AEROSPACE STANDARD

AS4461™	REV. D

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Revised 2021-07

Superseding AS4461C

Assembly and Soldering Criteria for High Quality/High Reliability Soldering Wire and Cable Termination in Aerospace Vehicles

RATIONALE

Fusible alloy thermal indicator acceptable and unacceptable limit photographs are added.

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1. SCOPE

1.1 Applicability

This standard is applicable to manual soldering and machine soldering processes utilizing controlled soldering devices, for electrical connections for wiring and cabling used in aerospace vehicles. Description of a component or device herein is not to be construed as authorizing the use of the component or device.

1.1.1 Safety Considerations

This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of users of this standard to comply with appropriate safety and health practices and regulatory limitations.

1.1.2 Strain Relief

The use of solder devices for wire or cable terminations in aircraft requires strain relief in all applications or designs with no strain on the solder terminations. Soldered wire or cable terminations may separate under physical load. The separation time is function of the ambient and electrical temperatures.

1.1.3 Solder Joint Protection

Sealing protection for solder terminations is recommended when a potential electrical overload could cause the solder to melt and short adjacent terminations.

2. REFERENCES

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR5444 Investigation of Whisker Formation on Tin Plated Conductors

ARP1931 Glossary of Terms with Specific Reference to Electrical Wire and Cable

AS5768 Tool, Stripper, Electrical Insulation, General Specification for

AS81824 Splice, Electric, Crimp, Copper, Environment Resistant,

AS83519 Shield Termination, Solder Style, Insulated, Heat-Shrinkable, Environment Resistant, General Specification for

2.2 IPC - Association Connecting Electronics Industries Publications

Available from IPC, 3000 Lakeside Drive, 309 S, Bannockburn, IL 60015, Tel: 847-615-7100, www.ipc.org.

J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies

J-STD-004 Requirements for Soldering Fluxes

J-STD-005 Soldering Pastes Requirements for

J-STD-006 Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications

2.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Drycleaning Solvents)

ASTM D471 Standard Test Method for Rubber Property-Effect of Liquids

ASTM D1007 Specification for Sec-Butyl Alcohol

ASTM D1193 Standard Specification for Reagent Water

ASTM D3622 Specification for n-Propyl Alcohol (1-Propanol)

2.4 U.S. Government Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

2.4.1 Specifications

2.4.1.1 Federal

O-M-232 Methanol (Methyl Alcohol)

2.4.2 Standards

2.4.2.1 Military

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts

MIL-STD-1686 Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

2.4.3 Handbooks

2.4.3.1 Military

MIL-HDBK-263 Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)

2.4.4 Federal Regulations

Copies of these documents are available online at https://govinfo.gov.

27 CFR 20.112 Alcohol, Denatured

27 CFR 20.113 Alcohol, Denatured

27 CFR 21.35 Alcohol, Denatured

3. DEFINITIONS

3.1 Terms and Definitions

The definitions applicable to this standard shall be in accordance with ARP1931.

PROCURING ACTIVITY: A user activity (Government Procuring Agency [e.g., DLA] or Air Framer [e.g., Boeing, Lockheed], etc.) which procures the soldered assembly.

SUPPLIER: A manufacturer soldering the component.

TERMINAL: A solder joint holding two or more electrical components together (i.e., solder cups, hooks, etc.).

4. GENERAL REQUIREMENTS

4.1 Conflict

In the event of conflict between the requirements of this standard and the applicable procuring activity approved assembly drawing(s), the requirements of the assembly drawing(s) shall govern.

4.1.1 Line Drawings

Line drawings, illustrations, and photographs depicted herein are provided as aids for determining compliance with the written requirements and shall not take precedence over the written requirements.

4.2 Acceptance Criteria

Acceptance requirements and illustrations for use as comparison criteria for soldering shall be as specified herein. The written requirements shall take precedence over the illustrations.

4.3 Visual Inspection

One hundred percent inspection of all soldered connections and assemblies shall be performed using the magnification aids of 4.6.1.3. The soldered connections and assemblies shall conform to the requirements specified herein. Sampling may be used in lieu of 100% inspection when performed as part of a statistical process control system approved by the procuring activity.

4.4 Electrostatic Discharge

Where applicable, electrostatic discharge control criteria for the protection of electrical and electronic parts, components, assemblies, and equipment shall be in accordance with MIL-STD-1686 and MIL-HDBK-263.

4.5 Solderability

All surfaces to be soldered shall be tested no more than 120 days prior to soldering for conformance to the requirements of MIL-STD-202, Test Method 208, except that 1 hour steam aging with insulation removed shall be required for wires and cables not having silver plated conductors or shields. Items not meeting these requirements shall be tinned prior to termination. Tin plated conductor and to some extent nickel plated conductor surfaces oxidize over time with non-conductive coatings. An active flux is typically required for these plated surfaces, but its use may be restricted by the governing activity (see 4.7.2).

4.6 Facilities and Equipment

4.6.1 The Soldering Facility

4.6.1.1 Environmental Conditions

Assemblies containing electrostatic discharge (ESD) sensitive devices shall be processed in accordance with MIL-STD-1686.

4.6.1.2 Cleanliness

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

4.6.1.3 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 requirements:

a. Shall be suitable to permit inspection of each solder connection in its entirety.

b. The optical system shall have a magnification power not less than 2X nor more than 4X, and shall be capable of rendering appropriate contrast, proportional dimensions, and adequate resolution.

c. Light source for no shadow illumination of the area being viewed.

4.6.2 Conductor Preparation Tools

4.6.2.1 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 (see Figure 1). Temperature controls shall be sufficient to prevent damage to the wire or unstrapped insulation.

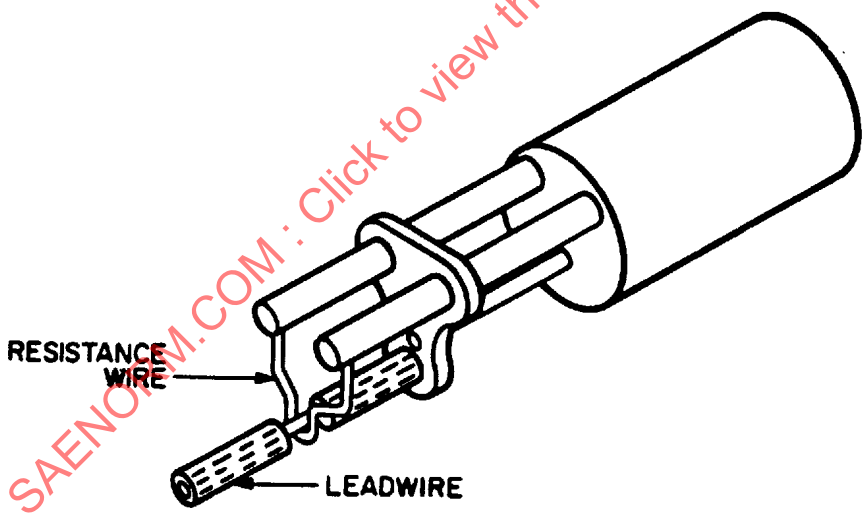


Figure 1 - Typical thermal stripper (see 4.6.2.1)

4.6.2.2 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 in accordance with AS5768 (see Figure 2). 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 un-stripped insulation.

4.6.2.3 Wire and Lead Cutting Tools

Cutters shall be of a shear type, designed to cut squarely without leaving burrs, excessive ridges, or sharp points.

4.6.2.4 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.

4.6.3 Soldering Equipment

Soldering equipment shall not produce levels of electromagnetic, electrostatic, electromechanical, electrical, or other forms of energy which will be detrimental to the item(s) being soldered. Protective devices to prevent potential differences greater than 2 mV rms measured between 50 to 500 Hz shall be used when voltage sensitive devices are being soldered. Transformer type soldering guns shall not be used.

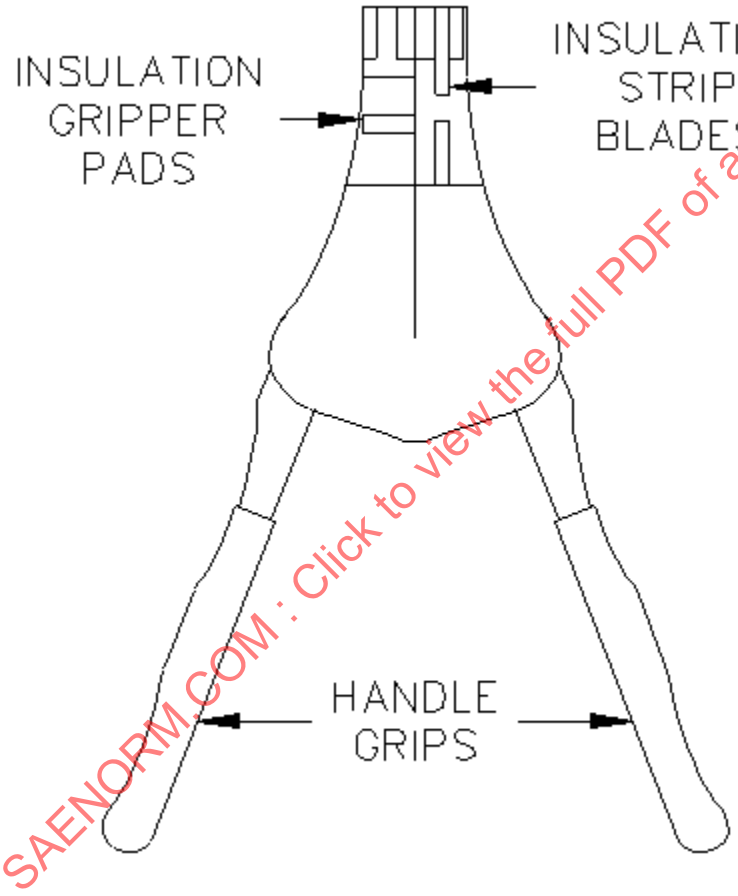


Figure 2 - AS5768 mechanical hand wire stripper (see 4.6.2.2)

4.6.3.1 Soldering Irons

Soldering irons shall be of the temperature controlled type, controllable within ±10 °F (±5.5 °C) of the preselected idling temperature unless it can be demonstrated to the procuring activity that uncontrolled soldering 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, and shall have a thermal capacity adequate to make a solder connection in not more than 5 seconds.

4.6.3.2 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.

4.6.3.3 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 applying excessive mechanical stress or heat sinking.

4.6.3.4 Solder Pots

Solder pots shall be capable of maintaining the solder temperature within ±10 °F (±5.5 °C) of the preselected temperature specified in 4.9.2. Solder pots shall be grounded.

4.6.3.5 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.

4.6.3.6 Anti-Wicking Tools

Anti-wicking tools shall be of a design which fits only a specific conductor gage size and shall be marked with that conductor gage size.

4.6.3.7 Wiping Pads

Sponge pads for wipe cleaning the soldering iron tip shall be moistened and finely textured.

4.6.3.8 Heating Tools for Controlled Soldering Devices

Hot air heating tools used for installing controlled soldering devices, and for installing heat-shrinkable insulating products over soldered terminations, shall produce a stream of heated air of sufficient volume and temperature for the heat-shrinkable product and application. Suitable air reflectors shall be used to concentrate and control the heated air around products being installed and to prevent damage to adjacent components or insulation. Controlled infrared or other type heating tools may be used where suitable for the heat-shrinkable product and application.

4.7 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 be incompatible in some combinations. It shall be the responsibility of the supplier to select those materials and processes that will produce acceptable products.

4.7.1 Solder

Solder composition Sn60, Sn62, or Sn63, solder form optional, conforming to J-STD-004, -005, and -006 as applicable shall be used. Sb5, Sn5, Sn10, or Sn96 solder may be used for high-temperature soldering when specified on the assembly drawing. Flux of cored solder shall be type R or RMA. (Solder alloys not listed in J-STD-004, -005, or -006 may be used when specified on the procuring activity assembly drawings.)

4.7.2 Flux

Rosin based fluxes conforming to types ROL0 or ROL1 of J-STD-004 shall be used for making soldered connections, except that Type M and Type H flux may be used in controlled soldering devices that are used for soldering nickel or nickel/chromium plated wiring, but may not to be used for tinning stranded wires. Other types of flux conforming to J-STD-004 may be used for tinning insulated, solid conductor wire and the solid leads of sealed, discrete components (see 4.5), provided that:

a. The pre-tinning is accomplished in a controlled work area separated from the cable and harness soldering area.

b. The flux used is restricted to the pre-tinning area, and is not allowed in the cable and harness soldering work area.

c. Flux and flux residues are completely removed within 1 hour after pre-tinning.

d. Data showing process compatibility, such as that described by J-STD-001 Appendix C, will be available for review.

4.7.3 Cleaning Solvents

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. Use of the solvents and cleaners listed in Table 1 is acceptable where appropriate. This list is not intended to exclude other appropriate cleaners and solvents. Other appropriate solvents or cleaners not listed in Table 1 must have procuring activity approval.

Table 1 - Acceptable solvents and cleaners

Description[1, 2]	Specification
Ethyl alcohol	27 CFR 21.35, 27 CFR 20.113 (Type IV), or 27 CFR 20.112 (Type V)
Isopropyl alcohol	ASTM D471
Methyl alcohol[3]	O-M-232, Grade A
N-Propyl alcohol	ASTM D3622
Butyl alcohol, secondary[3]	ASTM D1007
Stoddard solvent[4]	ASTM D235
Reagent water (Type II)	ASTM D1193
Additional solvents or cleaners	As approved by the procuring activity

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

1 Blends and 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.

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

3 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.

4 Stoddard solvent 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.

4.7.4 Tin Whisker Growth

Pure tin and high-tin content alloys may be subject to tin whisker growth. Pure tin coatings are not advocated for use on electronic equipment where components are closely spaced. When specified, electrodeposited tin coatings should be alloyed to mitigate whisker growth (for more on tin whiskers, refer to AIR5444).

4.8 Preparation for Soldering

4.8.1 Insulation Removal

Insulation shall be removed from wire conductors by one of the following methods, using the tools specified in 4.6.2. After insulation removal, the insulation deformation shall not exceed 20% of the insulation thickness. The insulation shall not have gouges, ragged edges, nor be loose or frayed (see Figure 3). At no time during the soldering process shall insulation that is degraded from the use of solvents be acceptable. Conductors shall not have more nicked or broken strands than specified in Table 2. Nicks shall not expose the basis metal of coated conductors. There shall be no birdcaging of the wire strands. For termination to solder barrels, the length of the stripped portion of the conductor shall be at least long enough to reach the bottom of the solder barrel. The maximum length shall be such that the exposed length of conductor between the end of the wire insulation and the end of the barrel does not exceed the following dimensions:

a. For wire size 12 and smaller: 1/32 inch

b. For wires sizes 6 through 10: 1/16 inch

c. For wires larger than size 6: 1/8 inch

NOTE: It is recommended that insulation slugs not be removed until immediately prior to soldering.

4.8.1.1 Thermal

When insulation is removed using a thermal stripping tool, the lay of the wire strands shall be restored, if disturbed, without using bare finger contact. Insulation discoloration resulting from thermal stripping is permissible. Severe discoloration of the conductor that shows evidence of overheating shall be cause for rejection.

4.8.1.2 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.

4.8.1.3 Chemical

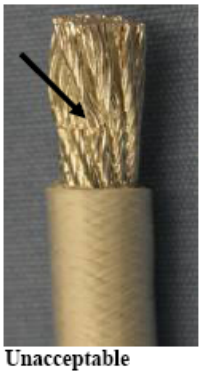
Chemical solutions, pastes, and creams shall not be used to strip wire insulation.

Acceptable
Wire insulation removed without disturbing the normal lay of the wire, as shown. Wire strands are free of nicks or cuts.

Unacceptable
Strands, retwisted and overlapping each other, as shown, will result in increased stress and difficulty in forming a

Unacceptable
Wire strands that are retwisted in excess of their normal lay exert increased stress and may break.

Acceptable
Normal lay of strands, disturbed during stripping operation, may be re-twisted to the original wire lay, if strands have not been damaged.

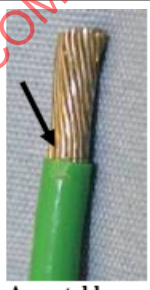


Unacceptable
Wire strands show evidence of a ringed condition (arrow) caused by stripper blades. Outer strands are weakened and may break.

Unacceptable
Several wire strands are cut (arrow). This condition may be the result of placing the wire in the wrong hole size of the mechanical stripper.

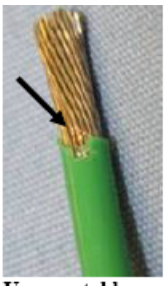
Unacceptable
Wire strands are bird-caged, due to misalignment of wire and stripping blades.

Acceptable
Wire stripped with mechanical strippers, which shows no evidence of damage to either the insulation or the wire strands.



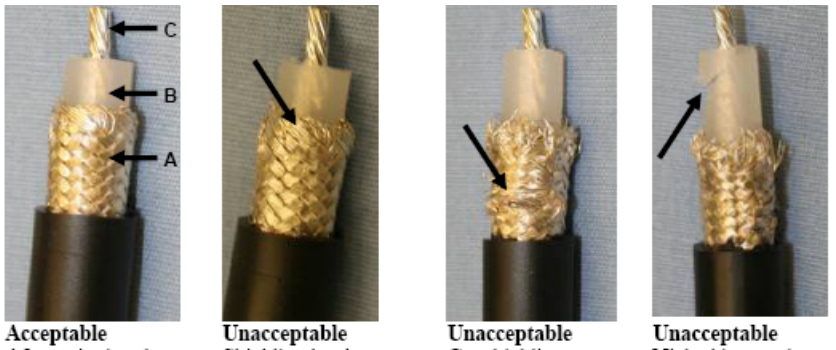
Acceptable
Although wire insulation appears to be cut or split, close examination shows that only the outer coating is damaged and does not exceed 1/32 inch or 50% of insulation's thickness (whichever is greater).

Unacceptable
The insulation has been pinched by the mechanical strippers. This condition was caused by using too small hole/setting of the mechanical stripper.



Unacceptable
Wire strands are nicked, due to misalignment of wire and stripping blades. Nicked strands reveal base metal and may break.

Figure 3 - Insulation stripping examples



Acceptable	Unacceptable	Unacceptable	Unacceptable
After stripping there should be no nicks or cuts on the shielding (A) or inner wire insulation (B) or the conductor (C).	Shielding has been cut unevenly, indicating poor trimming technique. Shielding strands have spread apart, making installation of solder sleeve difficult. Strands may puncture solder sleeve during shrinking.	Cut shielding strands, as shown, are caused during outer insulation removal.	Nicked inner wire insulation occurs during shielding removal.

Figure 3 - Insulation stripping examples (continued)

Table 2 - Maximum allowable nicked and broken strands (see 4.8.1)

Conductor Material	Number of Strands Per Conductor	Total Allowable Nicked and Broken Strands (see 5.1.5.3)
Copper or Copper Alloy	1 and 7	None nicked, broken, or severed
	19	2 nicked, none broken or severed
	37	4 nicked, none broken or severed
	more than 37	6 nicked or broken

4.8.2 Preparation of Gold Plated Areas

When gold plated areas to be soldered have gold thickness less than 0.000050 inch (0.00127 mm), gold removal or pretinning is not required.

Areas with gold plating thickness of 0.000050 to 0.000100 inch (0.00127 to 0.00254 mm) shall be single dip tinned.

Areas with gold plating thickness over 0.000100 inch (0.00254 mm) shall be prepared for soldering by either of the following methods:

NOTE: Only the area to be soldered need be tinned or have the gold removed.

Method 1 - Static Bath(s): Immerse the fluxed, gold plated item in solder bath number one for 2 to 5 seconds. Only the portion of the item to be soldered shall be immersed. Gold contamination level in solder bath number one shall be less than 4%. Immerse the fluxed tinned item in solder bath number two for 2 to 5 seconds. Contaminants in bath number two shall not exceed the limits specified in Table 3. A single static bath may be used in lieu of two baths if the contaminants are controlled to the limits specified in Table 3.

Method 2 - Dynamic Bath: Immerse the fluxed gold plated item in a flowing solder bath for 2 to 5 seconds. Only the portion of the item subsequently to be soldered shall be immersed. Contaminants in the solder bath shall not exceed the limits specified in Table 3.

Upon conclusion of the gold removal process, the solder coated portion shall conform to the acceptance criteria of MIL-STD-202, Method 208.

Table 3 - Solder bath maximum contaminant levels

Contaminant	Maximum Allowable Percent of Contaminant[1]	Testing Frequency (Number of 8-Hour Operating Days Between Tests)[3] (see 4.9.2.1.2) A	Testing Frequency (Number of 8-Hour Operating Days Between Tests)[3] (see 4.9.2.1.2) B	Testing Frequency (Number of 8-Hour Operating Days Between Tests)[3] (see 4.9.2.1.2) C
Copper	0.75	15	30	30
Gold	0.50	15	30	30
Cadmium	0.01	15	30	60
Zinc	0.008	15	30	60
Aluminum	0.008	15	30	60
Antimony	0.50	15	60	120
Iron	0.02	15	60	120
Arsenic	0.03	15	60	120
Bismuth	0.25	15	60	120
Silver[2]	0.75	15	60	120
Nickel	0.025	15	60	120

[1] The tin content of the solder shall be from 59.5 to 63.5% tin and tested at the same frequency as testing for copper or gold contamination. The balance of the solder shall be lead with one or more of the listed contaminants.
[2] Not applicable for Sn62 solder. Limits to be 1.75 to 2.25.
[3] An operating day constitutes any 8-hour period, or any portion thereof, during which the solder is liquefied and used.

4.8.3 Preparation of Solder Cups

Solder cups shall be prefilled as follows. For solder cups that are not gold plated or that are gold plated up to 0.0001 inch (0.00254 mm), only steps 1 and 6 are applicable (see 4.9.5.1).

Step 1: Clean solder cups using a solvent specified in 4.7.3.

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

Step 3: Heat solder cup sufficiently to melt solder and allow all gases and flux to escape (cups should be 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 5.1.6.2).

Step 7: Repeat Steps 3 through 6 one time.

4.8.4 Tinning of Stranded Wire

The solder shall penetrate to the inner strands of the wire along the entire length of the area tinned. Tinning of stranded wire shall not obscure the wire contour. Wicking of solder under the insulation of stranded wire that is in accordance with 5.1.5.5 is acceptable.

4.8.5 Preparation of Shielded Wire

4.8.5.1 Coaxial Connectors

Coaxial connectors shall be assembled in accordance with detailed work instructions prepared to reflect procedures recommended by the connector manufacturer except that, if solder or fluxes other than those specified in 4.7.1 and 4.7.2 are recommended for connector assembly, such solders or fluxes shall be documented on an approved assembly drawing.

4.8.5.2 Semi Rigid Coaxial Cable (Hardline)

Semi rigid coaxial cable shall be assembled in accordance with detailed work instructions that have been prepared to reflect the requirements documented on an approved assembly drawing.

4.8.5.3 Braided Shield Terminations

Controlled soldering devices for shield termination shall be installed in accordance with AS83519. Shield terminators shall be assembled in accordance with this document (see 5.2.3) or in accordance with detailed work instructions prepared to reflect the requirements and documented on an approved assembly drawing.

4.8.6 Precleaning

Items to be soldered shall be free of contamination.

4.8.7 Handling and Storage of Parts

Surfaces of wires and terminals or other components to be soldered 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. This requirement does not apply to operators when parts are being soldered.

4.8.8 Component Workmanship

Immediately before wires are joined to their mating parts, both surfaces to be joined shall be examined for conformance to the requirements of 4.8 through 4.8.6. There shall be no evidence of scratches that expose basis metal, delamination of plating material, or contamination of the surfaces to be soldered.

4.8.8.1 Delamination of Coatings

There shall be no evidence of delamination, lifting, or cracking of plated materials adjacent to the tinned area.

4.8.8.2 Surface Contamination

When tinned areas show evidence of surface contamination, the contamination shall be removed in accordance with 4.7.3. After cleaning, the surface shall meet the requirements of 4.8.8 or shall be reworked per 4.11.

4.9 Manual Soldering

Manual soldering shall be accomplished using the facilities, tools, and materials specified in 4.6 and 4.7. 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.

4.9.1 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 4.6.3.7). A thin, bright, tinned surface shall be maintained on the working surface of the tip to ensure 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.

4.9.2 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, shall be set at a preselected temperature within the range of 500 to 518 °F (260 to 270 °C) for Sn60 or Sn63 solder or at the temperature specified on the approved assembly drawing or work order for other solder types. Solder purity shall be controlled in accordance with 4.9.2.1. Immersion time shall be less than 5 seconds.

4.9.2.1 Maintenance of Solder Purity

To maintain the proper purity of solder, the following procedures shall be followed:

4.9.2.1.1 Dross Removal

Before the start of soldering operations, dross shall be removed from the solder surface using a PTFE or stainless steel tool. Dross shall be removed from the solder surface periodically during operation, to assure that dross does not contact the items being soldered. Automatic or manual methods for removing dross are acceptable.

4.9.2.1.2 Chemical Analysis

Solder in solder pots shall be chemically or spectrographically analyzed for each contaminant or renewed at the testing frequency levels shown on Table 3, column B. These intervals may be lengthened to those 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 3, intervals between analyses or replacement shall be shortened to those 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 maintained.

4.9.3 Flux Application with Soldering Iron Heating

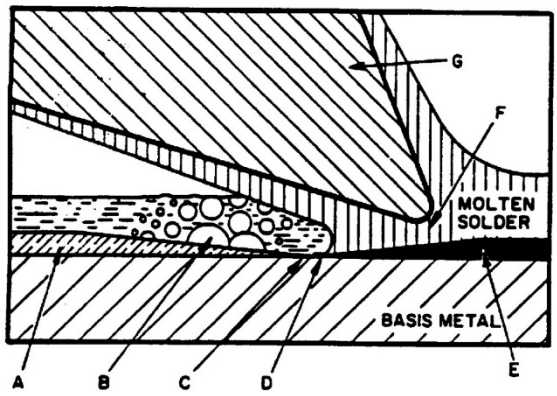
Flux in accordance with 4.7.2 shall be utilized for all soldered electrical connections. Liquid flux, when used, shall be applied in a thin, even coat and shall be limited to those surfaces to be joined prior to application of heat. The use of excess flux shall be avoided. When used, cored solder shall be placed in such a position that allows the flux to flow and cover the connection elements as the solder melts.

4.9.4 Heat Application with Soldering Iron

The elements 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, insulation, or adjacent wires.

4.9.5 Solder Application with Soldering Iron

Except for transfer soldering, the area to be soldered shall first be properly heated and then the solder, in accordance with 4.7.1, shall be applied at the junction of the soldering iron tip and the parts or components being soldered (see Figure 4). 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 between the soldering iron tip and the surface being soldered 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. Wicking of solder under the insulation of stranded wire that is in accordance with 5.1.5.5 is acceptable. As a guide the soldering operation shall be completed in 2 to 5 seconds.



A. Flux solution lying above oxidized metal surface
B. Boiling flux solution removing the film oxide
C. Bare metal in contact with fused flux
D. Liquid solder replacing fused flux
E. Tin reacting with basis metal to form new alloy
F. Solder forming heat bridge
G. Soldering iron tip shown not touching basis metal for clarity

Figure 4 - Solder application and bridging (see 4.9.5)

4.9.5.1 Cup and Hollow Cylindrical Type Terminals

Solder cup terminals shall be cleaned and tinned or prefilled prior to insertion of the wire in accordance with the requirements of 4.8.3, as shown in Figure 6. 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 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 the solder cup is filled, the wire(s) shall be inserted straight into the cup cavity until the wire(s) strike the bottom (Figure 5). Continuous soldering iron control shall be maintained throughout the soldering operation (see Figure 7).

Solder shall follow the contour of the cup and shall fill at least 75% of the mouth of the cup. 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.

Prefilling and soldering of cup and hollow cylindrical terminals shall be in accordance with Figures 5, 6, and 7.

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.

4.9.6 Prior to solidification of the solder, no liquid shall be used to cool a soldered connection. Heat sinks may be used to expedite cooling. Accelerated cooling may be used providing that the cooling process is controlled and no thermal shock damage results.

4.10 Soldering by Use of Controlled Soldering Devices

Controlled soldering devices, as referred to in this document, shall be interpreted as self-sealing, heat shrinkable soldering devices (such as AS83519) that encapsulate the soldered connections. Such devices shall be exempt from the cleaning requirements of this document.

4.10.1 Preparation and Assembly

Wire preparation and assembly shall be as specified in the applicable manufacturer's instructions or approved assembly drawing. In shielded connector contacts, cable shields and the cable conductors shall be visible through the inspection holes.

4.10.2 Heat Application

Heat shall be applied using the heating tool, including reflector, specified for the controlled soldering device. Heating shall be continued until the solder melts, flows, and forms a fillet of solder between the surfaces to be joined. Heating tools shall be operated in accordance with the manufacturer's operating instructions, and the applicable detailed termination procedures shall be followed for each type of controlled soldering device.

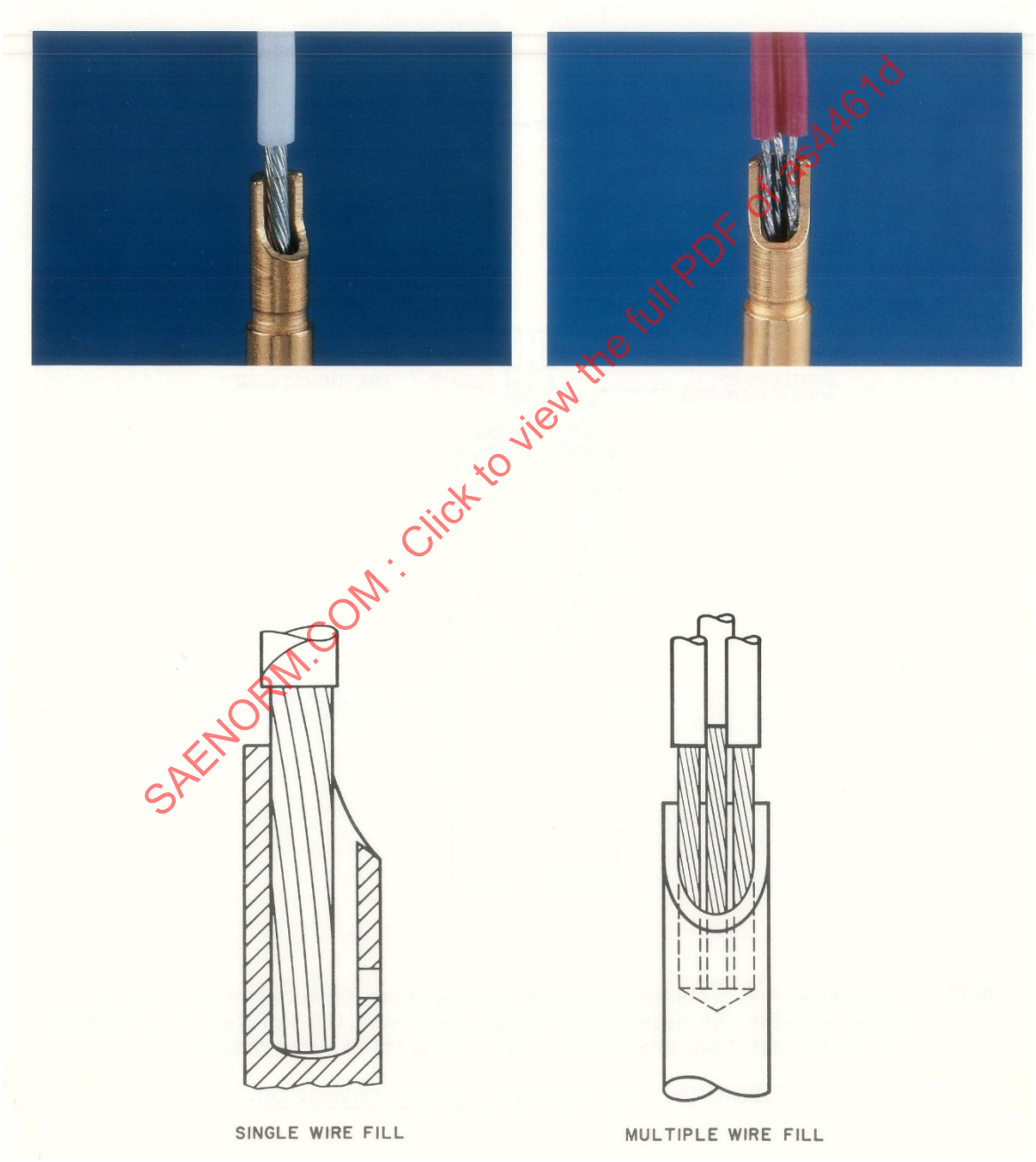


Figure 5 - Cup type terminals (see 4.9.5.1)

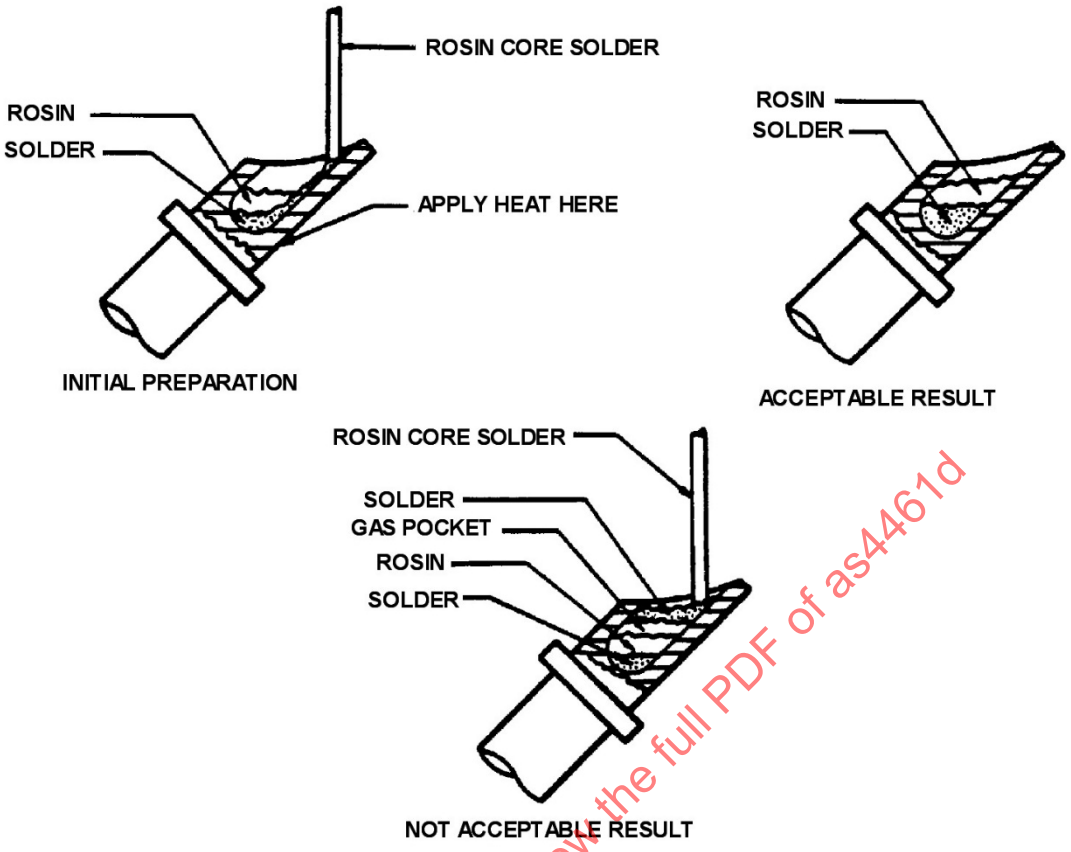


Figure 6 - Prefilling hollow cylindrical terminals (see 4.9.5.1)

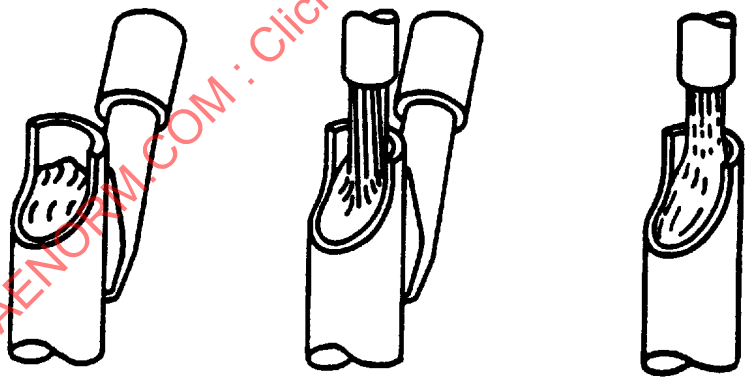


Figure 7 - Soldering of hollow cylindrical connections (see 4.9.5.1)

4.11 Post Soldering Operations

4.11.1 Rework of Unsatisfactory Solder Connections

Nonconforming solder connections shall be recorded on appropriate document prior to rework. This information shall be used to provide corrective action to reduce future rework.

4.11.1.1 Reheat Method of Rework

The reheating and addition of flux and solder. If required may be used to correct the following defects:

a. Rosin solder connections

b. Cold solder connections

c. Fractured (disturbed) solder connections

d. Solder physical appearance

e. Unsoldered connections

f. Insufficient solder

g. Pin holes

h. Insufficient wetting

4.11.1.2 Resolder Method of Rework

Defective solder connections which cannot be corrected in accordance with 4.11.1.1 shall be reworked by removing the solder with a vacuum device or by wicking. After the solder has been removed, the connection shall be cooled to room temperature before reapplying heat. Solder joints reworked to correct deficiencies must meet the requirements of this standard.

CAUTION: Extreme care shall be exercised to prevent damage.

4.11.1.3 Rework of Controlled Soldering Devices

Under heated controlled soldering devices can be reheated, using the same procedure as for initial heating, but continuing the process until correct heating is obtained. Overheated, damaged, or improperly assembled controlled soldering devices must be removed and a new controlled soldering device used to re-terminate the wire(s). After removal of a controlled soldering device, excess solder must be removed from conductors, and the conductors and insulations must be inspected for proper preparation and evidence of damage.

4.11.2 Cleaning

A solvent or combination of solvents (see 4.7.3) shall be used to remove all residual flux and other contaminants as soon as practicable, but no later than 1 hour after solidification of the solder connection. Cleaning is not required for soldered connections using controlled soldering devices where the solder joint is encapsulated within a heat-shrinkable insulator. Ultrasonic cleaning may be used only where no insulation damage occurs, and marking is not affected.

4.12 Workmanship

Workmanship shall be of a level of quality adequate to assure that the processed products meet the performance requirements of the applicable drawings and criteria delineated herein.

5. DETAIL REQUIREMENTS

5.1 Inspection Criteria for Manually Soldered Connections

All solder connections shall be visually inspected using the magnification aids specified in 4.6.1.3. Each connection shall be inspected to ensure that the entire connection conforms to the requirements of 5.1.1 through 5.1.6.

5.1.1 Finish

The appearance of the solder joint surface shall be smooth, nonporous, non-crystalline, and continuous.

5.1.2 Wetting and Filleting

Solder shall wet the surfaces of all connection elements and shall form a fillet between connection elements over the complete periphery of the connection.

5.1.3 Coverage

Solder shall be of sufficient amount to cover all elements of the connection but shall not be of such quantity that the outline of any included lead or lead wire is not discernible in the solder. Insufficient or excessive solder shall not be acceptable.

5.1.4 Insulation Clearance

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

a. Minimum Clearance: The insulation may butt against the solder. It shall not, however, be embedded in or surrounded by the solder. The insulation shall not be melted, charred, seared, or diminished in diameter beyond the limits of 4.8.1.

b. Maximum Clearance: The maximum clearance shall be two wire diameters (including insulation) or 0.062 inch (1.6 mm), whichever is larger, but shall not be such that it permits shorting between adjacent conductors.

c. High Voltage Clearance: The insulation clearance for high voltage wires (greater than 6 kV) shall be 0.125 inch ± 0.062 inch (3.2 mm ± 1.6 mm) unless otherwise specified in the assembly drawing.

5.1.5 Physical Attributes

The solder connection shall be free of scratches, sharp edges, solder points, peaks, icicles, pin holes, blow holes, pits, voids, globules, flux residue, and foreign material. Solder shall not bridge between adjacent conductors.

5.1.5.1 Terminals and Connector Contacts

Terminals and connector contacts shall be perpendicular with respect to connector bodies, panels, or chassis members within tolerances as specified on applicable drawings or, if not specified, within ±10 degrees.

5.1.5.2 Wire Insulation

Insulation on wires and wiring shall be free of cuts and shall not be shrunk (see 5.1.4), melted, burned, charred, or abraded. Insulation shall not be pinched, shaved, cold flowed, or otherwise reduced in thickness.

5.1.5.3 Wire Strands

Wires or strands in the completed solder joint shall meet the requirements of 4.8.1 for broken or nicked strands. Broken strands in the completed joint shall follow the same lay as the conductor. A missing strand shall be considered as a broken strand for count purposes. The lay of the strands shall meet the requirements of the stranded wire specification.

5.1.5.4 Birdcaging

Soldered connections with birdcaged strands shall be unacceptable.

5.1.5.5 Wicking

Wicking under the insulation of stranded wire soldered to a terminal area is permissible provided that:

a. The insulation is of a type which can withstand soldering temperatures, and there is no enlargement of the wire.

b. The application does not require that the wicked portion of wire under the insulation be bent.

c. The criteria for the extent of wicking are specified for the particular application on applicable approved drawings.

5.1.6 Criteria for Specific Applications

5.1.6.1 Soldering of Wires and Leads to Hook Terminals

Solder shall wet the terminal and wire or lead and form a visible fillet between all areas of contact between the terminal and wire or lead. The solder shall cover the wire or lead over the extent of the wrap but shall not obscure the contour of the wire or lead (see Figures 8 and 9).

5.1.6.2 Soldering of Wires and Leads to Solder Cups

Solder shall visibly wet between the cup and wire or lead. As a minimum, solder shall almost fill the cup and shall follow the contour of the cup entry. Solder may overfill the cup, but shall not overflow on the sides of the cup. Tinning (thin solder film) of the outside of the cup is permissible (see Figures 10 and 11).

5.1.6.3 Soldering of Wires and Leads to Contacts

Solder shall visibly wet between the cup and wire or lead. Any solder on the outside surface of the solder cup shall be in the form of a thin film only. Solder shall be visible in the inspection hole, may rise slightly above it, but shall not spill onto the side of the contact (see Figure 12).

5.2 Inspection Criteria for Controlled Soldering Devices

Solder connections shall be visually inspected using the magnification aids specified in 4.6.1.3. Each connection shall be inspected to ensure that the entire connection conforms to the requirements of 4.10, 5.1, 5.2.1, and 5.2.2, or with the requirements of the approved assembly instructions. Melt seals, when present, shall not flow into the solder joint.

5.2.1 Finish

The appearance of the solder joint surface shall be smooth, nonporous, non-crystalline, and continuous. The surface of the solder may show the texture of the inside surface of the heat-shrinkable sleeve. Encapsulated flux may be visible on the surface of the solder.

5.2.2 Wetting and Filleting

The solder preform shall have melted and flowed, wetting all elements being soldered and forming a fillet between connected elements. The original contours of the solder preform shall no longer be present.

5.2.3 Criteria for Specific Applications

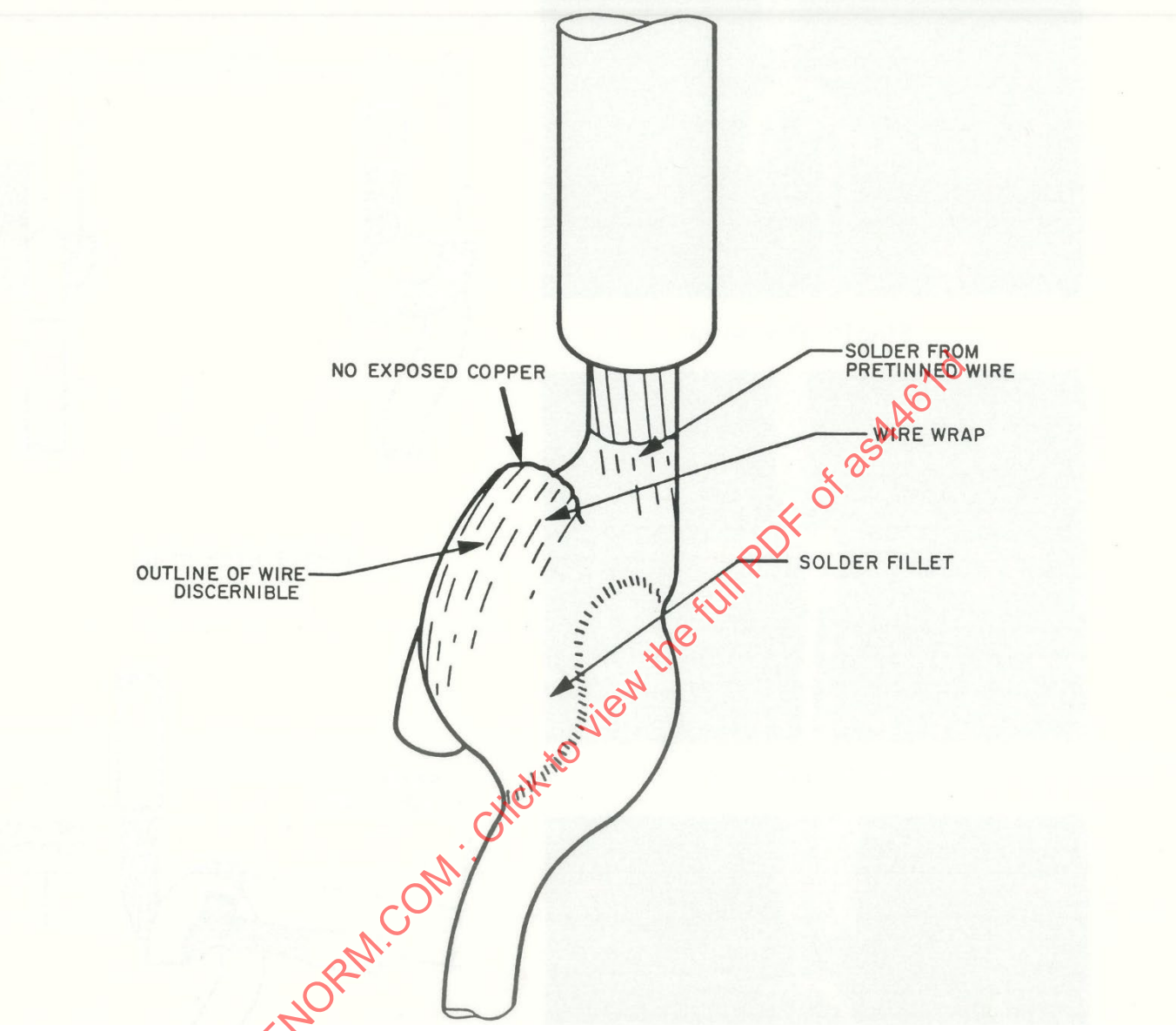
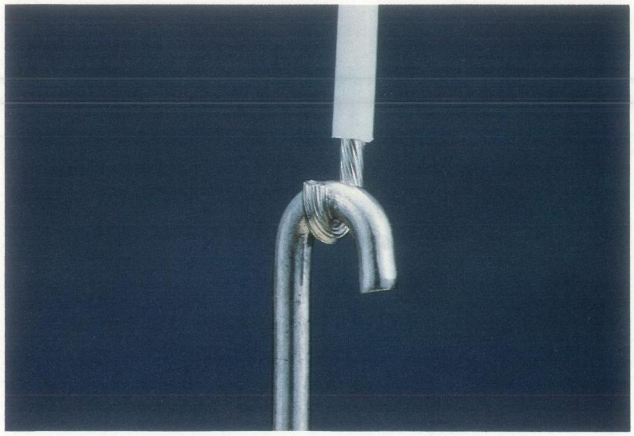
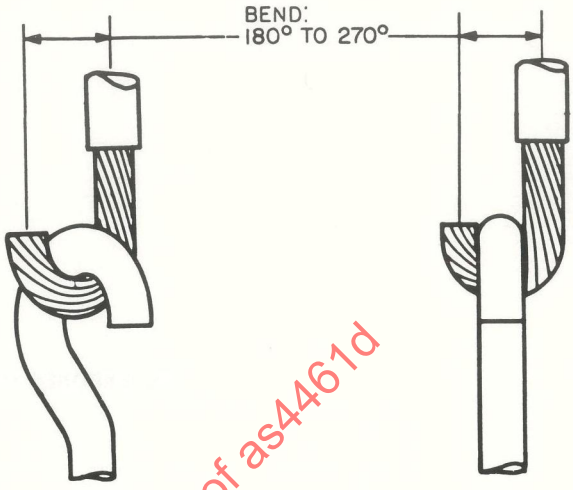


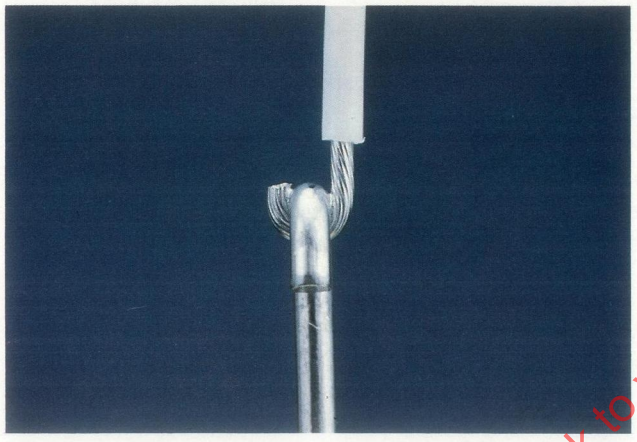
Figure 8 - Hook terminal, solder connection (see 5.1.6.1)



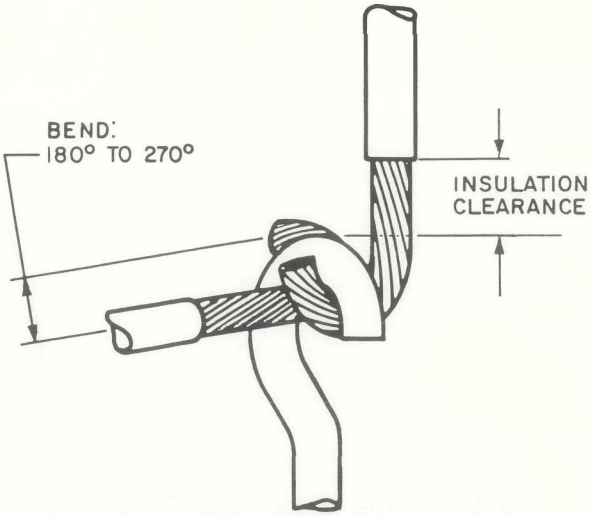
Single wire wrap



Single wire wrap



Single wire wrap

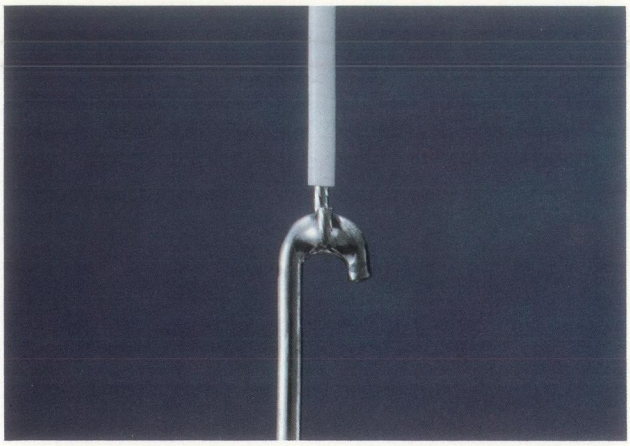


Double wire wrap

Double wire wrap

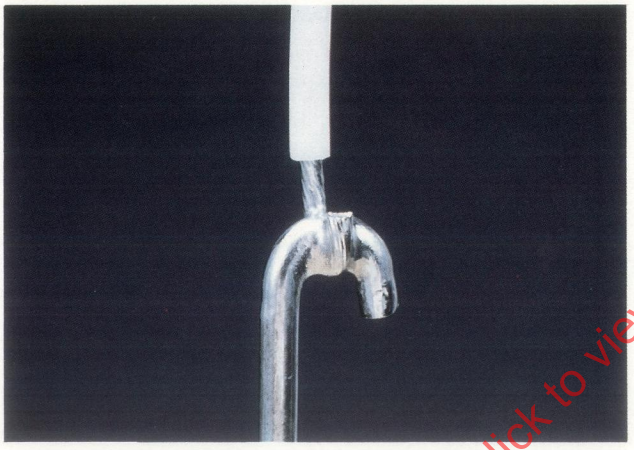
NOTE: Line drawings, illustrations and photographs depicted herein are provided as aids for determining compliance with the written requirements and shall not take precedence over the written requirements.

Figure 9 - Hook terminal, wire connection methods (see 5.1.6.1)



MAXIMUM ACCEPTABLE

Good solder flow and wetting, but outline of wire nearly obscured by solder.



PREFERRED

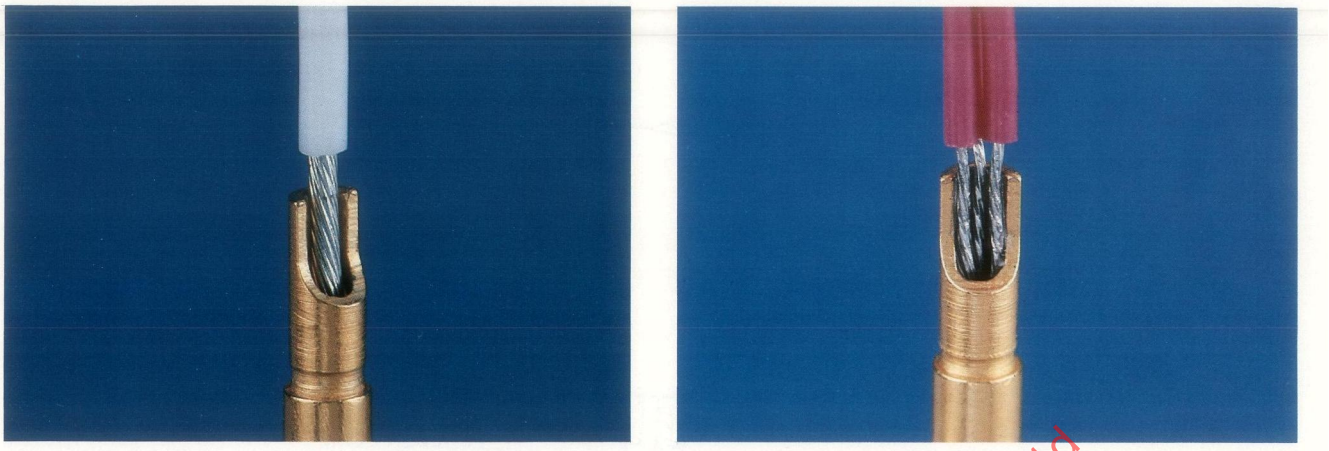
Solder is smooth, bright, continuous and feathered out to a thin edge. No bare lead material is exposed and there are no sharp protrusions or evidence of contamination. Contour of lead or wire is clearly discernible beneath solder.

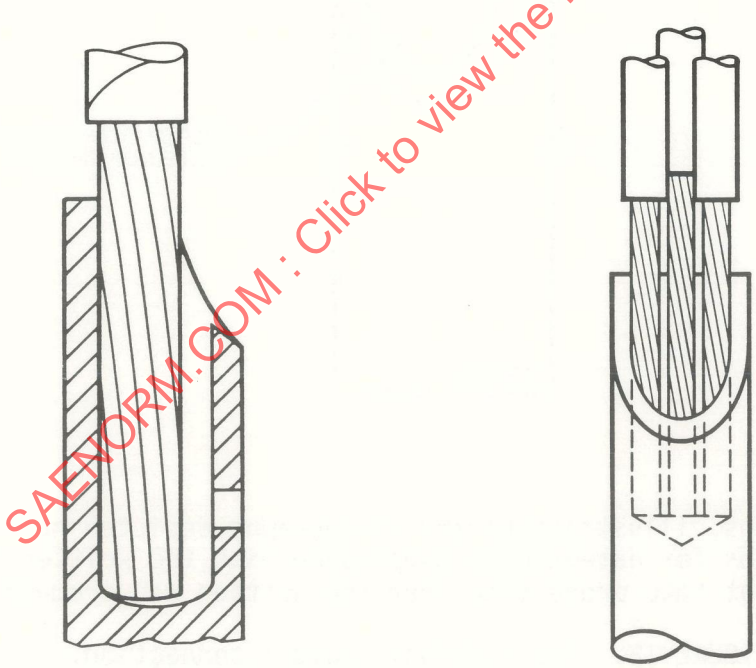
MINIMUM ACCEPTABLE

Good solder flow and wetting, but solder fillet only as wide as wire.

NOTE: Line drawings, illustrations and photographs depicted herein are provided as aids for determining compliance with the written requirements and shall not take precedence over the written requirements.

Figure 9 - Hook terminal, wire connection methods (see 5.1.6.1) (continued)



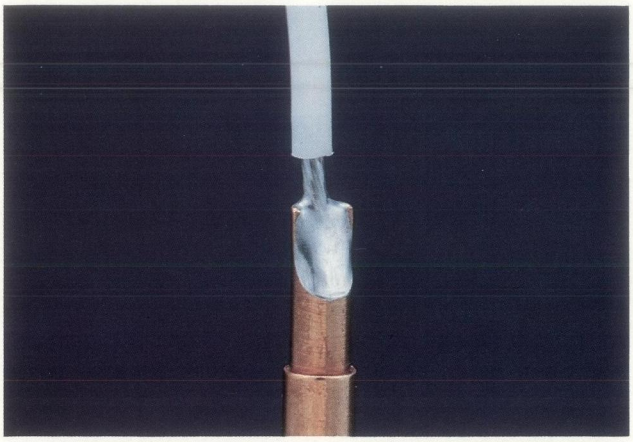


SINGLE WIRE FILL

MULTIPLE WIRE FILL

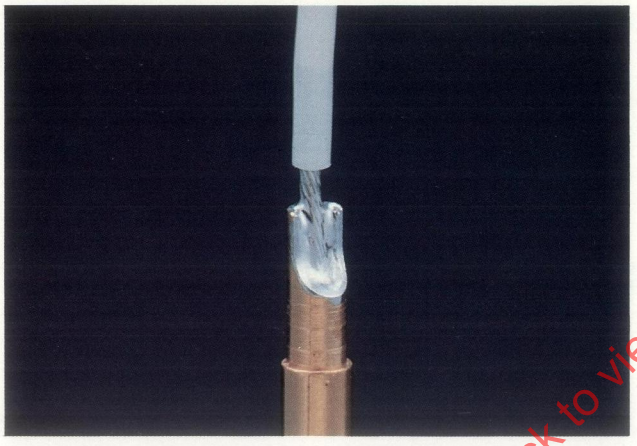
NOTE: Line drawings, illustrations and photographs depicted herein are provided as aids for determining compliance with the written requirements and shall not take precedence over the written requirements.

Figure 10 - Cup terminal, wire insertion (see 5.1.6.2)



MAXIMUM ACCEPTABLE

Good solder flow and wetting. Wire completely obscured by solder, but solder does not extend beyond cup area.



PREFERRED

Solder is smooth, bright, continuous and flows to front lip of terminal. Slight fillet above top of terminal to wire. No sharp protrusions or evidence of contamination. Contour of wire is clearly discernible beneath solder.

MINIMUM ACCEPTABLE

Good solder flow and wetting, but minimal fillet extending to front lip of terminal. Solder within cup is level with lower lip.

NOTE: Line drawings, illustrations and photographs depicted herein are provided as aids for determining compliance with the written requirements and shall not take precedence over the written requirements.

Figure 10 - Cup terminal, wire insertion (see 5.1.6.2) (continued)

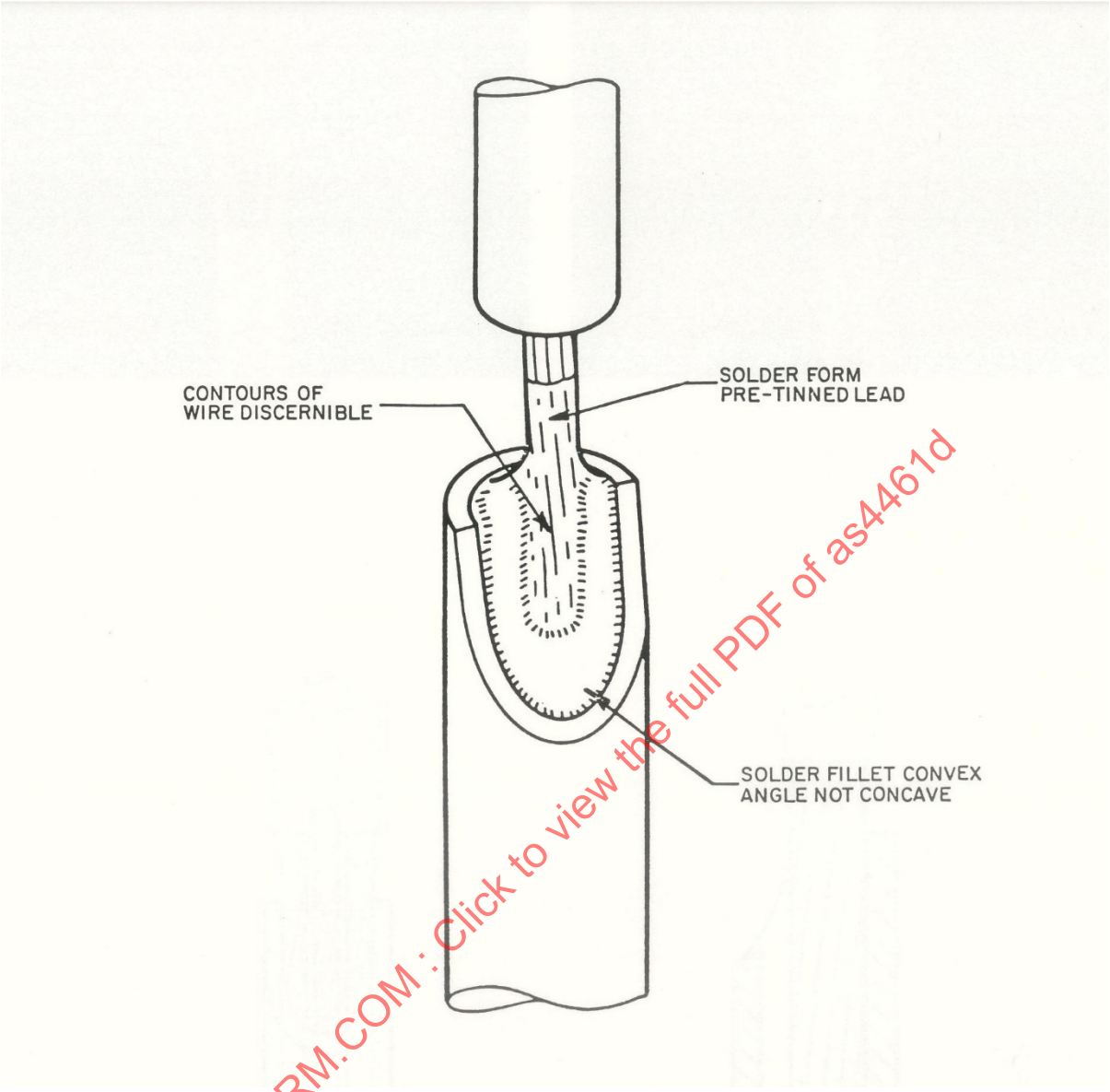


Figure 11 - Cup terminal, solder connection (see 5.1.6.2)

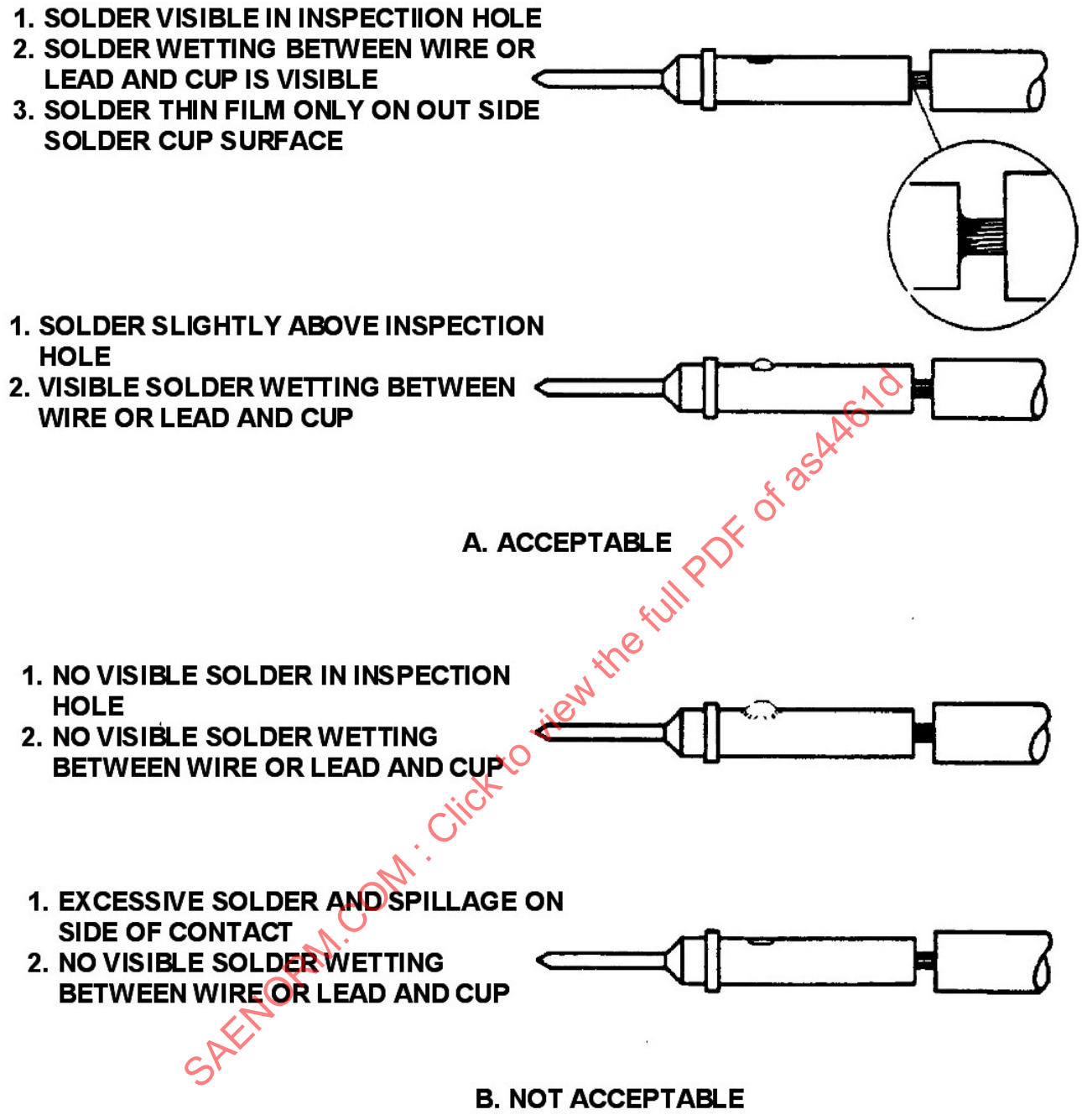


Figure 12 - Wire and lead soldering to contacts (see 5.1.6.3)

5.2.3.1 Shield Terminations (AS83519)

A solder fillet shall be clearly visible along the interface between the shield and the ground lead or terminal. The solder preform shall have melted and the contour of the solder preform shall not be visible. If the solder device contains a thermal indicator to show proper heating, the applicable indication of proper heating shall be observable. Sealing inserts, if present, shall melt and flow along the wires. When more than one wire is terminated to the shield, the additional wires may be tinned prior to termination. The contours of the shield and the ground lead or terminal shall not be obscured by solder. The outer sleeve may be darkened, but the connection area shall be visible. Slight discoloration of the wire insulation outside of the sleeve is acceptable (see Figure 13).

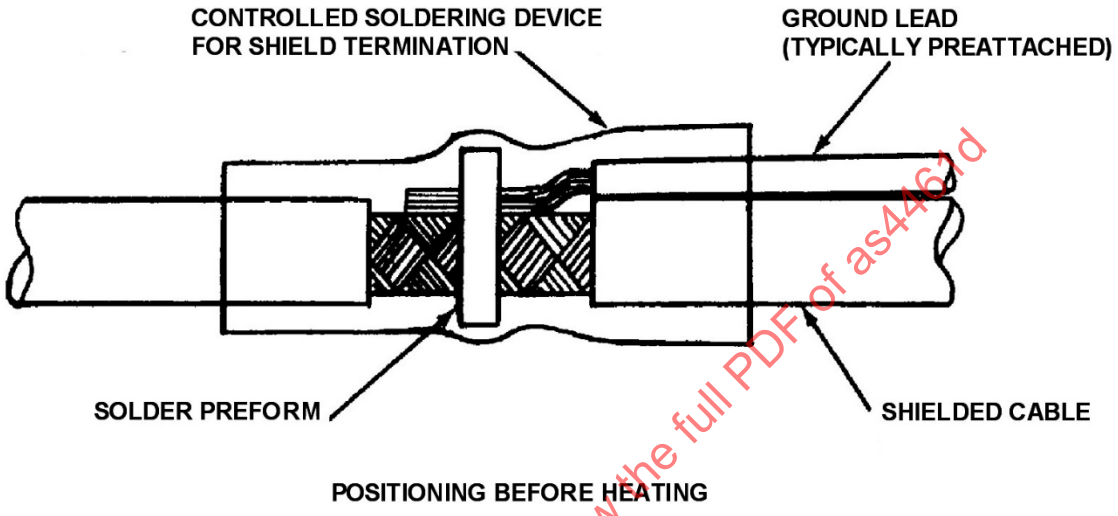


Figure 13 - Controlled soldering device - shield termination (see 4.10 and 5.2.3.2)

Solder Sleeve Examples

Figure 13 - Controlled soldering device - shield termination with thermochromic thermal indicator (see 4.10 and 5.2.3.2) (continued)