 mm). Areas to be soldered on gold plated connectors and component leads, the gold plating of which is in the range of 0.000050 to 0.000100 inch (.00127 to .00254 mm) thickness shall be single dip tinned. Areas to be soldered which have gold plating exceeding 0.000100 inch (.00254 mm) shall be prepared for soldering by implementation of either of the two following methods:

Method 1. Static bath. Immerse the fluxed gold plated lead in solder bath number one for 2 to 5 seconds. Only the portion of the lead subsequently to be soldered need be immersed. Gold contamination level in solder bath number one shall be less than 4 percent. Immerse the fluxed tinned lead in solder bath number two for 2 to 5 seconds. Gold contamination in bath number two shall not exceed the limits specified in table III.

Method 2. Dynamic bath. Immerse the fluxed gold plated lead in a flowing solder bath for 2 to 5 seconds. Only the portion of the lead to be subsequently soldered need be immersed. Gold contamination in the solder bath shall not exceed the limits of column 1 (Preconditioning) of table III.

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TABLE III. Solder bath contaminant levels.

Contaminant	Maximum allowable percent of contaminant per solder operation		Testing frequency 8 hr. operating days <u>5/</u>		
	Preconditioning (Lead or wire) tinning <u>1/</u>	Machine soldering <u>1/</u> , <u>2/</u>	Columns		
			A	B	C
Copper	0.75	0.30	15	30	30
Gold	0.50	0.20	15	30	30
Cadmium	0.01	0.005	15	30	60
Zinc	0.008	0.005	15	30	60
Aluminum	0.008	0.006	15	30	60
Antimony <u>3/</u>	0.20 to 0.50	0.20 to 0.50	15	60	120
Iron	0.02	0.02	15	60	120
Arsenic	0.03	0.03	15	60	120
Bismuth	0.25	0.25	15	60	120
Silver <u>4/</u>	0.75	0.10	15	60	120
Nickel	0.025	0.01	15	60	120

- 1/ The tin content of the solder shall be from 59.5 to 63.5 percent tin and tested at the same frequency testing for copper or gold contamination. The balance of the solder shall be lead with one or more of the listed contaminants.
- 2/ The total of copper, gold, cadmium, zinc and aluminum contaminants shall not exceed 0.4 percent for soldering.
- 3/ The minimum amount of antimony present in the solder for either operation (column 1 or column 2) shall be 0.20 percent.
- 4/ Not applicable for Sn62 solder. Limits to be 1.75 to 2.25 (both operations).
- 5/ An operating day constitutes any 8 hour period, or any portion thereof, during which the solder is liquified and used.

4.18.2.1 Cup type connections. The inside portion of cup type connections shall be tinned in accordance with a or b below:

- a. Steps 1 through 6 below shall be performed if solder cups are not gold plated or are gold plated to a thickness between 0.000050 and 0.000100 inches (0.00127 and 0.00254 mm).
- b. Solder cups gold plated in excess of 0.000100 inches (0.00254 mm) shall be tinned in accordance with steps 1 through 7 below.

Step 1: Clean solder cups using a solvent or cleaner specified in 4.16.4.

Step 2: Place sufficient solder in the solder cup to completely fill the solder cup, to the milled lip, after melting.

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- Step 3: Heat solder cup sufficiently to melt solder and allow all gases and flux to escape (cups should be at approximately a 45 degree angle to prevent entrapment of gases and flux).
- Step 4: Remove solder by wicking or extraction device.
- Step 5: Inspect inside of cup to ensure complete tinning of solder cup.
- Step 6: Place sufficient solder in the solder cup to allow proper fillet after wires are inserted into the cup (see 5.1.8).
- Step 7: Repeat Steps 3 through 6 one time.

4.18.2.2 Post gold removal processing. Upon conclusion of the gold removal process, the solder coated portion of the component shall conform to the Acceptance Criteria of MIL-STD-202, Method 208. If parts are not soldered into an assembly within 1 year of gold removal, the parts shall be tested and shall meet the solderability requirements of paragraph 4.17.1.

4.18.3 Automatic lead forming devices. Automatic lead forming devices are acceptable. Smooth impression marks (base metal not exposed) resulting from bending tool holding forces shall not be cause for rejection.

4.18.4 Lead bends. The distance between the body of the component or weld and the bent section of a lead shall be in accordance with mounting criteria specified in DOD-STD-2000-2.

4.18.5 Stress relief. Components with wires or leads terminated at a solder connection shall be mounted to assure stress relief of the component in accordance with DOD-STD-2000-2.

4.18.5.1 Solder in the lead bend radius. Solder fillets shall not extend into the bend radius on any lead bend configuration except for components with a body diameter of 0.125 inch (3.18 mm) or less and with leads formed to the 90-degree bend as shown in figures 2A and 2B. Components with body diameters of 0.125 inch (3.18 mm) or less and lead configurations of figures 2A and 2B may have a solder fillet which extends into the bend radius on one lead only but this solder fillet shall not touch the component body or end seal.

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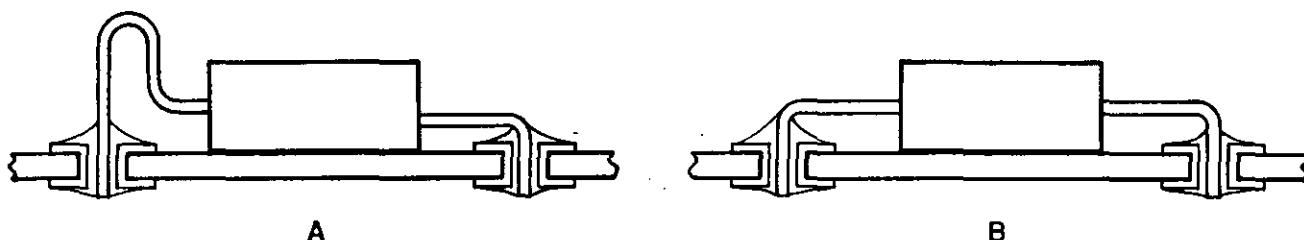


FIGURE 2. Solder in the lead bend radius (see 4.18.5.1).

4.18.6 Lead trimming. Wires and leads shall be cut to their proper length prior to soldering. When leads are cut after insertion in the printed wiring board, the cutting action shall not damage the printed wiring board or components mounted thereon. When automatic lead cutting is performed, a maintenance program shall be implemented to provide assurance that blades or saws are monitored for wear, and that the feed system is calibrated to match the needs of the materials and density of leads being cut. Cutting shall not bend the lead nor leave sharp spurs on lead ends.

4.18.7 Tinning of stranded wire. Prior to the soldering operation, that portion of stranded wire to be soldered to another surface shall be tinned (see figure 3) with the solder penetrating to the inner strands of the wire. Tinning of stranded wire shall not obscure the wire contour of the individual outer strands and the entire stripped end shall be tinned to within $1/16 \pm 1/32$ inch (1.6 ± 0.8 mm) from the end of the insulation.

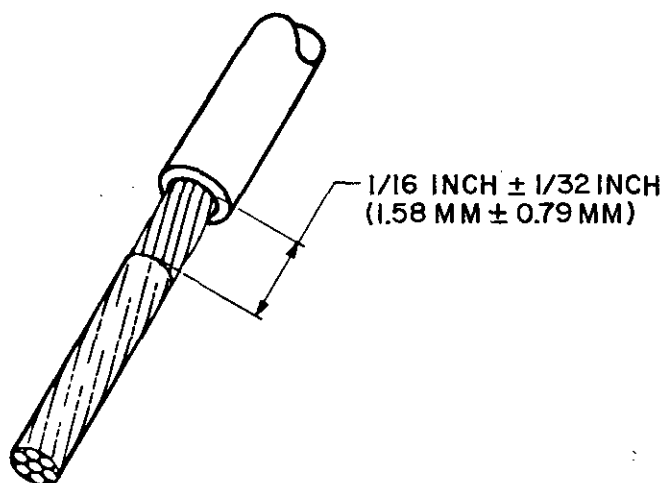


FIGURE 3. In-process step for tinning stranded wire (see 4.18.7).

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4.18.8 Precleaning. Items shall be clean prior to soldering or bonding. The solvents of 4.16.4 shall be used for cleaning.

4.18.9 Handling and storage of parts. Leads and to-be-soldered surfaces of component wires and printed wiring boards shall not be handled with bare hands. If the parts cannot be handled without touching the surface to be soldered, protective devices such as clean nylon or cotton gloves, finger cots, or special tooling shall be used.

CAUTION: Finger cots and nylon gloves should not degrade electrostatic discharge protection as defined in DOD-STD-1686.

NOTE: Printed wiring boards should be oven dried prior to being used in any soldering process to prevent defects such as measles, crazing and delaminations.

4.18.10 Printed wiring board condition. Before components or terminals are mounted on a printed wiring board, the board shall have been examined for conformance to the requirements of 4.16.8 and 4.17.2. There shall be no evidence of any of the following defects:

- a. Scratches which expose basis metal.
- b. Separation of the conductor pattern (including terminal areas) from the base laminate.
- c. Blisters in the conductor pattern.
- d. Measling or crazing.
- e. Delamination of the base material.
- f. Wrinkles in the conductor pattern.
- g. Dirt, grease, or other foreign matter on the printed wiring boards.
- h. Pits or inclusions.

4.18.11 Mounting of component parts. Components shall be mounted in accordance with DOD-STD-2000-2.

4.18.12 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. There shall be visible clearance between the insulation and solder connection. The insulation shall not abut the solder nor shall it be embedded in or surrounded by the solder. Neither shall the insulation be melted, charred, seared, nor diminished in diameter.

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- b. Maximum clearance. Clearance shall be less than two wire diameters (including insulation) or 1/16 inch (1.58 mm), whichever is larger, but shall not be such to permit shorting between adjacent conductors.
- c. High voltage clearance: The insulation clearance for high voltage wires (thick walled insulation) shall be $1/8 + 1/16$ inch ($3.18 + 1.58$ mm) unless otherwise specified in the assembly drawing.

4.19 Interfacial and interlayer connections. Interfacial connections of circuitry on double sided printed wiring boards or assemblies shall be of the plated-through hole configuration of paragraph 4.19.1 or the clinched wire configuration of paragraph 4.19.2. The plated-through hole configuration shall be used for all designs approved after January 1, 1987. Interfacial and interlayer connections of circuitry of multilayer printed wiring boards or assemblies shall be of the plated-through hole configuration. Standoff terminals, eyelets, rivets, snug fit pins, or braided sleeves shall not be used to provide interfacial or interlayer connection nor shall terminals, eyelets, rivets, or snug fit pins be installed in any plated-through hole utilized for interfacial or interlayer connection. Quasi-interfacial connections shall conform to all requirements applicable for interfacial connections. Neither buried nor blind interstitial via holes shall be used without prior approval by the Government Contracting Officer.

4.19.1 Plated-through holes. Plated-through holes without leads or wires installed shall be such that the solidified solder is not only continuous from one side of the printed wiring board to the other but also extends onto each terminal area a minimum of 0.005 inch (.127 mm) from the hole. The solidified solder may be depressed on each or either side of the printed wiring board but total depression shall not exceed 20 percent of the hole depth (d) measured from the surface of the terminal area(s) (see figures 4A and 4B). A plated-through hole used for lead or wire attachment shall be solder filled such that the solidified solder is not only continuous from one side of the printed wiring assembly to the other but also extends onto and covers the terminal areas on each side of the printed wiring assembly (see figure 4C). Solder may be depressed on the component side of the lead attachment connection provided that wetting to both the lead and the terminal areas is acceptable. No depression of solder in a plated-through hole with a part lead shall exceed 10 percent of the hole depth as measured from the surface of the terminal area whether or not wetting to both the lead and terminal areas is acceptable (see figure 4D).

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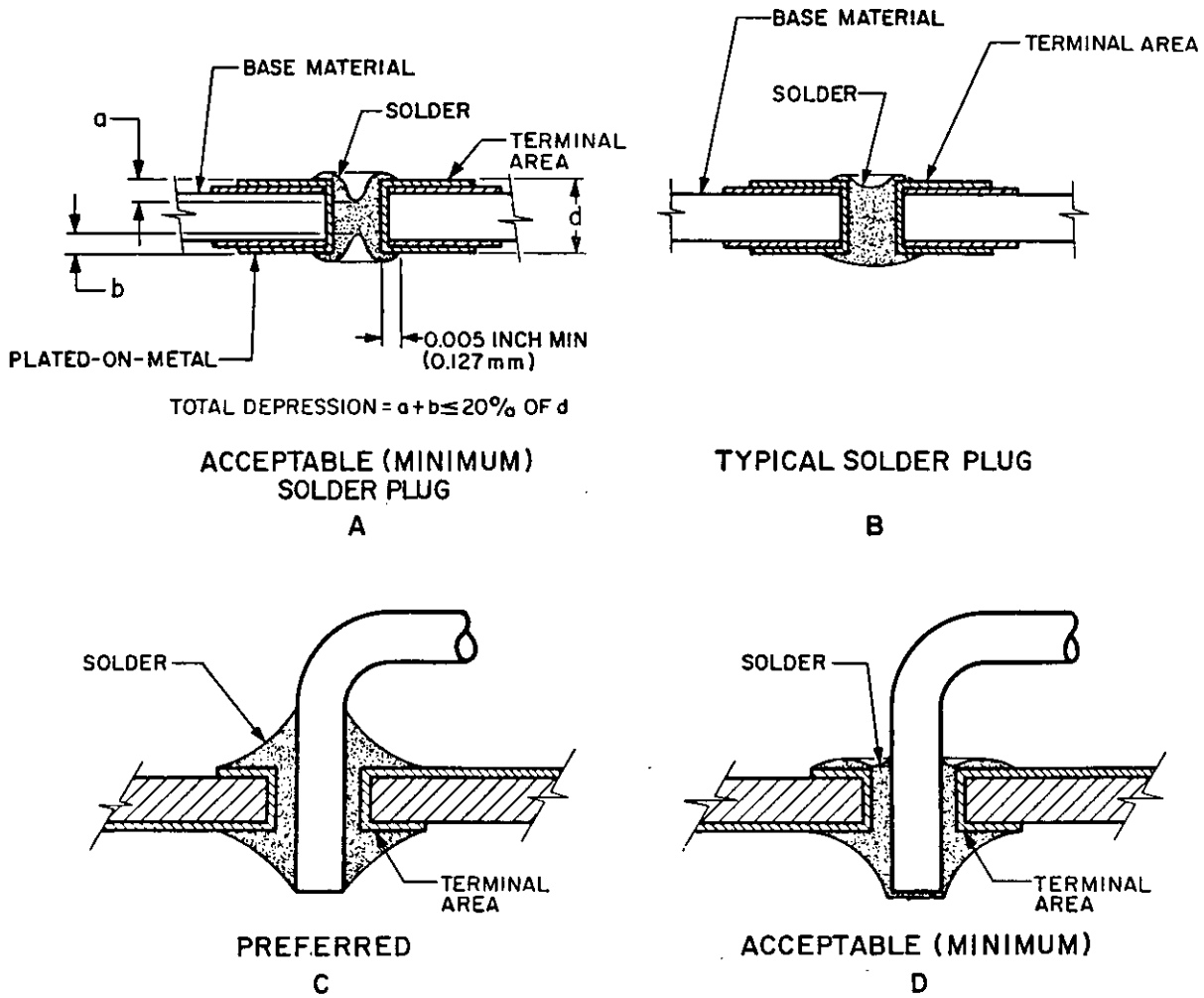


FIGURE 4. Plated-through hole interfacial and interlayer connections (see 4.19.1).

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4.19.2 Clinched wire interfacial connections. Interfacial connections of circuitry on double-sided printed wiring boards or assemblies which are not completed via a plated-through hole shall have a wire clinched on both sides (see figure 5). The wire connecting circuitry on opposite sides of the board or assembly 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 springback to one half the wire diameter is acceptable). The clinched portions of the wire shall meet the requirements for clinched component leads as specified in DOD-STD-2000-2. Unless both clinched portions are soldered and cooled simultaneously, the two connections shall be step-soldered.

NOTE: Clinched wires may be utilized for greater reliability in conjunction with plated-through interfacial holes. Step-soldering is neither essential nor desired for such connections inasmuch as the connection(s) will cool as a unit.

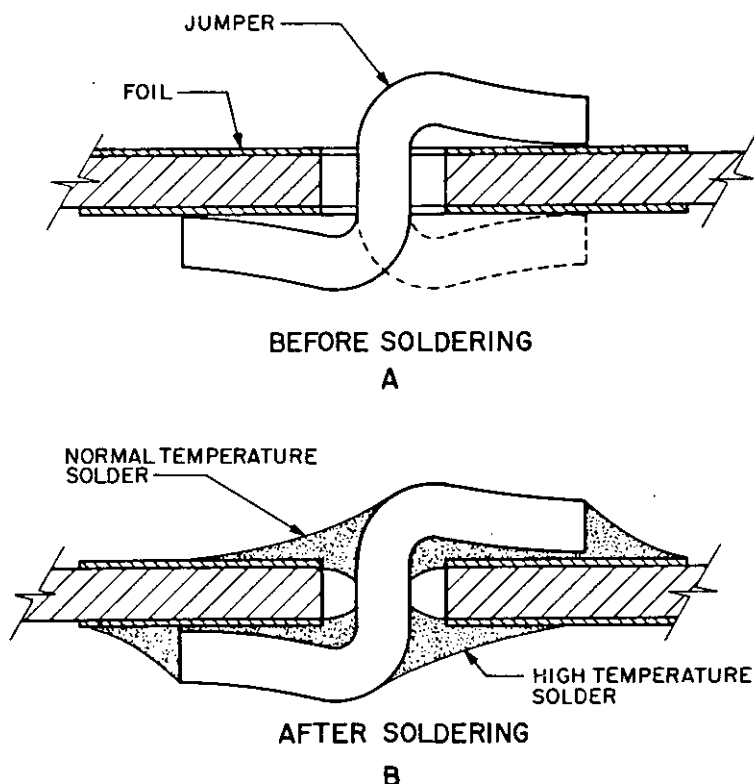


FIGURE 5. Clinched wire interfacial connections (see 4.19.2).

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

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5. DETAIL REQUIREMENTS

5.1 Manual soldering (Class 1). Manual soldering shall be accomplished using the facilities, tools and materials specified in paragraphs 4.11 and 4.16. Tools used in the soldering process shall be cleaned prior to use, be free of dirt, grease, flux, oil and other foreign matter, and be kept clean during use.

5.1.1 Preparation of the soldering iron. The soldering iron tip shall be fully inserted into the heating element casing, which shall be tightly attached to the handle. The soldering iron shall be heated and upon reaching a temperature which causes solder to melt, the tip shall be first tinned with a light coat of solder and then cleaned by wiping lightly on a clean, moist wiping pad (see 4.11.2.11). A thin, bright, tinned surface shall be maintained on the working surface of the tip to insure proper heat transfer to the connection being soldered. Oxidation scale shall not be allowed to accumulate on the tip or between the heating element and the tip.

5.1.2 Use of solder pots. Solder pots to be used for cleaning and tinning of areas to be soldered shall be temperature controlled, and unless otherwise specified, be set at a preselected temperature within the range of 500° to 525°F (260° to 270°C). Solder purity shall be controlled in accordance with 4.11.3.4. Total time in the solder of areas to be soldered shall not exceed 5 seconds per immersion cycle.

5.1.3 Use of thermal shunts. Thermal shunts (heat sinks) shall be used to protect heat sensitive components such as semiconductors, transistors, ceramic capacitors, crystal devices, and insulating materials from heat damage while soldering (see figure 6). Thermal shunts so utilized shall not damage the component being soldered.

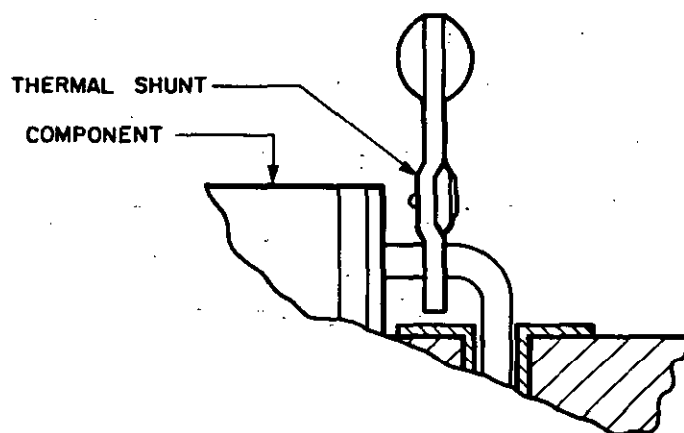


FIGURE 6. Thermal shunt (heat sink) (see 5.1.3).

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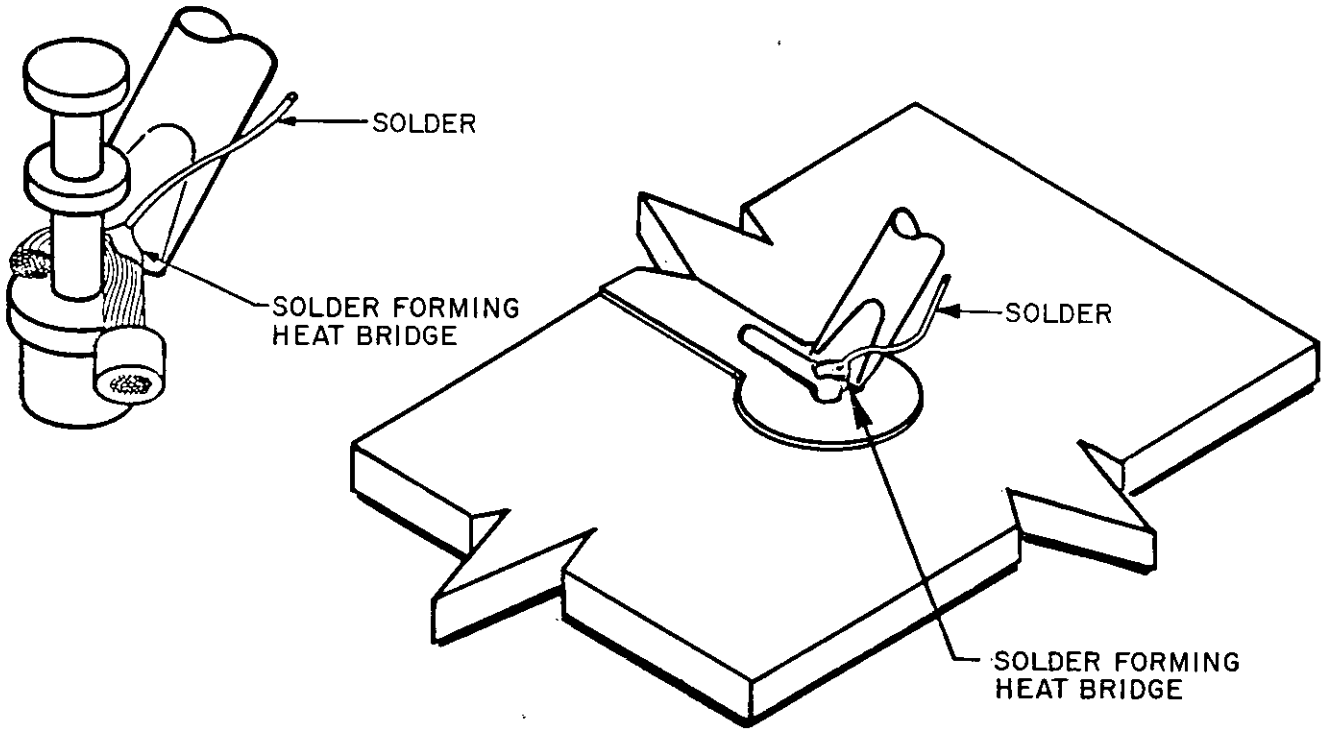
5.1.4 Flux application. Flux in accordance with 4.16.2 shall be utilized for all soldered electrical connections. Liquid flux, when used, shall be applied in a thin, even coat and shall be limited to those surfaces to be joined prior to application of heat. The use of excess flux shall be avoided. When used, cored solder shall be placed in such a position that allows the flux to flow and cover the connection elements as the solder melts. When an external liquid flux is used in conjunction with flux cored solders, the flux shall be of the same manufacturers type.

5.1.5 Heat application. The elements to be soldered shall be sufficiently heated to cause melting of the solder and wetting of the surface. Excessive heating time, pressure, and temperature shall be avoided to prevent unreliable joints or damage to parts, printed circuitry, insulation, or adjacent components.

5.1.6 Solder application. The area to be soldered shall first be properly heated and then the solder, in accordance with 4.16.1, shall be applied at the junction of the soldering iron tip and the parts or components being soldered (see figure 7). When soldering printed wiring assemblies with plated-through holes, solder shall only be flowed from the solder side of the printed wiring assembly. As an exception, the use of transfer soldering techniques shall be approved by the Government Contracting Officer prior to use. Precautions shall be taken to prevent any change in wire or lead positioning within the solder connection before the solder has completely solidified. Solder bridging shall be maintained throughout the soldering process. Wicking of solder underneath the insulation of stranded wire during the soldering operation shall be minimized through use of anti-wicking tools, heat sinks, or other appropriate methods and techniques. As a guide the soldering operation shall be completed within 2 to 5 seconds.

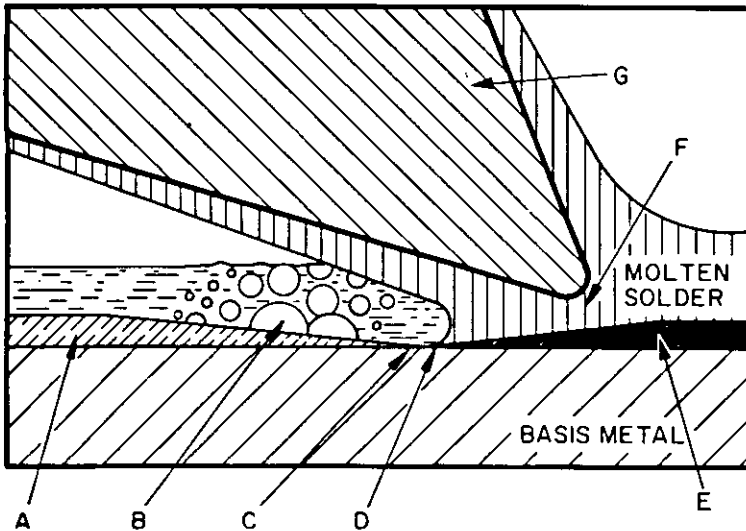
5.1.7 Cooling. The molten solder shall be cooled at room temperature only; forced air or liquid material shall not be used to accelerate solidification.

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INITIAL BRIDGING BEING FORMED

A



- A. FLUX SOLUTION LYING ABOVE OXIDIZED METAL SURFACE.
- B. BOILING FLUX SOLUTION REMOVING THE FILM OF OXIDE
- C. BARE METAL IN CONTACT WITH FUSED FLUX.
- D. LIQUID SOLDER REPLACING FUSED FLUX.
- E. TIN REACTING WITH THE BASIS METAL TO FORM A NEW ALLOY.
- F. SOLDER FORMING HEAT BRIDGE.
- G. SOLDERING IRON TIP SHOWN NOT TOUCHING BASIS METAL FOR CLARITY.

B

FIGURE 7. Solder application and bridging (see 5.1.6).

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5.1.8 Cup and hollow cylindrical type terminals. Solder cup terminals shall be cleaned, pretinned and prefilled prior to insertion of the wire. Sufficient solder shall be used to fill the cup or receptacle when the wire is inserted. Sufficient heat shall be applied during filling of the cup to assure that all of the flux has risen and is not trapped at the cup bottom. 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 to permit multiple wire insertion. After filling, the wire(s) shall be inserted straight into the cup cavity (see figure 8), touching the back of the inner wall of the cavity for the full length of the cavity and until it strikes the bottom. Continuous soldering iron control shall be maintained throughout the soldering operation.

The solder should rise slightly above the top of the cup and follow the contour of the cup entry slot. The contour of the wire shall not be obscured at the termination end of the insulation. Solder should not spill over and adhere to the sides of the terminal. Excess solder that spills over the terminal or from a weep hole shall be removed, such that the solder remaining on the outside of the solder cup is only in the form of a thin film.

The prefilling and soldering of cup and hollow cylindrical terminals is illustrated in figures 8, 9, and 10.

NOTE: If the solder is fed too fast, a gas pocket may be formed or flux entrapped. This produces a false fill, since not enough solder is in the cup. This condition can be corrected by applying heat to the terminal base, reflowing the solder, and adding solder to fill the cup.

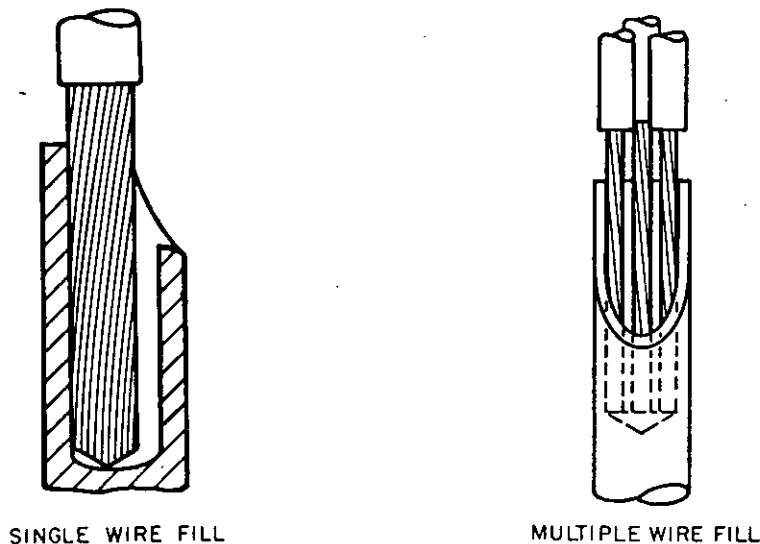


FIGURE 8. Cup type terminals (see 5.1.8).

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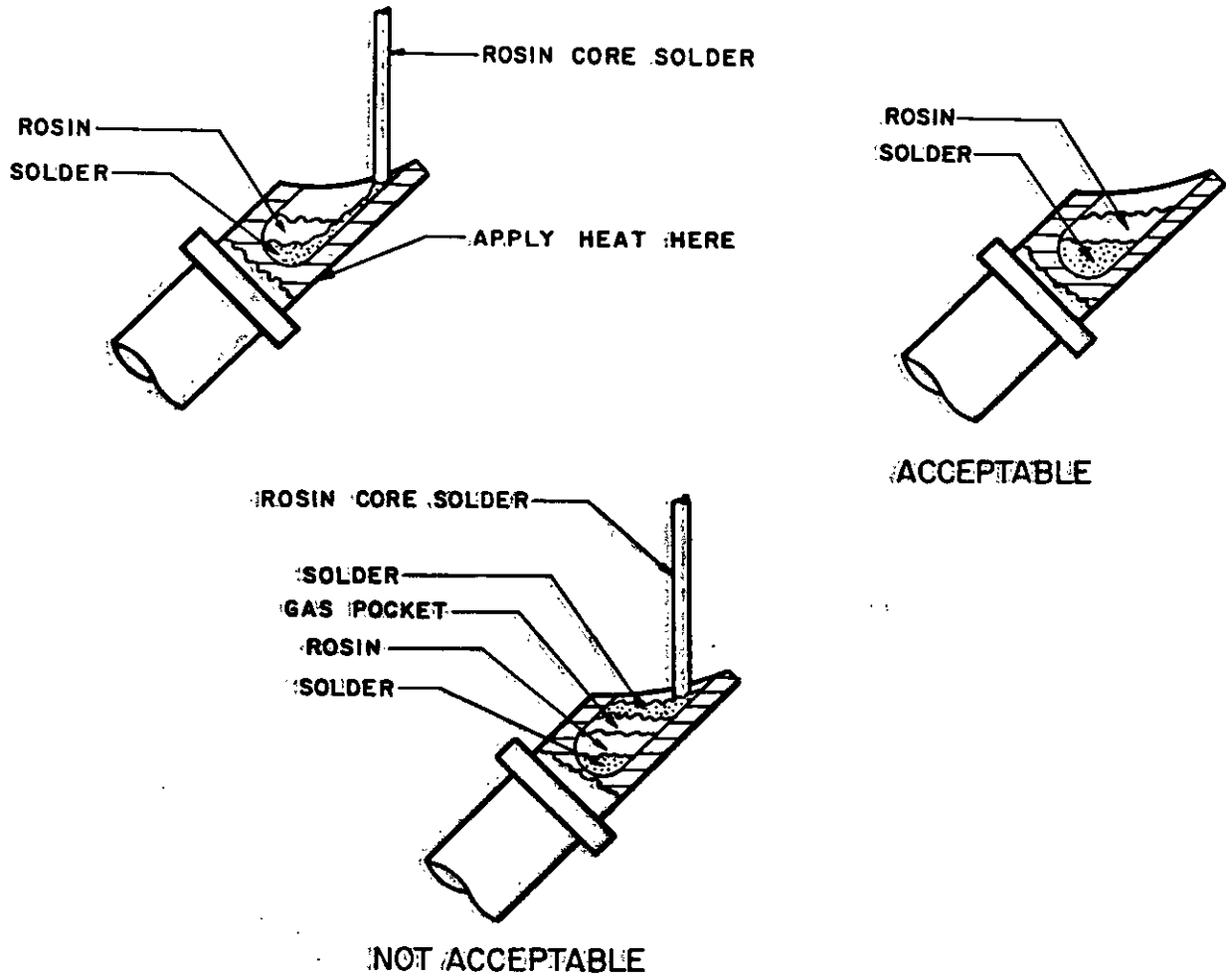


FIGURE 9. Prefilling hollow cylindrical terminals (see 5.1.8).

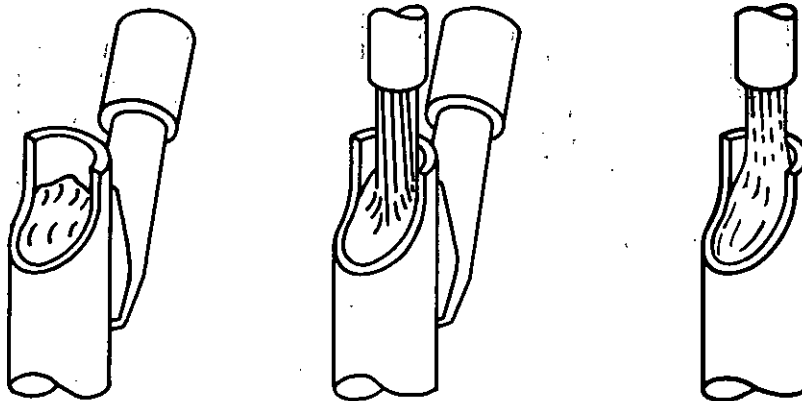


FIGURE 10. Soldering of hollow cylindrical connections (see 5.1.8).

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5.1.9 Preparation of shielded wire.

5.1.9.1 Coaxial connectors. Coaxial connectors shall be assembled in accordance with detailed contractor work instructions prepared to reflect procedures recommended by the connector manufacturer except that, if solder or fluxes other than specified in 4.16.1, 4.16.2 and 4.16.3 are recommended for connector assembly, such solders or fluxes shall be used only upon specific approval for this application only, by the Government Contracting Officer, prior to use.

5.1.9.2 Semirigid coaxial cable (hardline). Semirigid coaxial cable shall be assembled in accordance with detailed contractor work instructions that have been approved by the Government Contracting Officer.

5.1.9.3 Braided shield terminations. Solder sleeves shall be installed in accordance with MIL-S-83519. Other braided shield terminations shall be in accordance with detailed contractor work instructions that have been approved by the Government Contracting Officer or in accordance with assembly drawings approved by the Government.

5.1.10 Connection of conductors, component leads and terminals.

5.1.10.1 Insulation tubing applications. When required, insulation tubing which conforms to the requirements of 4.16.5, 4.16.6 and 4.16.7 shall be used and shall be installed as follows:

- a. Tubing shall be placed over wires and leads prior to their attachment.
- b. Tubing shall be held far enough from the connection so as not to interfere with or be damaged during the securing and soldering operations.
- c. After the connection has cooled, been cleaned, and then inspected, the tubing shall be slipped over the connection and heat shrunk where applicable.

After installation, the tubing shall extend above the stripped portion of the attached conductor a distance equal to or greater than twice the shrunken tubing diameter.

5.1.10.2 Use of solder sleeves with shielded wires. The procedure for preparing shielded wire for use with solder sleeves and for the installation of solder sleeves shall conform to MIL-S-83519. This requirement is applicable to insulated wires with a rated operating temperature of 302°F (150°C) minimum.

5.1.11 Termination of magnet wires. For wire termination, the insulation shall be carefully stripped to a minimum of 1/2 inch (12.7 mm) and then tinned.

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Polyurethane coatings shall be stripped as specified in 4.18.1.4. When chemical strippers are used, the chemical residue shall be neutralized and the wire shall be cleaned. When used, the service lead wire insulation shall also be stripped a minimum of 1/2 inch (12.7 mm). The stripping shall be performed in accordance with 4.18.1.3. Damage to the insulation and wire shall be limited to the amount specified in DOD-STD-2000-3. The size of the service leads shall be governed by the magnet wire size as follows:

<u>Magnet wire size (AWG)</u>	<u>Service lead size (AWG)</u>
40-50 (ultra fine magnet wire)	Double service lead required. Magnet wire connected to 35-gauge wire which in turn is connected to 26 stranded service lead.
34-44	28-32 (stranded).
34	Connect the magnet wire directly to terminal.

5.1.11.1 Joining of magnet wire to service lead. The magnet wire shall be wrapped securely around the service lead a minimum of three turns, commencing 1/8 inch (3.18 mm) from the insulation. Any excess length shall be cut off.

5.1.11.2 Joining of magnet wire to magnet wire (winding-to-winding splice). The ends of the wires to be joined shall be placed parallel to each other, and twisted together a minimum of three turns.

5.1.11.3 Soldered splices for small diameter magnet wire. Small diameter magnet wire (AWG-34 gauge through 50 gauge) may be spliced to wires of larger diameter (service leads) which in turn can be attached to terminals (leading). When required by the design, splices may be made between the leads of individual windings. The requirements of 5.1.11.3.1, 5.1.11.3.2 and 5.1.11.3.3 are applicable only in the manufacture of transformers, inductors and coils.

5.1.11.3.1 Soldering of splice. The splice shall be soldered as specified in 5.1.6, taking care that the solder is applied not closer than 1/16 inch (1.58 mm) to the insulation. The solder shall be smooth with no sharp solder points.

5.1.11.3.2 Applying insulation. After cleaning and inspection, the spliced portion shall be bent back against the larger wire. The insulation shall be equivalent to or better than the original or specified insulation, and shall cover a minimum of 5/8 inch (15.88 mm) over the wire insulation.

5.1.11.3.3 Anchoring service lead. Unless otherwise specified on the applicable drawing, the service lead shall be taped or secured with non-reactive adhesive for a minimum length of 1/2 inch (12.7 mm) to the coil winding after application of the insulation.

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5.2 Automated machine soldering (Class 2). Machine soldering shall be accomplished using any integral system (see 4.12) which also incorporates:

- a. Temperature controlled preheating and soldering stages (see 5.2.2.5 and 5.2.2.6).
- b. An automatic fluxing stage (see 5.2.1.6).
- c. A cooling stage (see 5.2.1.7).
- d. A speed controlled conveyor stage (see 5.2.2.3).

Components shall be constrained in accordance with 5.2.1.3. Processes for drag soldering and other systems not specified herein shall be approved by the Government Contracting Officer prior to use.

5.2.1 General requirements.

5.2.1.1 Machine maintenance. Machines incident to the automated soldering process shall be maintained to assure capability and efficiency commensurate with design parameters established by the original equipment manufacturer.

5.2.1.2 Machine controls. The contractor shall have operating procedures describing the soldering process and the proper operation of the automatic soldering machine and associated equipment. For the soldering machine, these procedures, as a minimum, shall define the preheat temperature, solder temperature, rate of travel, frequency of temperature verification measurements and frequency of solder bath analysis. If any of the above mentioned characteristics must be adjusted for different printed wiring assemblies, the procedure shall identify by printed wiring assembly, drawing number, or other positive identification means, the setting to be utilized.

5.2.1.3 Holding fixtures and materials. Devices, materials or techniques used to retain parts and components to the printed wiring board through preheat, fluxing, soldering, and cooling stages shall not contaminate, mar, or otherwise damage or degrade printed wiring boards, parts, or components. The devices, materials or techniques shall not only be adequate to maintain component positioning but shall permit solder flow through plated-through holes and complete coverage of terminal areas on the component side of the printed wiring board. If used, skin packaging shall be vented to permit hole fill and terminal area coverage. Skin packaging shall not be utilized if it results in electrostatic discharge damage or degradation to components.

5.2.1.4 Carriers. Devices used for the transport of printed wiring assemblies through preheat, fluxing, soldering, or cooling stages shall be in accordance with 4.13.

5.2.1.5 Masking. Areas of printed wiring boards not to be soldered (including plated-through holes in which leads or wires are to be later inserted and soldered) shall be masked prior to the application of flux. The maskant materials used shall not cause fire or create fire or health hazards (see 4.16.10).

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5.2.1.6 Fluxing. Flux shall be applied by the wave, foam or spray method which will produce an even coated bottom surface and hole fill. The solids content of the flux shall be maintained with a nonchlorinated solvent recommended by the flux manufacturer or with a Government Contracting Officer approved substitute.

5.2.1.7 Cooling (printed wiring). The printed wiring assembly shall be retained on the conveyor until the solder has solidified. There shall be no forced cooling.

5.2.2 Wave soldering.

5.2.2.1 Solder bath. The solder bath shall be set to a preselected temperature between 480° and 520°F (249° and 271°C). The temperature measurement shall be made 1/16 to 1/8 inch (1.58 to 3.17 mm) (actual measurement is not required except for referee purposes) below the crest(s) of the molten solder wave(s) when no board is traversing the wave(s). The temperature and the time of contact between the printed wiring assembly and the solder shall be dependent upon such factors as preheating, thickness of board, number of contacts or conductors, and the type of parts. The period of exposure of any printed wiring assembly to a solder bath shall be limited to a duration which will not cause damage to the board or parts mounted thereon. The solder bath shall be periodically analyzed to insure that contamination levels do not exceed the limits specified in table III.

5.2.2.2 Maintenance of solder purity. To maintain the proper purity of solder, the following procedures shall be adhered to in machine soldering of printed wiring assemblies:

5.2.2.2.1 Before the start of soldering operations, dross shall be removed from the solder bath surface. Dross shall be periodically removed from the solder bath to assure that dross does not contact the items being soldered. Automatic or manual methods for removing dross are acceptable.

5.2.2.2.2 Solder in solder baths shall be chemically or spectrographically analyzed or renewed at the testing frequency levels shown in table III, column B. These intervals may be lengthened to the 8 hour operating days shown in column C when the results of analysis provide definite indications that such action will not adversely affect the purity of the solder bath. If contamination exceeds the limits of table III, intervals between analyses or replacement shall be shortened to those 8 hour operating days shown in column A, or less, until continued purity has been assured by analysis. Records containing the results of all analyses and solder bath usage shall be readily available for review by the Government Contracting Officer.

5.2.2.3 Conveying. Preloaded and precleaned printed wiring assemblies shall be transported through the fluxer and preheater to the solder bath and on through the cooling stage at a rate preselected to assure compliance with 5.2.2.6. The speed shall not vary more than 1 inch (25.4 mm) per minute.

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5.2.2.4 Lead trimming. Leads may be trimmed provided the cutters used impart no physical shock to the components and the leads are cut perpendicular to the axis of the lead within 10 degrees (actual measurement is not required except for referee purposes) with no spikes, peaks, or drag. When lead cutting is performed after flow soldering, one repass over the solder pot shall be made to cover ends and to reflow the solder terminations to prevent metallurgical disturbances caused by side loading. When the number of leads cut after soldering is small, manual touch-up may be used to reflow solder, including coverage of lead ends.

5.2.2.5 Preheating. The areas of the PWB to be soldered shall be preheated to 160 to 220°F (71° to 105°C) as measured on the component side at the surface of the laminate base material where there is no metal. All subsequent temperature measurements shall be made at the selected point for each board type. A preheat schedule shall be prepared for each type of board (as identified by PWB assembly part number designations) to be soldered based upon thickness and density and shall include the proper heater settings for preheating the boards to the required temperature. The selected temperature from board-to-board (of the same type) as measured on test specimens, shall be maintained within 10°F (5.5°C) but not to exceed the specified limit. Printed wiring assemblies shall be preheated to a temperature compatible with the flux, conveyor speed, solder temperature, and time of board contact with the solder bath.

5.2.2.6 Solder application. Solder shall be applied to the printed wiring assembly through contact with a solder wave compatible with the type of soldering machine being used. The time of contact between any point of the printed wiring assembly and the solder shall not exceed 5 seconds without prior approval by the Government Contracting Officer and shall be preselected, dependent upon preheating, thickness of the board, number of connections and conductors and the type of components. The temperature of the solder shall be measured at a point 1/16 to 1/8 inch (1.58 to 3.17 mm) (actual measurement not required except for referee purpose) below the crest(s) of the wave(s) in the path of the board and shall be the preselect temperature (T) +11°F (+6°C) (see 5.2.2.1). The height of the wave and depth of immersion shall be maintained to assure effective contact and solder pressure sufficient for hole fill and solder spread to terminal areas on the component side of the printed wiring assembly.

5.2.3 Planar (Reflow) soldering.

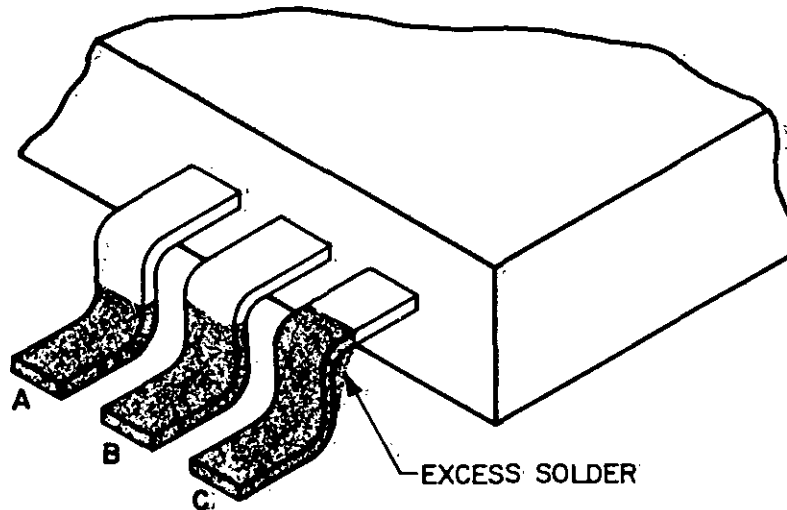
5.2.3.1 Solder application. Solder shall be deposited or plated on both metal surfaces to be joined prior to positioning the components in place.

5.2.3.2 Component positioning. Component mounting shall be in accordance with DOD-STD-2000-2.

5.2.3.3 Flux application. Prior to the soldering process, a uniform coating of flux, solder cream, or solder paste shall be applied to the pad surfaces or joint area where the component leads are to be soldered.

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5.2.3.4 Solder thickness. The thickness of the solder coating on component leads or ribbon conductors plus the solder thickness on the termination area shall be $0.0025 + 0.0010$ inches ($0.064 + 0.025$ mm). The coating shall extend from the end of the ribbon lead up to and including the radius of the heel bend but shall not extend past the radius of the knee bend (see figure 11).



- A - Minimum Acceptable: Extends past first radius
- B - Maximum Acceptable: Tinning extends to second radius
- C - Reject: Solder extends past second radius

FIGURE 11. Lead tinning of ribbon leads (see 5.2.3.4).

5.2.3.5 Heat application. The component terminations to be soldered shall be heated to 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 surfaces being soldered shall be restrained to preclude movement relative to the terminal area as solder is solidifying.

5.2.4 Condensation (Vapor Phase) soldering. The condensation (Vapor Phase) reflow soldering method is generally used for back planes and connector reflow soldering. Prior to using this method for component soldering, supportive information that no damage will occur to the components shall be submitted to the Government Contracting Officer. The condensation reflow system shall be mechanized to provide for smooth transition of the work piece, control of temperature, level of vapors and dwell time. There shall be a smooth transition out of the vapors after completion of the soldering operation to prevent disturbed solder connections prior to solidification.

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5.3 Post soldering operations.

5.3.1 Rework of unsatisfactory solder connections. Rework operations shall be performed only by assembly personnel (operators) certified in accordance with 5.4.1. Inspection personnel shall perform no soldering or rework operations. Rework of unsatisfactory solder connections shall not be performed until inspection personnel have documented the discrepancy. This data shall be used to provide an indication as to possible causes and to determine the corrective action necessary to reduce future rework.

5.3.1.1 Methods for rework by hand soldering.

5.3.1.1.1 Reheat method of rework. When rework is required, one reheating of a solder connection and adding flux and solder if necessary may be used for the following types of defects:

- a. Nonsoldered connections.
- b. Cold solder connections.
- c. Fractured or disturbed connections.
- d. Insufficient solder.
- e. Poor wetting.
- f. Pits, holes, or voids in connection.
- g. Visible basis metal in solder connection.
- h. Solder points, peaks, or icicles.

5.3.1.1.2 Resolder method of rework. When rework is required, defective solder connections and other defects which cannot be corrected in accordance with 5.3.1.1.1 shall be reworked by removing the solder by a vacuum device or wicking. After the solder has been removed, the connection shall be cleaned and the defect corrected. All connections shall be cooled to room temperature before applying heat. Connections shall be resoldered in accordance with 5.1.6.

CAUTION: Extreme care should be exercised when wicking solder out of plated-through hole.

5.3.1.2 Machine resolder method of rework. Assemblies may be resoldered by machine soldering a maximum of one time in accordance with 5.2. Assemblies that have been resoldered by machine shall not be reworked by machine soldering. Assemblies which are initially soldered by machine soldering in accordance with 5.2.2 or 5.2.3 and which contain defective solder connections, may be reworked by passing them through the same machine soldering process, with process control corrections, a single time to reflow all connections. The requirements of 5.2.2 or 5.2.3 shall be adhered to during the resoldering.

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5.3.1.3 Connection reinspection. Each reworked defect including each resoldered or reheated connection shall be reinspected. Assemblies which have been reworked in accordance with 5.3.1.2 shall be completely reinspected.

5.3.2 Cleaning. Connections to terminals, chassis elements and printed wiring assemblies shall be cleaned using a solvent, cleaner or combination of solvents (see 4.16.4) within a time frame that affords total removal of contaminants and flux residue. The time between solidification of the solder and assembly cleaning shall not exceed 30 minutes except for connections that are hand soldered and interim cleaned during production assembly or during rework or repair operations. In those cases, removal of flux residue may be delayed for up to one hour after completion of soldering provided the final cleaning process used results in removal of all flux and contaminants from the finished product. Printed wiring assemblies, terminal board assemblies to which electrical components are added, and electrical/electronic modules shall be cleaned in a manner that will prevent both thermal shock to the assemblies, modules, or components thereon or therein and moisture intrusion into components not totally sealed. The cleaning shall be accomplished in accordance with 5.3.2.1, 5.3.2.2, 5.3.2.3, 5.3.2.4 or combinations thereof.

5.3.2.1 Dip tanks. Printed wiring assemblies, terminal board assemblies, and electrical or electronic modules shall be subjected to three separate cleaning baths each of which contain a solvent or blend of solvents (see 4.16.4) identical to that in the other two. The solvent in the tanks shall be changed in accordance with the schedule detailed below or the solids contents of the solvent in tank 3 shall be measured each 8-hour work shift and the solvents changed before the solids content reaches 10 ppm or when it is evident that the solids content will exceed 10 ppm before the next immediate measurement is scheduled. Immersion time in each tank shall be limited to 60 seconds. To change solvents, the solvent in tank 1 shall be discarded; the solvent in tank 2 may be placed in tank 1; the solvent in tank 3 may be placed in tank 2 and fresh solvent shall be added to tank 3.

- | a. <u>Order of cleaning</u> | <u>Change of solvent</u> |
|-----------------------------|--|
| Tank 1:
first cleaning | After 2,500 square inches (1.6 square meter) of board surface per quart (0.95 liters) of solvent |
| Tank 2:
second cleaning | After 2,500 square inches (1.6 square meter) of board surface per quart (0.95 liters) of solvent |
| Tank 3:
third cleaning | After 2,500 square inches (1.6 square meter) of board surface per quart (0.95 liters) of solvent |
- b. Use of a clean brush is permissible.

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- c. The printed wiring assembly shall be air dried after cleaning, using ambient air or compressed air which is oil-free and has a moisture content less than 2500 ppm measured at room ambient temperature. Air pressure up to 40 pounds per square inch gauge (psig) (276 kPa) may be used, provided it does not damage the assembly.

5.3.2.2 Vapor degreasing. Use of vapor degreasing for cleaning printed wiring assemblies, terminal board assemblies, soldered chassis elements, and electrical or electronic modules is permissible provided that solvents are in accordance with 4.16.4 and are compatible with the particular vapor degreaser utilized for cleaning. The solid contents of the solvent in the (cold or final) sump of the degreaser shall not exceed 10 ppm.

5.3.2.3 Detergent cleaning. The use of detergent or saponifying cleaning systems is permissible for cleaning printed wiring assemblies and electrical or electronic modules only if the detergent or saponifier and the cleaning process are approved in advance by the Government Contracting Officer.

5.3.2.4 Ultrasonic cleaning. The use of ultrasonic cleaning devices on components or printed wiring assemblies is prohibited except for assemblies containing only terminals or connectors without internal electronics. Ultrasonic cleaning may be used on bare printed wiring boards.

5.3.3 Cleanliness testing. After cleaning in accordance with 5.3.2, the printed wiring assemblies, terminal boards, and electrical/electronic modules shall be subjected to a cleanliness test before the end of the production shift. The resistivity of solvent extract test, 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 test 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. One representative sample of each printed wiring assembly (PWA) type processed during each production shift, shall be subjected to the cleanliness verification test. Each type of printed wiring assembly shall consist of either the assemblies having the same part number or of different part numbered assemblies having the same size or assembly configuration using the same volume of resistivity solution. If the sample fails the cleanliness test, all lots represented by the failed sample shall be re-cleaned, retested and sampled, as a minimum, in accordance with MIL-STD-105, Inspection Level S-2, AQL-1.0 percent defective. Two subsequent lots shall be tested in accordance with MIL-STD-105 inspection level S-2, AQL 1.0 percent defective.

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

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- 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 microhmos/cm).
- b. Clean a funnel, 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.

5.3.3.2 Sodium chloride salt equivalent ionic contamination test.

Sodium chloride salt equivalent ionic contamination shall be measured as follows (see table IV):

- 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 20×10^6 ohm-centimeters (0.05 micromhos/centimeter) before each sample is tested.

TABLE IV. 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 10.0 micrograms/square inch.

5.3.3.3 Cleanliness testing prior to conformal coating or encapsulation. Prior to conformal coating or encapsulation, one representative sample of each printed wiring assembly (PWA) type processed during each production shift, shall be subjected to the cleanliness verification test. Each type of printed wiring assembly shall consist of either the assemblies having the same part number or of different part numbered assemblies having the same size or

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assembly configuration using the same volume of resistivity solution. If the sample fails the cleanliness test the entire lot shall be recleaned sampled in accordance with MIL-STD-105, inspection level S-2, AQL 1.0 percent defective and retested in accordance with 5.3.3 prior to conformal coating.

5.3.4 Handling and storage after cleaning. After final cleaning, and prior to application of conformal coating or encapsulation, unfinished printed wiring assemblies shall not be handled such that areas to be conformally coated or encapsulated come in contact with bare hands or visibly contaminated tools. Such assemblies shall be stored and processed in a controlled environment (see paragraph 4.11.1.2).

5.3.5 Measling and crazing after assembly. There shall be no evidence of burning, scorching or heat damage to boards or parts. After soldering and other assembly operations are complete, printed wiring boards shall include no measled area or craze on either side of the wiring board which exceed any of a, b and c below. For the purpose of this document the term "measled area" means all measles, crazing or a combination thereof included within any given area of the printed wiring board. If measling or crazing occurs on more than five percent of the printed wiring boards, action shall be taken to preclude continued occurrence of this problem.

- a. All measling, crazing or combination thereof contained in a given measled area shall be totally enclosed within a super-imposed square measuring 1/4 inch by 1/4 inch (6.35 x 6.35 mm) (see figure 12).

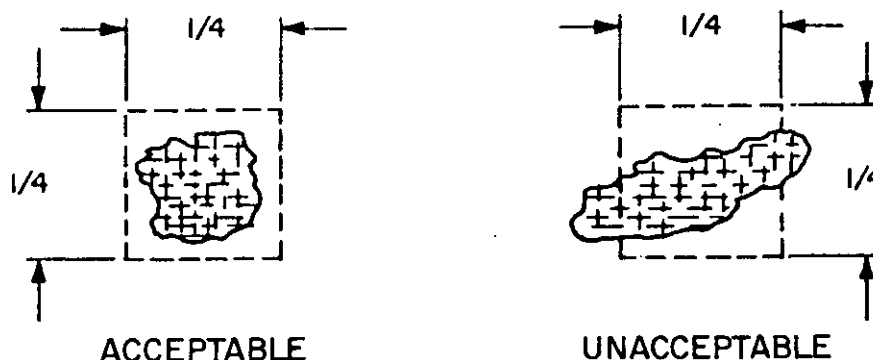


FIGURE 12. Maximum measled or crazed area (see 5.3.5a).

- b. The sum of the measled areas, crazes or combination thereof, on both sides of the PWB shall not exceed three percent of the total area of one side of the board. Each measled area shall be the area enclosed by an imaginary line around all measles within 1/8 inch (3.17 mm) of each other (see figure 13). Measles less than 1/8 inch x 1/8 inch (3.17 x 3.17 mm) area shall be summed as being 1/8 inch x 1/8 inch (3.17 x 3.17 mm). Percentage of measled area shall be the sum of the measled areas on both sides of the PWB divided by the total area of one side of the PWB times 100.

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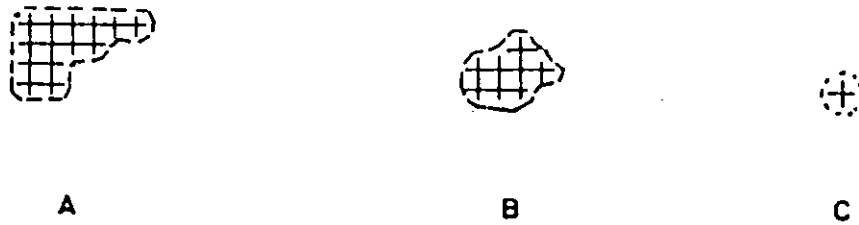


FIGURE 13. Examples of determining measled surface areas (see 5.3.5b).

c. When measled areas lie between conductors, the minimum conductor spacing shall be reduced no more than 50 percent of the minimum spacing for coated or uncoated PWBs as specified in DOD-STD-2000-2 (see figure 14).

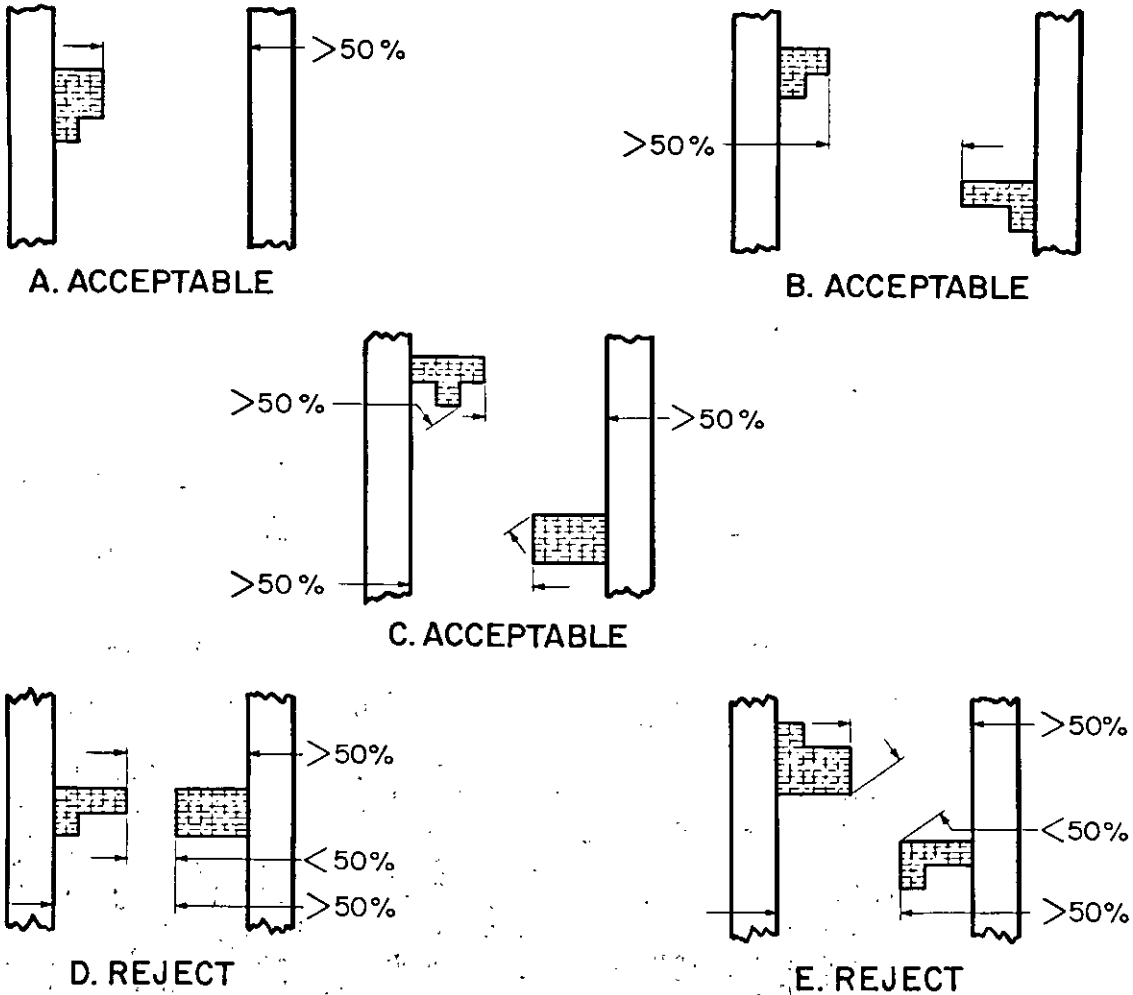


FIGURE 14. Measled areas between conductors (see 5.3.5c).

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5.3.6 Conformal coating process. To facilitate the removal of defective components, the printed wiring assembly should be functionally tested prior to the conformal coating or any encapsulation process.

5.3.7 Conformal coating. Unless applicable Government-approved assembly drawings include a specific note stating that conformal coating is not to be applied, printed wiring assemblies shall be conformally coated with material conforming to MIL-I-46058 and in accordance with a through i below. The coating shall be applied to both sides of the printed wiring assemblies using either a brush, dip, spray or vacuum deposition system which is suitable to the particular assembly.

- a. Assemblies shall be free of polar and nonpolar contamination immediately prior to coating.
- b. The cured coating shall be homogeneous, uniform, transparent and shall include no areas of resin reversion.
- c. Areas specified on appropriate assembly drawings to be uncoated shall be free of coating and coating spatter.
- d. The cured coating shall be free of voids or bubbles which expose components, printed wiring (including ground planes), or other conductors.
- e. The cured coating shall be free of bubbles or pin holes in an area where the coating covers printed wiring.
- f. No bubble nor void shall exceed a diameter or width of 0.010 inch (0.254 mm) if adjacent to a component or component lead nor shall any bubble or void exceed a diameter or width of 0.025 inch (0.635 mm) at any other location on the surface of the printed wiring assembly.
- g. Clusters of bubbles or microbubbles in open areas of a printed wiring assembly shall be unacceptable if any dimension of the cluster exceeds 1/4 inch (6.35 mm) or, if the cluster is adjacent to the body of a component, any dimension greater than 25 percent of the span of the side of the component to which it is adjacent, or 1/4 inch (6.35 mm), whichever is less.
- h. There shall be no voids, pinholes, bubbles, or clusters of same located between conductive elements unless such voids, pinholes, bubbles, or clusters are of a dimension less than 50 percent of the spacing between such conductors and the 50 percent spacing is greater than the minimum clearance spacing specified in MIL-STD-275.
- i. The conformal coating shall contain no visible blisters, cracks, crazes, mealing, peeling, wrinkles nor foreign particles.

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5.3.7.1 Conformal coating application. Conformal coating material shall be as specified on the Government approved assembly drawing. The material specification and manufacturer's instructions, as applicable, shall be followed and the material shall be used within the time period specified (both shelf-life and pot life). The coating shall be a minimum thickness (see 5.3.7.6) and fillets shall be kept to a minimum consistent with the size, weight, and mounting provisions of the components. A continuous coating shall be applied to both sides of the printed wiring assembly, using either a brush, dip, spray or vacuum deposition method which is suitable to the particular assembly and within the following criteria (see paragraphs 5.3.7.2 through 5.3.7.9). The coating shall be applied without bubbles, blisters, or breaks which might affect the printed wiring assembly operations, or sealing properties of the conformal coating.

5.3.7.2 Conformal coating on adjustable components. Assemblies having adjustable components shall not have the adjustable portion covered with the coating. Shafts of adjustable components shall be adjusted and sealed in accordance with 5.3.8.2.

5.3.7.3 Conformal coating on connectors. Mating connector surfaces of printed wiring assemblies shall not be coated with the conformal coating. Conformal coating shall, however, provide a seal between the connector and board and around all mounting devices of the connector.

5.3.7.4 Conformal coating on brackets. Printed wiring assemblies having brackets or other mounting devices shall not have the mating surfaces of said devices coated with conformal coating. However, the junction between these devices and the board and all attaching hardware shall be coated to provide a seal between the mounting device and the board.

5.3.7.5 Conformal coating thickness. When thickness is not specified on the Government approved assembly drawing or material or process specification the coating thickness for conformal coating, as defined in MIL-I-46058 for Types AR, ER and UR shall be $0.002 + 0.001$ inch ($0.05 + 0.025$ mm). For Type SR, the coating thickness shall be $0.005 + 0.003$ inch ($0.127 + 0.076$ mm). When Type XY is required by the approved assembly drawing the coating thickness shall be 0.0005 to 0.0012 inch ($.013$ to $.03$ mm). All thicknesses are measured on a flat unencumbered surface.

5.3.7.6 Conformal coating on flexible leads. Components which are electrically connected to the printed wiring assembly by flexible leads shall have, as a minimum, the junction of the leads with the components and the printed wiring assembly coated.

5.3.7.7 Perimeter coating. Unless otherwise specified on the government approved assembly drawing, the outer perimeter of printed wiring assemblies shall not be increased in total thickness, by more than $.040$ inch (1.02 mm) as a result of conformal coating. The "outer perimeter" is defined as the area on each side of the board a distance of not more than $1/4$ inch (6.35 mm) inward from the outer edge.

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5.3.7.8 Edge coating. Unless otherwise specified on the government approved assembly drawing, the dimensions of the printed wiring assemblies shall not be increased in length or width by more than 0.030 inch (0.762 mm) on each edge, total 0.060 inch (1.524 mm), by application of conformal coating.

5.3.8 Adjustable components.

5.3.8.1 Adjustment. When required, printed wiring assemblies shall be calibrated or adjusted per drawing requirements after conformal coating.

5.3.8.2 Staking of adjustable components. After calibration adjustment of components, the movable shafts or other adjustable features which are not mechanically retained shall be staked with quick drying cellulose lacquer sealant unless otherwise specified on the drawing. Sealant shall be used unthinned and shall be applied sparingly by brush or applicator to limit penetration to the minimum practicable.

5.3.9 Repair after conformal coating process. All processes which necessitate removal of conformal coating or encapsulation shall be classified as a repair operation.

5.4 Certification of personnel.

5.4.1 Certification. Certification as to the ability of personnel to meet the requirements of this standard, DOD-STD-2000-2 and DOD-STD-2000-3 shall be made available to the Government Contracting Officer. Personnel shall be certified in accordance with the requirements specified herein, prior to performing or inspecting soldering on engineering or experimental models, prototype models, or deliverable articles. Each individual's certification card shall be on his person or visibly displayed at his work station.

5.4.2 Visual acuity. All candidates for certification in any category (see 5.4.3) shall, as a minimum, meet the following vision requirements:

- a. Far vision: Snellen chart 20/40, or better.
- b. Near vision: Jaeger 1 or 0.50 mm letters at 14 inches (355.6 mm) or better.
- c. Color perception: Normal as determined by means of standard color plates (i.e., Dvorine pseudo-isochromatic plates, Ishihara plates, or equivalent).
- d. Depth perception: Normal binocular vision for fine, close work as determined by standard testing methods.

All personnel certified to this standard shall be given an eye test by an accredited eye examiner to determine their ability to meet these vision requirements. Frequency of eye tests shall be annually for persons 35 years of age or older and every two years for persons less than 35 years of age, except frequency for an individual may be increased if so prescribed by a

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Licensed ophthalmologist. Use of prescription lenses to meet the vision requirements is permissible. When such lenses are required, the certification card shall so state and such lenses shall be used whenever soldering or inspection is being performed. When a binocular microscope, with individually adjustable eyepieces, is used for the soldering or inspection operation, prescription lenses are not required. Failure to meet any of these requirements shall disqualify a candidate for training and certification or shall result in revocation of any certification previously granted.

5.4.3 Certificate categories. Certificates shall be issued in the following ten categories:

- A Government Senior Examiner
- B Government Instructor and Examiner (except category M)
- C Contractor Instructor and Examiner
- D Inspector (Contractor)
- E Operator (Contractor)
- F Government Inspector (except category N)
- G Government Operator
- H Process Examiner
- M Government Contract Administration Office (GCAO) Instructor and Examiner
- N Government Contract Administration Office (GCAO) Quality Assurance Representative (QAR)
- R Restricted Operator or Inspector

Contractor personnel, (category C), shall be certified by an approved school; contractor personnel, (categories D, E, and R), shall be certified by the contractor.

5.4.3.1 Category A Government Senior examiner.

5.4.3.1.1 Category A Authority. Category A personnel are authorized to train, certify and require certification and recertification of personnel of all other categories. Category A personnel are also authorized to monitor and evaluate soldering processes, workmanship, training programs, and facilities for conformance to this standard.

5.4.3.2 Category B Government instructor and examiner (except category M).

5.4.3.2.1 Category B Authority. Category B personnel are authorized to require recertification of personnel of categories C, D, E, R, F, and G, to monitor contractor soldering processes and workmanship for conformance to this standard and to perform soldering operations and inspections at Government facilities for conformance with this standard.

5.4.3.3 Category C Contractor instructor and examiner.

5.4.3.3.1 Category C Contractor personnel. Category C personnel shall be contractor personnel certified after satisfactory completion of an 80 hour soldering course (see 5.4.7.4). Category C personnel certification and performance shall be reviewed on an annual basis.

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5.4.3.3.2 Category C Authority. Category C personnel are authorized to train or require recertification of personnel of categories D, E, and R provided that the personnel are in the employ of:

- a. The same company, or
- b. a division of the same company, or
- c. a subcontractor of the same company as that which employs the category C person on a full time basis.

Category C personnel are authorized to monitor soldering processes and workmanship for compliance to this standard, to perform inspections for conformance with this standard, and to determine the operations or procedures that are appropriate for a category R inspector or operator.

5.4.3.4 Category D Inspector.

5.4.3.4.1 Category D Contractor personnel. Category D personnel shall:

- a. Have completed all requirements for Category E operator as specified in 5.4.3.5, and
- b. be certified by the contractor after satisfactory completion of an additional 20 hour minimum inspector course conducted by a certified Category C instructor and examiner.

5.4.3.4.2 Category D Authority. Category D personnel are authorized to perform inspections for conformance with this standard provided that the personnel are in the employ of:

- a. The same company, or
- b. a division of the same company, or
- c. a subcontractor of the same company as that which employs the category C person on a full time basis.

5.4.3.5 Category E Operator.

5.4.3.5.1 Category E Contractor personnel. Category E personnel shall be certified by the contractor after satisfactory completion of a 40-hour soldering course conducted by a certified category C instructor and examiner.

5.4.3.5.2 Category E Authority. Category E personnel are authorized to perform soldering operations in conformance with this standard provided that the personnel are in the employ of:

- a. The same company, or
- b. a division of the same company, or

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- c. a subcontractor of the same company as that which employs the category C person on a full time basis.

5.4.3.6 Category F Government inspector (except category N).

5.4.3.6.1 Category F Authority. Category F personnel are authorized to perform inspections for conformance with this standard.

5.4.3.7 Category G Government operator.

5.4.3.7.1 Category G Authority. Category G personnel are authorized to perform operations in conformance with this standard.

5.4.3.8 Category H process examiner.

5.4.3.8.1 Category H personnel. Category H personnel shall be certified by the Government after satisfactory completion of an 80-hour soldering course, with primary emphasis on inspection and machine processes. Category H personnel certification and performance shall be reviewed on an annual basis. Contractors are not required to have Category H personnel as all requirements for Category H personnel may be accomplished by Category C personnel.

5.4.3.8.2 Category H authority. Category H Government personnel are authorized to recommend recertification of category H contractor personnel and personnel of categories C, D, E and R, to inspect soldering processes and workmanship for conformance to this standard, to perform quality assurance actions, and to participate in materials review board (MRB) decisions. Category H contractor personnel are authorized to recommend recertification of contractor personnel of categories D, E and R, to inspect contractor soldering processes and workmanship for conformance to this standard, to perform quality assurance actions, and to participate in material review board decisions.

5.4.3.9 Category M GCAO instructor and examiner.

5.4.3.9.1 Category M Authority. Category M personnel are authorized to require recertification of personnel of categories C, D, E, R, and N, and to monitor contractor soldering processes and workmanship for conformance to this standard.

5.4.3.9.2 Category M Training authority. Category M personnel are authorized to train category N personnel to this standard.

5.4.3.10 Category N GCAO Quality Assurance Representative (QAR).

5.4.3.10.1 Category N Authority. Category N personnel are authorized to monitor and verify the certification status of Category C, D, E and R contractor personnel and to recommend recertification when appropriate. Category N personnel are authorized to monitor contractor soldering processes and workmanship to verify contractor conformance to these standards.

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5.4.3.11 Category R Restricted operator or inspector.

5.4.3.11.1 Category R Contractor personnel. Category R personnel shall be selected by the contractor for performance of a limited number of operations or procedures. The training program shall, as a minimum, include the operations or procedures for which the category R personnel are to be certified. Functions or operations using a category R operator or inspector at the contractor facility require prior approval of a Category A Government Senior Examiner. Similar operations conducted by a subcontractor requires approval of the prime contractor and is subject to review by category A or B personnel in accordance with 5.4.3.1.1 and 5.4.3.2.1.

5.4.4 Achievement of certified status. To be certified in category C, personnel shall attend and successfully complete an 80-hour formal training program at a Government approved school, as specified by the procuring activity. To be certified in categories D and E, personnel shall attend and successfully complete a 40-hour formal training program conducted by a category C instructor and examiner.

5.4.5 Training programs.

5.4.5.1 Contractor training program.

5.4.5.1.1 General. The contractor shall establish and maintain an effective written training program to qualify, certify and recertify all personnel performing operations applicable to this standard under the cognizant Government activity contracts and shall include subcontracts, inter-plant work orders, and purchase orders. The program shall provide for training using the methods, equipment and materials described in this standard. Upon satisfactory demonstration of proficiency, personnel shall be issued a contractor certificate. The contractor shall prepare and maintain records of personnel training and performance.

5.4.5.1.2 Training records. The contractor's training records shall be maintained for the term of the contract and shall include, for each trainee during the time of his or her certification, the following:

- a. Trainee fabricated test specimen depicting satisfactory conformance to the applicable requirements of this standard.
- b. Graded copies of written tests.
- c. Employer, plant division, and location of employment.
- d. Certification category.
- e. Date of certification or recertification.
- f. Records of latest visual acuity examination.

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5.4.5.1.3 Program evaluation. The training program is subject to review by a category A senior examiner to assure that the program is compatible with this standard. The category A senior examiner reserves the right to disapprove the training program at any time the objectives of this standard are not being met.

5.4.5.2 Government training program. The Government is responsible for certification of its personnel.

5.4.6 Maintenance of certified status.

5.4.6.1 General. Based on a quality audit, review of inspection data, or observation of quality of articles fabricated, soldering personnel involved may be required to either demonstrate proficiency or be retrained in the category concerned and be recertified (see 5.4.7).

5.4.6.2 Continuous performance evaluation. Category D and E personnel shall be subjected to a continuous performance evaluation as specified in 5.4.7.2.

5.4.7 Recertification.

5.4.7.1 Requirements. Recertification shall be required under the following circumstances:

- a. Proficiency requirements herein are not met.
- b. New techniques have been developed which require new skills.
- c. Certificate holder changes employment.
- d. There is a reason to question proficiency or workmanship.
- e. Work period interruptions exceeding 90 days (categories C, D, E and R).
- f. Twelve months after last certification.

5.4.7.2 Procedures. The recertification procedure shall be as follows:

- a. Category C personnel shall annually attend a minimum 8-hour update course conducted by one of the certification centers (see 5.4.7.4) and shall demonstrate proficiency to a Category A senior examiner or designated Category B representative. Category C personnel failing to demonstrate proficiency shall be required to satisfactorily complete a certification course prior to further performance. Personnel passing the update course will have their certification extended for a period of one year. Every fourth year after initial certification, Category C personnel shall attend a minimum 40 hour recertification course held at one of the centers (see 5.4.7.4). The

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recertification course shall be in lieu of the annual update course. Upon satisfactory completion of the 40 hour course, Category C personnel will be recertified and continue in the update and recertification cycle.

- b. When 5.4.7.1b applies, category C personnel shall be recertified after attending a recertification course, and demonstrating proficiency in new techniques.
- c. Category D, E and R personnel shall be recertified as specified by category A, B, or C personnel in accordance with the requirements of 5.4.5.1.1. All recertification programs shall include a requirement to score a minimum of 80 percent correct on a written test compatible with that taken in the original certification course.

5.4.7.3 Revocation of certified status. Certifications issued by the contractor shall be revoked when the:

- a. Certificate holder fails to be recertified when required.
- b. Contractor training program fails to meet the objectives of this standard.
- c. Certificate holder leaves employment of the contractor for which certificate was originally issued.
- d. Certificate holder fails to meet visual acuity requirements.
- e. Quality of work has deteriorated as determined by a category A, B, C, or M instructor and examiner.

5.4.7.4 Certification resources. Addresses and telephone numbers of approved schools may be obtained from:

U.S. Army Missile Command
Soldering Technology & Certification Center
AMSMI-QA-QE-QT
Redstone Arsenal, AL 35898-5290
Telephone: Commercial 205-876-5273/5516
AUTOVON 746-5273/5516

Commanding Officer
Naval Weapons Center
Soldering Technology Branch
Code 3681
China Lake, CA 93555-6001
Telephone: Commercial 619-939-1800
AUTOVON 437-1800

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Commanding Officer
 Naval Air Engineering Center
 Code 9313
 Lakehurst, NJ 08733-5100
 Telephone: Commercial: 201-323-2258
 AUTOVON 624-2258

6. NOTES

6.1 Supersession note. This standard is one of a series of documents for High Quality/High Reliability soldering. The series consists of DOD-STD-2000-1 Soldering Technology, High Quality/High Reliability; DOD-STD-2000-2 Part and Component Mounting for High Quality/High Reliability Soldered Electrical and Electronic Assemblies; DOD-STD-2000-3 Criteria for High Quality/High Reliability Soldering Technology. As a set this series is intended to supersede the documents listed below. The listed documents will remain in effect until they are cancelled by separate notice.

MIL-S-45743	Soldering, Manual Type, High Reliability, Electrical and Electronic Equipment
MIL-S-46844	Solder Bath Soldering of Printed Wiring Assemblies
MIL-S-46860	Soldering of Metallic Ribbon Lead Materials to Solder Coated Conductors, Process for Reflow
MIL-S-50826(AR)	Soft Soldered Electrical Connections for Special Weapons Items Including Other Related Electronic Devices
MIL-S-50827(AR)	Soft Soldered Electrical Connections for Conventional Weapons Items Including Other Related Electronic Devices
MIL-STD-252(CR)	Classification of Visual and Mechanical Defects for Equipment, Electronic, Wired and Other Devices
MIL-STD-1460(AR)	Soldering of Electrical Connections and Printed Wiring Assemblies, Procedures for
QWS-10.00B	Acceptance Criteria for Solder Connections and Wiring in Electronic Equipment
WS-4554	Wave Soldering of Printed Wiring Assemblies, Automatic Machine Type
WS-6536	Process Specification Procedures and Requirements for Preparation and Soldering of Electrical Connections
WS-14146	Preparation, Soldering and Inspection of Electrical Connections

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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
 Degreaser
 Electronic components assembly
 Flux, soldering
 Insulation sleeving, electrical
 Printed circuit board
 Printed wiring, flexible
 Printed wiring board
 Solder
 Soldering iron
 Solvent, stoddard's
 Wiring harness

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

Preparing Activity:

Navy - AS
 (Project No. SOLD-0022)

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

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APPENDIX A

PROCEDURE FOR MEASURING 2mV POTENTIAL AT SOLDERING IRON TIP.
(See 4.11.3)

10. SCOPE. This Appendix establishes the procedure for measuring 2 mv potential at the soldering iron tip.

20. REFERENCED DOCUMENTS. Not applicable.

30. DEFINITIONS Not applicable.

40. GENERAL REQUIREMENTS.

40.1 Equipment requirements. Minimum use specifications are the principal parameters required to perform the measurement and are included to assist in the selection of alternative equipment which may be used at the discretion of the using laboratory. Voltmeters must bear evidence of end-date calibration.

TABLE A-I. Equipment requirements.

Item	Minimum use specifications	Measurement equipment and devices (see 40.2)
TRMS voltmeter	Accuracy: $\pm 10\%$ at 2 mV RMS Frequency range: 50-500 Hz Input impedance: 10 megohms	Hewlett-Packard model 3400A or Keithley model 132F
Cable	Type: shielded BNC (male) to alligator	Pomona Electronics model AL-B-BNC-36
Ground clip	Type: oscilloscope probe to alligator	Tektronix part numbers 175-0125-01 and 344-0046-00
Shim stock	Material: brass or copper Thickness: 0.008-0.020 inches Size: approximately 1.5 x 0.75 inches	
Solder	Type: rosin core	

40.2 The instruments used in this procedure and listed in table A-I were selected from those known to be available at Department of Defense facilities, and the listing by make or model number carries no implication of preference, recommendation or approval by the Department of Defense for other agencies. It is recognized that equivalent equipment produced by other manufacturers may be capable of equally satisfactory performance in the procedure and may be used.

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APPENDIX A

50. DETAIL REQUIREMENTS.

50.1 Preliminary operations.

50.1.1 Preparation of conduction plate.

50.1.1.1 Remove any dirt and corrosion from surface of shim stock. If sufficient solder pool is already present on shim stock, proceed to step 50.1.2.

50.1.1.2 Using the soldering iron under test (UUT), bond a small pool of solder to the shim stock as shown in figure A-1.

NOTE: Heat shim stock to sufficient temperature to create a well-wetted bond between shim stock and solder.

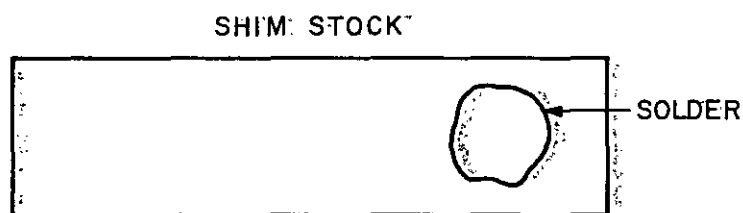


FIGURE A-1. Preparation of conduction plate.

50.1.2 Set-up of test equipment (see figure-A-2).

50.1.2.1 Attach BNC cable connector to input of TRMS voltmeter (if Keithley model 132F is used, an additional banana (male) to BNC (female) adapter will be needed).

50.1.2.2 Attach ground clip probe clip to ground pin of UUT input plug.

50.1.2.3 Select appropriate range and/or function of TRMS voltmeter.

50.1.2.4 Plug TRMS voltmeter and UUT into the same duplex AC wall receptacle (Keithley model 132F is battery operated with no plug-in required).

50.1.2.5 Attach cable red wire alligator clip to conduction plate.

50.1.2.6 Attach cable black wire alligator clip to conduction plate.

50.1.2.7 Attach ground clip alligator to conduction plate.

50.2 Measuring process.

50.2.1 Measure test system RMS level.

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APPENDIX A

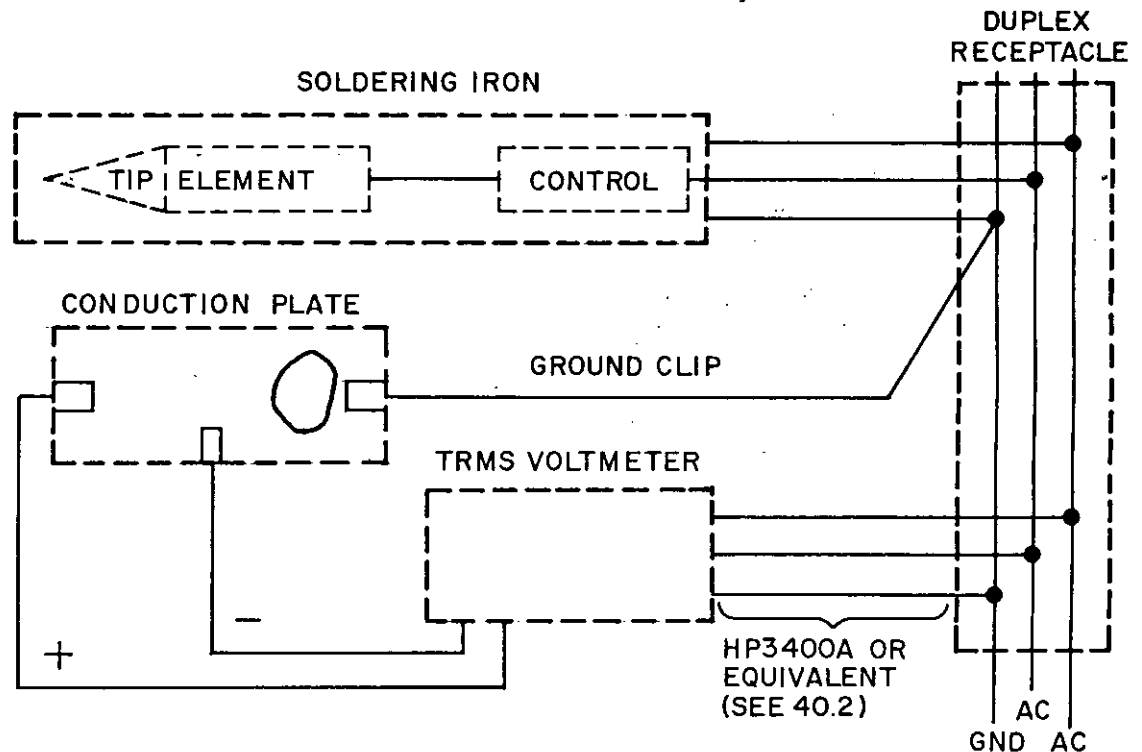


FIGURE A-2. Measurement of test system RMS level.

50.2.1.1 Turn on power to TRMS voltmeter and UUT. For temperature adjustable UUTs, set temperature control to maximum temperature. Allow 15 minutes warmup.

50.2.1.2 Record TRMS voltmeter value V_1 . This is the test system RMS level.

50.3 Measure UUT RMS level (see figure A-3).

50.3.1 Remove cable black wire alligator clip and ground clip alligator clip from conduction plate.

50.3.2 Attach cable black wire alligator clip to ground clip alligator clip.

50.3.3 Remove soldering element from holder and firmly press soldering tip against solder pool on conduction plate. Allow approximately 30 seconds for stabilization.

50.3.4 Record TRMS voltmeter value V_2 .

50.3.5 Calculate and record UUT RMS level C_1 such that $C_1 = V_2 - V_1$.

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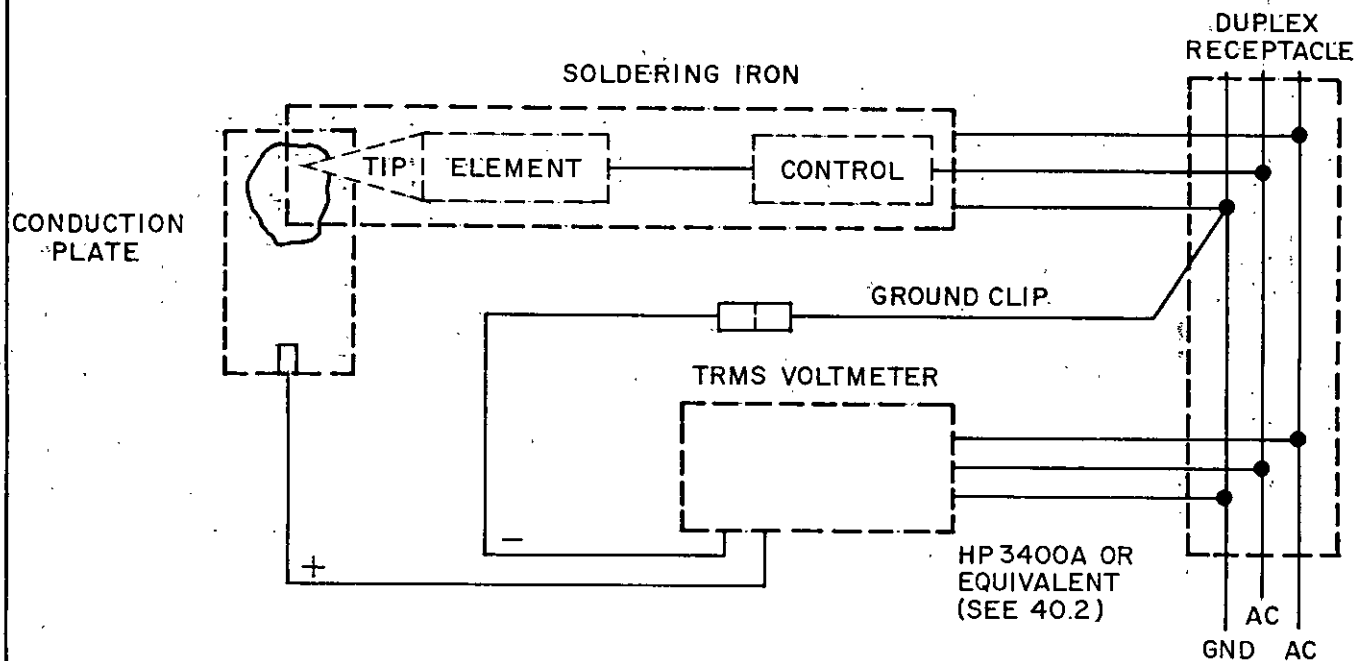


FIGURE A-3. Measurement of UUT RMS level.

50.4 Measurement report. A measurement report for each UUT shall be written and shall contain, as a minimum, the following information:

- a. Description of UUT (Make, Model, Identification Number).
- b. Test system RMS level V1.
- c. RMS level V2.
- d. UUT RMS level C1.

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APPENDIX B

STODDARD PETROLEUM DISTILLATE SOLVENT (See 4.16.4 and 4.16.4.6)

10. SCOPE. This appendix specifies the requirements for a petroleum distillate, referred to commonly as "Stoddard solvent" which shall be capable (see 30.1) of meeting the requirements herein and those of ASTM D 235, Type I. The requirements of this appendix correspond to the requirements of NAVAIRSYSCOM Drawing 200AS311.

10.1 Classification. The material shall be classified in accordance with ASTM D 235, Type I.

20. REFERENCED DOCUMENTS.

20.1 Government documents. The following document forms a part of this appendix to the extent specified herein.

SPECIFICATIONS

FEDERAL

TT-T-266 Thinner: Dope and Lacquer (Cellulose-Nitrate)

(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 Government Contracting Officer.)

20.2 Other publications. The following documents form a part of this appendix to the extent specified herein.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 235 Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)

ASTM E 168 Recommended Practices for General Techniques of Infrared Quantitative Analysis

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

30. DEFINITIONS.

30.1 Capable of. "Capable of" shall mean that the requirements shall be met; however, the supplier is not required to inspect to the requirements of the drawing. The purchaser, however, may inspect and if the material does not meet a specified requirement, it shall be cause for rejection.

30.2 Petroleum distillate. Petroleum distillate shall mean a hydrocarbon distilled from petroleum and not contaminated with oxygenated, halogenated or other functional solvents not found naturally in petroleum.

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APPENDIX B

40. GENERAL REQUIREMENTS.

40.1 Tabulated requirements. See table B-I.

TABLE B-I. Tabulated requirements.

Constituent	Percent; Max. by Vol.
1. Compounds with olefinic or cyclo-olefinic unsaturation	5
2. Aromatic compounds with 8 or more carbon atoms except ethylbenzene	8
3. Total of aromatics and olefins	20
4. Oxygenated solvents	Negative test

50. TEST REQUIREMENTS.

50.1 FED Spec TT-T-266, para 4.3.12 for compliance with tabulated requirements (see table B-I).

50.2 Solvent must meet all requirements of ASTM D 235.

50.3 Infrared analysis (see ASTM E 168) for compliance with 30.2.

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