JERG-0-039D(E)

General

STANDARD FOR SOLDERING PROCESS FOR SPACE USE

Mar. 29, 2022

Japan Aerospace Exploration Agency

This is an English translation of JERG-0-039D and does not constitute itself.
Whenever this document conflicts with the original document in Japanese, the original document takes precedence.

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1. GENERAL

1.1 Purpose

This standard describes the requirements for high reliability electrical connection soldering applicable to launch vehicles and spacecrafts.

1.2 Scope

(1) This standard describes the requirements for hand and wave soldering to obtain reliable electrical connections.

(2) This standard shall apply to cases prescribed in the contractual specifications. In such a case, this standard shall apply to both the supplier and their subcontractors responsible for performing parts of the contract.

(3) This standard shall not apply to internal solder joints of parts. Soldering for surface mounting, including chip parts reflow soldering, shall be as per JERG-0-043.

(4) If prescribed in the specifications and unless otherwise instructed, this standard shall apply, according to the classification of newly developed articles, to the range of articles as per Paragraph 1.2.1.

(5) In case of any discrepancy or inconsistency between the requirements herein and those in the contractual specifications, the latter shall take precedence.

(6) In case of any discrepancy or inconsistency between the requirements herein and those in other technical standards, consultation shall be held with the competent inspector of the Japan Aerospace Exploration Agency (hereafter the “JAXA”).

(7) For BGA/CGA, refer to JERG-0-054.

1.2.1 Type of development model, development model definition

Designing, prototyping and manufacturing of new launch vehicles and spacecrafts shall be classified as follows:

(1) Development model

The application of this standard to development models shall be optional. If environmental or life testing is required, however, this standard shall apply.

(2) Flight equivalent model

This standard shall apply to flight equivalent models.

(3) Repair and spare parts

This standard shall apply to repair and spare parts.

1.2.2 Foreign product

Regardless of the provisions in Paragraph 1.2.1, the following documents shall apply in lieu of this standard to foreign devices that are designed, prototyped, manufactured, or modified abroad for installation into launch vehicles and spacecrafts and hence are unsuitable for the application of this standard.

a. J-STD-001*S "Space Applications Electronic Hardware Addendum to IPC J-STD-001* Requirements for Soldered Electrical and Electronic Assemblies"
b. ECSS-Q-ST-70-08C "Manual soldering of high-reliability electrical connections"

Note that * indicates the latest version.

1.3 Supplement

(1) Review of soldering process

Using the form shown in Figure 1-1, the supplier shall prepare and submit to JAXA for review a summary of the recertification training for the soldering process, the certification testing therefore, and the Soldered-Parts Mounting Method Plan and Checklist, which incorporates considerations including at least items (a) to (c) listed below. The review shall be conducted as part of Preliminary Design Review and Critical Design Review.

a. New aspects of the process and the impact thereof on important quality characteristics
b. Extent of constraints on functional and performance verification during the testing and inspection processes
c. Frequency of nonconformance of comparable articles in the past

(2) Incorporation of review results

The supplier shall incorporate the review results regarding the application of this standard into the materials (drawings, manufacturing process specifications, procedures, administrative rules, etc.) relevant to the implementation items (design standardization, engineering documentation, shop floor control) of the quality, reliability, or safety/development assurance program plan.

(3) Product verification

The supplier shall plan and verify, with the help of manufacturing engineers, initial-lot products to which the review results are applied, products normally commercially unavailable, and mission-critical products.

Soldered Parts Mounting Method Plan and Checklist

Parts shapes or As-assembled configuration thereof	Mounting method	Staking method	Specifications of PWB, etc.	Soldering type	Necessity of manufacturing engineer's witnessing	* Necessity of recertification	Necessity of process certification test	Remarks: Reasons and supplementary comments
				Hand soldering: H Wave soldering: W Reflow soldering: R				

* Indicate "Required" when required to adopt a new process with no history of previous application to spacecraft or when any change has been made to the content of the certification.

Other special issues:

Figure 1-1 Soldered parts mounting method plan and checklist form

2. RELATED DOCUMENTS

The related documents are as follows. Disclosure of some mechanistic documents and materials may be restricted.

2.1 Applicable documents

The documents listed below form a part of this standard to the extent specified herein. Unless otherwise specified, their latest versions at the time of application of this standard shall be used.

(1) JAXA standards
  a. JERG-0-040: Standard for Electronic Bonding Process for Space Use
  b. JERG-0-041: Standard for Electrical Wiring Process for Space Use
  c. JERG-0-042: Standard for Printed Wiring Boards and Assemblies for Space Use
  d. JERG-0-043: Standard for Surface Mount Soldering Process for Space Use
  e. JERG-0-054: Standard for BGA/CGA Mounting Process for Space Use

(2) Public standards
  IPC standard
  a. J-STD-004: Requirements for Soldering Fluxes
  b. J-STD-006: Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications
  JIS standard
  c. JIS Z 3282: Soft Solders—Chemical Compositions and forms

2.2 Reference documents

The following documents provide information supplementary to the contents of this standard:

JIS standard
  a. JIS K 3282: Soft Solders—Chemical Compositions and forms

MIL standard
  a. MIL-STD-1276: Leads for Electronic Component Parts

ASTM standards
  a. ASTM B 488: Electrodeposited Coatings of Gold for Engineering Uses
  b. ASTM B 545: Standard Specification for Electrodeposited Coatings of Tin
  c. ASTM B 700: Standard Specification for Electrodeposited Coating of Silver for Engineering Use
AMS standards

a. AMS 2418: Plating Copper
b. AMS 2422: Plating, Gold

SAE-AMS (Aerospace Material Specification)
a. SAE-AMS-P-81728: Plating, Tin-Lead (Electrodeposited)
b. SAE-AMS-QQ-N-290: Nickel Plating (Electrodeposited)

JAXA document
a. JERG-0-039-TM001 Collection of Technical Data of Standard for Soldering Process for Space Use (JERG-0-039)

IPC standard
a. J-STD-001*S: Space Applications Electronic Hardware Addendum to J-STD-001* Requirements for Soldered Electrical and Electronic Assemblies

Note that * indicates the latest version.

ESA standard
a. ECSS-Q-ST-70-08C: Manual soldering of high-reliability electrical connections

3. TERMS AND DEFINITIONS

Reference shall be made to Appendix I for the terms and definitions used in this standard.

4. GENERAL REQUIREMENTS

4.1 General

The supplier shall prepare documents, including design standards, process specifications, work procedures, and inspection procedures, all conforming with the requirements herein, and shall perform application and control accordingly.

4.2 Training and certification

4.2.1 General

(1) Engineers in charge of mounting design for electronic devices (including Printed Wiring Board (PWB) pattern design) shall be highly knowledgeable of the requirements herein.

(2) The supplier shall be responsible for establishing and operating a training and certification system that is intended for operators and inspectors involved in solder mounting and is compliant with the requirements herein.

(3) The supplier shall ensure that soldering instructors (or manufacturing engineers) will provide work instructions on difficult soldering tasks and check work results. Soldering instructors shall preferably be certified for soldering and related skills by external organizations.

(4) Training shall be provided regarding electronic device soldering-related skills, techniques, equipment operation, and procedures. Records shall be retained of such training.

(5) Operators and inspectors shall be tested and certified to have the sufficient knowledge and skills required for the specified soldering.

(6) The certification shall be pertinent to typical soldering techniques used for the product.

(7) When operators are certified with restrictions (type of soldering on PWBs and/or terminals, cable termination, compulsory use of spectacles), it shall be explicitly stated on the certification record that contains their test performance. Figure 4-1 shows reference for a typical certification record sheet.

(8) Certification records shall be presented immediately upon request by the JAXA’s inspector or similarly authorized personnel.

(9) The records relating to education and training shall be retained as quality record for a fixed period of time.

(10) The training and certification program shall use actual samples, drawings, or photographs of acceptable solders. Any drawings and photographs contained herein may be used for supplementary information. Actual samples, drawings, or photographs of unacceptable solders may be used for clarification or comparison.

4.2.2 Vision requirements

Operators and inspectors shall, at the time of the initial certification or recertification, have their vision testing checked by a qualified medical doctor or personnel under his/her supervision. Alternatively, the vision testing may be administered by the certification examiner.

(1) Near vision

Operators shall meet one of the following requirements with uncorrected or corrected vision per eye or both eyes, or shall have equivalent vision.

a) Read the Jaeger #1 from 36cm (14inches) away.
b) Distinguish the target at 1.0 in the Landolt ring near vision testing chart (30cm) from 30cm away from the target.
c) Distinguish the target at 0.8 in the Landolt ring near vision testing chart (30cm) from 40cm away from the target.

(2) Color vision

Ability to distinguish colors required for practical reasons.

4.2.3 Recertification

Recertification of operators and inspectors shall be required when any one of the four conditions below applies. The recertification procedures shall include sufficient training or retraining appropriate for the work assigned to the operators or inspectors.

(1) Proficiency requirements herein are not met.
(2) New techniques have been approved that requires different skills.
(3) Work period interruption of greater than six (6) months occurs.
(4) The validity period of certification (two (2) years at longest) is exceeded.

4.2.4 Revocation of certified status

Certification shall be revoked when:

(1) Certificate holder fails recertification.
(2) Certificate holder fails to meet visual acuity requirements of Paragraph 4.2.2.
(3) Employment is terminated.

ABC Co., Ltd.
Certification Record of High Reliability Hand Soldering and Related Work

Name	Taro Handa	Dept./Sect.	Manufacturing Dept., Section 1		
Date of testing	May 10, 1991	Vision test	Use a new sheet for recertification Pass [✓ Fail] 2020/4/23	Working conditions	Vision Uncorrected/ [✓ Corrected]
Scope of certification		Performance			Note
	Process Spec	A	B	Fail	
a. Soldering to terminals					
1) Turret terminals	SOP-S-02		✓		May 10, 1991
2) Bifurcated terminal	Ditto		✓		Ditto
3) Hook terminal	Ditto		✓		Ditto
4) Solder cups	Ditto		✓		Ditto
5) Pierced terminals	Ditto		✓		Ditto
6) Special purpose terminals	SOP-S-03		✓		May 11,1993: Recertified
b. Soldering on printed wiring boards					
i) Straight-through lead terminations	SOP-S-01		✓		May 10, 1991
ii) Lapped lead terminations	Ditto				
iii) Clinched lead terminaitons	Ditto				
c. Solder sleeve	SOP-S-04		✓		Feb. 20, 1992: Recertified
d. Ferrule soldering	SOP-S-05		✓		Oct. 10, 1993: Recertified
e. Chip parts soldering	SOP-S-06				
f. Semi-rigid cable soldering	SOP-S-07				
Rework technique					
g. Wicking method	SOP-R-01		✓		
Written test results	92 Points	Final judgment	Pass May 10, 1991	Judged by	Tanaka
Special remarks on certification/recertification results					

Figure 4-1 Typical certification record sheet (1/2)

Vision test results

Apr. 23, 1991: Pass, uncorrected vision
Apr. 25, 1992: Pass, uncorrected vision
Apr. 10, 1993: Pass, corrected vision

Special remarks on certification/recertification results

Feb. 20, 1992 Skills training per process specifications Judged by Tanaka
(LP2111: Newly created)
Jun. 2, 1993 Skills training per process specifications Judged by Tanaka
(LP2111: Newly created)
Oct. 10, 1993 Skills training following revision of process specifications
Judged by Tanaka

Figure4-1 Typical certification record sheet (2/2)

4.3 Design conditions

Design requirements for PWB and assemblies thereof shall be as per JERG-0-042. Additional design requirements shall be as follows:

(1) The requirements herein shall be applicable to designed parts containing solder joints, the temperatures of which fall within the range of −55°C to 100°C during storage and operation. In case of deviations from this temperature range, appropriate design measures shall be implemented.

(2) Except for special purposes, solder shall conform to Sn63/Pb37 or Sn60/Pb40 composition as per J-STD-006 or JIS Z 3282 or equivalent compositions. Flux-cored solder shall be used with either RO-L0 flux (R equivalent) or RO-L1 flux (RMA equivalent). Lead-free solder shall not be used in lieu of Sn63/Pb37 or Sn60/Pb40 solder. In addition, the Sn-Ag system may be used when the reliability of the junction cannot be assured in paragraph 4.3 (4).

(3) Metal materials to be soldered shall have solder wettability and, unless otherwise specified, shall allow soldering with rosin-based flux.

(4) Materials selection shall provide minimal thermal expansion coefficient mismatch at the constraint points of the part mounting configuration. If large thermal expansion coefficient mismatch is unavoidable, comprehensive consideration shall be given to the soldering method, surface plating, type of solder, as well as temperature variation reduction through the use of built-in thermal control in the system, to ensure reliability.

(5) Unless otherwise instructed, stress relief shall be incorporated, wherever possible, to relieve thermal or mechanical stresses between two or more constraint points.

(6) Parts staking or conformal coating shall be performed carefully not to negate stress relief.

(7) Solder joints shall allow visual inspection.

For BGA/CGA, follow to JERG-0-054.

4.4 Process certification tests

When any one of the items listed below applies, the process shall be tested for certification or otherwise verified as certified.

(1) Soldered portions fall outside the temperature range of −55°C to 100°C during storage and operation.

(2) Any solder mounting unspecified herein is adopted.

(3) The consideration per paragraph 4.3 (4) finds that the process must be tested for verification regarding the thermal expansion coefficient mismatch. The test results shall be incorporated into detailed manufacturing specifications (surface plating, shape, clearance, etc.) and inspection specifications for solder joints.

4.4.1 Process certification test (I)

In the case of paragraph 4.4 (1) or (3), the following shall apply:

(1) Thermal cycle test

Thermal cycle test shall be conducted with a safety margin added to the temperature change pattern predicted by thermal analysis. The number of cycles shall be determined based on the required life. When an accelerated test is required, the thermal cycle test shall be conditioned taking into consideration the amount of thermal stress reducible from maximum and minimum temperatures.

(2) Visual inspection

After completion of the thermal cycle test per Item (1) above, visual inspection shall be conducted with minimum 15x magnification to verify that no deeply cracked solder joint or any other part damage has occurred. If visual inspection alone is insufficient for verification, cross-sectional inspection shall also be performed. This test shall use a multiple number of test specimens to verify the reproducibility of the design and manufacturing quality per the process specifications. The accept/reject criteria for cracked solder joints shall be evaluated and reviewed as necessary in cooperation with the JAXA’s inspector.

4.4.2 Process certification test (II)

In the case of Paragraph 4.4 (2), the following shall apply:

(1) Thermal cycle test

The test specimen shall be thermally cycled 200 times from room temperature to -55°C to 100°C and back to room temperature at a temperature gradient not exceeding 5°C per minute. Exposure time at maximum and minimum temperatures shall be 15 minutes. The duration of each cycle should average two hours. When a gas phase thermal shock test chamber is used, the chamber manufacturer’s recommended temperature gradient may be used.

If the thermal cycle test is replaced by a thermal shock test, the equivalent test conditions shall be established with reference to JERG-0-043-TM001 Technical Data 20.

(2) Vibration test

After completion of the thermal cycle test, the test specimen shall be subjected to vibration. The vibration test shall be conditioned taking into consideration the applicable environmental conditions, etc., and shall be reconditioned as necessary in cooperation with the JAXA’s inspector.

(3) Visual inspection

Visual inspection shall be conducted as per Paragraph 4.4.1(2).

- Note -

Prior to a process certification test, a test plan shall be prepared that explicitly states in detail the manufacturing requirements (surface plating, dimensions, clearance, work conditions, equipment and facilities, etc.) and inspection requirements (appearance and shape of fillet, amount of solder to be used, etc.), and test requirements (environment, items to be monitored).

4.5 Manufacturing conditions

(1) Unless otherwise contractually specified, solder joints may be reworked within the limits of applicability of this standard.

(2) Unless otherwise instructed, no repair of solder joints shall be allowed (e.g., repair of PWB solder lands, PWB processing for jumper wiring, etc.). Note, however, that nonconforming solder joints may be reprocessed according to the nonconformity handling procedures per the contract, on the condition that the intended function, performance, or reliability will not be adversely affected.

(3) A non-nondestructive method of inspection, such as X-ray inspection, shall be used as necessary to determine the acceptability of solder penetration.

(4) Materials and parts (including electrostatic discharge sensitive parts) shall be properly stored and handled to prevent contamination and electrical or physical damage.

(5) Protective goggles, gloves, ventilation systems, and other necessary measures shall be prepared to ensure personal safety.

Rework of soldered parts may be carried out within the scope of this document unless otherwise specified in the contract.

4.5.1 Manufacturing environment

(1) Facility cleanliness

a. The supplier shall ensure that the workplace used for the soldering is maintained in a clean and orderly condition.

b. Smoking, eating, and drinking in the work area shall be prohibited.

c. Nonessential items shall not be brought into the work area.

d. Each workshop shall have an internal pressure higher than that of the adjacent areas or shall be installed with a double-layered entry and exit system to minimize entry of external contaminants.

e. When any dust generating work is required, appropriate precautions shall be taken.

f. Tools for use in individual workstations shall be maintained clean. Any contaminants arising from the work (e.g., flux, solder droplets, metal filament, etc.) shall be removed immediately.

g. Some supportive materials may contain harmful substances. Sufficient ventilation shall be provided to ensure safety.

(2) Temperature and humidity

The temperature and humidity in individual soldering stations shall be controlled to the ranges specified below and shall be continuously monitored. Parts or equipment being processed that require more critical environmental conditions than the following shall have such requirements identified and specified in the engineering documentation.

a. Temperature; 24±5℃

b. Relative humidity; 30～65%

(3) Lighting

Light intensity shall be a minimum of 1,000 lux on the surface being processed. During high-precision work, supplementary lighting shall be used to increase the lighting intensity if needed.

4.5.2 In-progress storage and handling

(1) When handling or storing in-progress or finished PWB assemblies, appropriate precautions shall be taken to prevent damage, inclusions, or contaminants.

(2) No metal surfaces to be soldered shall be touched with the bare hands. In case of contact with the bare hands, the metal surface shall be cleaned immediately. If handling of metal surfaces to be soldered is unavoidable, clean antistatic lint-free gloves or finger cots shall be worn.

4.5.3 Electrostatic discharge control

When electrostatic discharge (ESD) sensitive parts and assemblies are soldered, all instruments and operators as well as the workplace shall be provided with the ESD control measures listed below with due consideration given to personal safety. Proper handling procedures shall be established, in which all operators and inspectors shall be trained to develop proficiency in ESD damage prevention.

(1) Workbench surfaces shall be made and kept electrically conductive and grounded.

(2) If a workbench surface is not electrically conductive or if no ESD control system is installed, each operator shall wear a wrist strap grounded via a protection resistor.

(3) Each operator shall wear a suit made of electrically conductive or non-electrostatically chargeable fabric.

(4) The power supply equipment installed in the workplace shall be grounded by a grounding circuit that will remain closed even during a power failure.

(5) Electrically conductive instruments and tools shall be used for work if necessary.
(6) Any container holding ESD sensitive parts in it shall be labeled to that effect.
(7) Only ESD-proof containers shall be used to keep parts or devices in it.

4.6 Quality assurance

(1) The accept/reject criteria shall be explicitly defined in drawings and process documentation.

(2) To verify conformance to the requirements herein, inspections shall be planned and performed at appropriate points of time during the process.
It is desirable that the first product, the product that is not normally flowing, and the critical product be confirmed by a manufacturing engineer.

(3) A quality assurance system shall be established to comprehensively review and verify the statements in the work and inspection records that the manufacturing requirements are all met.

(4) Parts or PWB to be used shall be kept free of damage or deterioration to maintain their solderability.

(5) The manufacturing environmental conditions (cleanliness, temperature, humidity, and lighting of the facilities) shall be verified.

5. DETAILED REQUIREMENTS

5.1 Tools and equipment

5.1.1 Tools and equipment control

(1) Tools and equipment to be used in soldering and in work preparation areas shall be selected appropriately to the intended function.

(2) Tools and equipment shall be cleaned and properly maintained.

(3) The handling and operating procedures for the tools and equipment shall be documented.

(4) All tools and apparatuses (e.g., soldering irons, insulation strippers) requiring periodic inspection and calibration shall be properly labeled for identification, controlled, and recorded per inspection and calibration procedures established therefore.

(5) No unauthorized, defective, or uncalibrated tools shall be kept in the work area. When temporary storage is required, all tools shall be properly labeled for identification.

5.1.2 Soldering tools and equipment

Soldering iron or equipment shall be selected as appropriate for the workpiece to obtain an appropriate temperature profile. The use of soldering gun shall be prohibited. (See Figure 5-1)

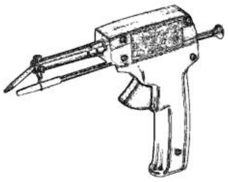


Figure 5-1 Typical soldering gun (Prohibited)

(1) Electrical tools, such as soldering irons and solder pots, shall have a three-core power cord with a ground terminal or shall be double insulation. All soldering tips shall be grounded that may directly contact parts and materials to be soldered. The tip-ground resistance shall not exceed 2.0 Ω. The leak voltage shall be below 2mV (effective value).

(2) Soldering irons

Soldering irons shall be of temperature-controlled type; controllable within ± 5.5°C of the set temperature.

(3) Solder pots

Solder pots used during tinning, etc., shall be capable of maintaining the solder temperature within ± 5.5°C of the intended range. Solder pots shall be grounded.

(4) Wave soldering equipment

Requirements for wave soldering equipment can be found in the paragraph 5.7.

(5) Supplemental heat sources

When supplemental heat is applied by hot gas, radiation energy, or any other source for aiding the hand and wave soldering process, the equipment shall be set up, operated, and maintained by personnel using established and documented procedures.

(6) Resistance-type soldering electrodes

Tweezer-type or clamp-type resistance soldering electrodes that come in contact with materials to be soldered shall be parallel to each other and free of pits, burns, corrosion, or contamination.

(7) Hot air equipment (including hand tools)

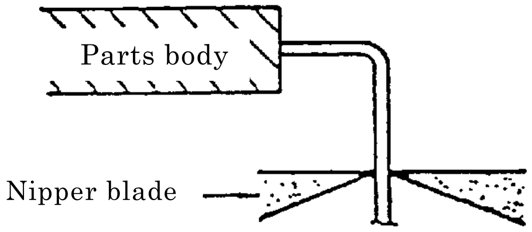
Hot air equipment to heat the parts uniformly during soldering and rework.

5.1.3 Conductor preparation tool

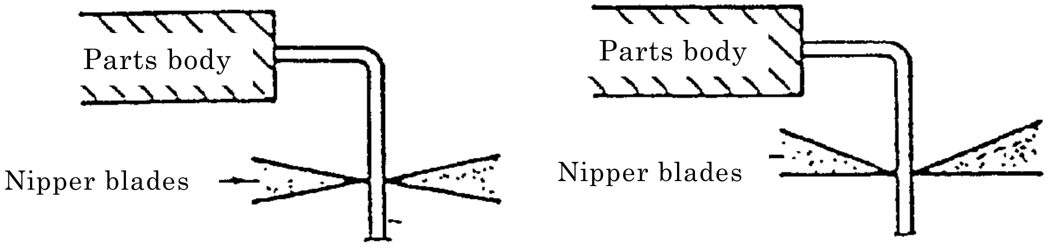
Conductor preparation tools shall be selected as follows: Insulation strippers and lead bending tools shall not nick, ring, gouge, or scrape conductors or otherwise damage parts. In addition, they shall not contaminate conductors or hinder solder wetting.

(1) Conductor cutting tools

Tools used to cut part leads shall not cause damage to printed wiring boards (PWB's), printed circuitry, or part leads or bodies. For flash cutting tools (nippers, etc.) with blades on diagonal, side or end surfaces shall be used to cut leads of mechanical shock-resistant parts (See Figure 5-2). Shear type cutters should be used to cut shock-sensitive part leads to prevent damage.



Appropriate example



Inappropriate example　Inappropriate example

Figure 5-2 Typical use of lead cutting nippers

(2) Insulation stripping tools and methods

Tools used to strip insulation from wires shall be of appropriate type and size to avoid nicking or scraping conductors or affecting the quality of insulation. Most appropriate tools that best suit the wire shall be selected from the following:

a. Mechanical strippers

Mechanical strippers used 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 5-3A,B). Automatic high volume machine strippers shall be of a type using 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 wire portions to be left for use.

b. Thermal strippers

Thermal strippers used to remove insulation from stranded and solid conductor wires shall be of a type that can provide a regulated temperature required for the insulation type. Temperature controls shall be sufficient to prevent damage to the wire portions to be left for use (See Figure 5-3).

c. Chemical strippers

Chemical solutions, pastes, or creams used to remove insulation from magnet wires shall be suitable for removal of the insulation to be stripped and shall not cause degradation to the wire. In addition, wires must be neutralized and cleaned of contaminants in accordance with manufacturer's recommended instructions.

d. Insulation removal using molten solder

Magnet wires can be stripped of polyurethane or similar type coatings by dipping in hot molten solder held at manufacturer’s recommended temperature.

Molten or re-solidified solder found at the termination ends of the remaining insulation shall not be cause for rejection.

(3) Holding devices

Tools, fixtures, and materials used to hold or restrain conductors and parts shall be of a design that will not damage or deform the conductors, conductor insulation, or parts.

(4) Bending tools

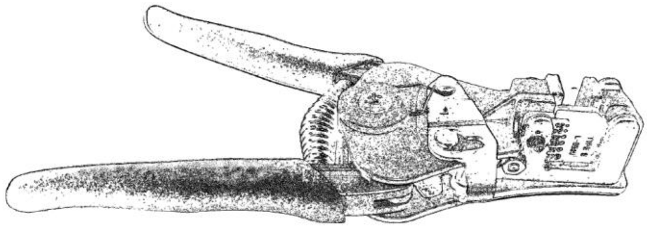
Tools used for conductor bending may be automatic or hand operated and shall be of a material that will not damage conductors or insulation. Bending tools shall be of a type that imparts no damage to the part bodies or seals. Smooth impression marks (base metal not exposed) resulting from bending tool-holding forces shall not be cause for rejection.

a. Automatic lead forming equipment

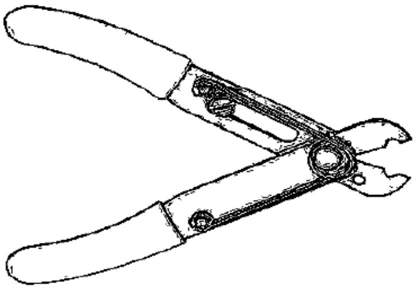
Automatic lead forming devices may be used that are capable of lead bending that meets the mounting requirements herein.

b. Clinching tools

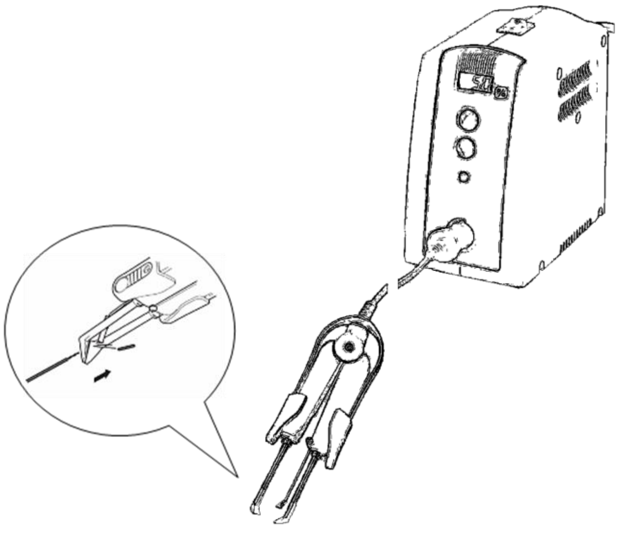
Clinching tools shall not cause damage to PWBs, conductive circuit, or part bodies or leads.



A. Typical adequate mechanical cutting strippers



B. Typical inadequate mechanical cutting strippers



C. Typical thermal stripper

Figure 5-3 Typical strippers

(5) Anti-wicking tools

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

(6) Cleaning tools

Cleaning tools shall be selected based on their ability to minimize the generation of static charge. Typical cleaning tools include natural bristle brushes, lint-free tissue, cotton swabs, etc. Steel-wire brushes, knives, erasers, emery cloth, sandpaper, and other devices that produce an abrasive action or cause contamination shall not be used.

5.1.4 Thermal shunts

Thermal shunts (also called heat sinks or heat dissipater clamps) shall be used to absorb heat from part leads as necessary to protect parts, insulating materials, and/or previously completed connections from damage during soldering operations. Care shall be taken in the selection, application and removal of thermal shunts to avoid damage to conductors, parts, insulation, or associated solder joints.

5.1.5 Inspection optics

Visual inspection shall be performed using magnification aids conforming to the following:

(1) Magnification aids that allow observation with both eyes are recommended for use in solder joint inspection.
(2) Magnification aids shall be capable of rendering true color and adequate resolution.
(3) The light source shall provide shadowless illumination of the area being viewed.
(4) Inspection optics fitted with glass lenses are recommended.

5.2 Materials

5.2.1 Solder

All solder shall conform to J-STD-006 or JIS Z 3282 or shall be their equivalents and, unless otherwise instructed, shall be selected as per the following guidelines:

(1) Composition Sn63/Pb37 or Sn60/Pb40

(2) Flux types

Material	Activation level	Remarks
RO	No Flux	S: Solid metal (no flux) equivalent
RO	L0	R: Rosin core-non-activated equivalent
RO	L1	RMA: Rosin core-mildly activated equivalent

Note: Material RO: Rosin

Type ROL0 flux (R equivalent) shall be used where cleaning cannot be sufficiently performed after soldering. Type ROL1 flux (RMA equivalent) shall be properly removed by sufficient cleaning after soldering.

[Reference] About solder

(1) Typical forms and applications of solder are as follows:

W (wire)	For hand soldering
R (ribbon)	For soldering using hot plate heating, etc.
B (bar)	For tinning and automatic soldering baths
I (ingot)	For tinning and automatic soldering baths

(2) Unless otherwise instructed, the above-mentioned solder compositions shall be used for soldering electronic devices. The following solder compositions may be useful for specific applications matching their physical properties. J-STD-006 or JIS Z 3282 shall be consulted for the details of solder compositions.

Solder composition	Melting range °C		Usage
	Solidus	Liquidus	
Sn62/Pb36/Ag2	179 Eutectic		Used to prevent silver coating on ceramic substrates from being diffused into solder and consequently thinned.
Sn96/Ag4	221 Eutectic		Used in high temperature environments. Superior to tin-lead solder in bond strength and excellent in creep rupture resistance.
Sn1/Pb97.5/Ag1.5	309 Eutectic		With a lead content of 97.5%. Used for high and cryogenic applications. Inferior to Sn63 in bond strength.

(3) For soldering operations where connections are to be subsequently reheated, use of high temperature solder alloy is effective. In such cases, the type of high temperature solder and the location requiring the high temperature solder shall be specified in the engineering documentation.

5.2.2 Liquid flux

(1) Unless otherwise instructed, all fluxes used for soldering operations shall be Type ROL0 (R equivalent) or ROL1 (RMA equivalent) liquid rosin flux per J-STD-004.

(2) Liquid flux used with flux-cored solder shall be chemically compatible with the

solder core flux and with the materials with which it will come in contact.

(3) Unless otherwise instructed, no corrosive water-soluble fluxes shall be used.

(4) The process documentation shall describe the types of fluxes, where each is used, and the necessary precautions.

(5) Use of Type ROM1 liquid rosin flux (RA equivalent) shall be allowed only for tinning of lead wires (solid conductor wires), solid bus wires, and terminals of sealed bodied parts. Soldering with Type ROM1 liquid rosin flux shall be allowed only in a closed area separated from the normal production line. No products soldered using Type ROM1 (RA equivalent) flux shall be returned to the production line without being completely cleaned of the flux.

[Reference] About fluxes

(1) Some high lead content, high-temperature solder alloys may require high flux activation temperature and use of inorganic corrosive flux. The inorganic corrosive flux shall be subsequently removed by cleaning.

(2) Water soluble fluxes may not cause troubles immediately after cleaning but may lead to insulation failure after long-term storage. In addition, these fluxes may leave residual moisture behind, due to which molten solder may be scattered during subsequent soldering operations.

(3) Normally, water-soluble fluxes contain polyethylene glycol (PEG) as solvent. According to an engineering document*1, resin components and PEG contained in glass-epoxy substrates are combined with each other at soldering temperatures to produce substances irremovable even by subsequent cleaning. Additionally, the document warns that the produced substances cause a rapid decrease in insulation resistance when placed in high-humidity environment (75% to 80% or higher). According to the same document, polypropylene glycol or its derivatives are alternative solvents effective to prevent this deterioration problem.

5.2.3 Solvents and cleaners

(1) Solvent and cleaner requirements

a. The solvents, cleaners, and cleaning systems thereof used for removal of grease, oil, debris, flux, and other contaminants shall be selected for their ability to remove both ionic and nonionic contamination. No use shall be made of the solvents or cleaners without properly evaluating and verifying their cleaning performance and effects on the parts or materials being cleaned.

b. The solvents or cleaners used shall not degrade the materials or parts being cleaned.

c. All solvent and cleaner containers shall be properly labeled for identification.

d. The solvents and cleaners shall be properly controlled to prevent them from being contaminated, absorbing moisture, or being degraded during use or storage.

(2) Typical solvents and cleaners

Approved solvents and cleaners are as follows:

a. Ethanol (Ethyl alcohol): JIS K 8101 (reagent) special grade or Grade 1 or equivalent

b. 2-Propanol (Isopropyl alcohol) : JIS K 8839 (reagent) special grade or Grade 1 or equivalent

c. Mixture of the above solvents

d. Deionized water: minimum specific resistance 10 kΩ・m

- Note -

No use shall be made of CFC, 1,1,1-trichloroethane, or any other substances prohibited under "Montreal Protocol on Substances that Deplete the Ozone Layer."

(3) When selecting deionized water, care shall be exercised to ensure that proper drying is accomplished immediately after its use.

(4) Solvents and cleaners may remove marking information from parts. Appropriate marking permanency testing shall be performed as part of the evaluation procedure for any solvent or cleaning system. If markings other than indelible ink may disappear, evidence shall be left.

[Reference]

Water-based saponifying detergents have relatively high surface tensions. Their use should be avoided in high-density mounting or surface mounting, in which substrate-part clearances may be too narrow for proper cleaning with them. Their residues may cause corrosion.

5.2.4 Requirements for conductors to be soldered

Oxides on conducting metal surfaces result in poor solder wetting. Hence, in soldering operations, surfaces are plated with oxidization-resistant metal for good solderability. There are also, however, various constraints on plating operations, including, e.g., solder's contamination susceptibility, long-term stability, and wettability. The plating specifications and materials selection shall take these points into consideration.

In bright plating operations, care shall be taken because organic substances contained in the brightener additive added to the plating bath may be entrapped in the plating film, thereby reducing the solder bond strength, and because plating containing excessive contaminants may result in reduced solderability.

[Reference]: About plating materials and methods
When a plating operation is required, the most appropriate plating method shall be selected with consideration given to their characteristics described below. For the specifications for part lead plating, MIL-STD-1276 shall be consulted.

(1) Gold plating

a. Gold plating reacts with tin contained in the solder, producing an intermetallic compound ($AuSn_4$). This gold-tin compound is harder than solder and is brittle. The gold-tin intermetallic layer can easily crack, thereby causing failures.

b. In gold-tin plating, gold diffuses faster than tin. Where a sufficient amount of gold plating remains, gold will diffuse with voids left in the remaining tin (See Figure 4-7-1 and 4-7-3 in JERG-0-039-TM001 Appendix: Technical Data 4). This phenomenon typically occurs at high temperature.

c. Bright gold plating soldered without tinning has lower creep characteristics. (See Figure 7-5-4 in JERG-0-039-TM001 Appendix: Technical Data 7)

d. To ensure high reliability, gold plating must be removed prior to soldering. Where gold plating is required (for, e.g., corrosion prevention), care shall be exercised to avoid making the gold plating layer thicker than necessary. Excessively thick gold plating may not be properly removed just by dipping in molten solder.

e. Typical specifications can be found in the following standards:
AMS 2422 and ASTM B 488: Plating thickness 0.8 to 1.3 μm
Where solderability specifications exist, solderability testing is compulsory. High-purity gold plating shall be applied within the above thickness range to ensure good solderability.

(2) Silver plating

a. Silver plating provides the best solderability second only to gold plating, but does not perform very well in terms of long-term storage. Additionally, silver plating also has the disadvantage of blackening due to sulfuration caused by sulfur and compounds thereof.

b. When applied with voltage under humid conditions, electrochemical migration occurs, thereby providing a possible cause of reduced insulation resistance or shorts. Silver plating shall be applied with careful consideration given to the conditions of intended use.

c. Typical specifications is shown in the following standards:

ASTM B 700: Plating thickness 3.8 to 8.9 µm

(3) Tin plating

a. Tin plating has good initial solderability but deteriorates significantly over time.

b. Tin plating is prone to diffusion with the base metal. During the burn-in operation of the product, the tin plating diffuses into, e.g., the base copper, yielding a dark gray intermetallic compound (Cu_3Sn), which causes non-wetting. This problem can be prevented by increasing the plating thickness to 2.5 µm or more.

c. Use of tin-plated and tin-based lead-free electrode parts shall be prohibited for fear of tin dendrite-induced electrical short-circuiting. When use of lead-free parts is unavoidable, prior consultation shall be held with JAXA.

(4) Electrodeposited tin-lead plating, etc.

a. Excellent in solderability and long-term stability.

b. Typical specifications is shown in the following standards:

SAE-AMS-P-81728 (tin 50 to 70% + lead)

Average plating thickness after fusing: 7.6 to 12.7 µm

c. Molten solder coating shall be applied over any of the above-described plating.

Typical coating thickness: 5.1 µm or more

(5) Underplating

a. Use of zinc-containing base alloys, such as brass, may result in reduced solderability due to diffusion of the zinc over the plating surface. To prevent this phenomenon, nickel or copper plating shall be applied to a thickness of 2.5 µm or more.

b. Typical specifications for nickel plating and copper plating can be found in SAE-AMS-QQ-N-290 and AMS 2418, respectively.

c. Nickel plating shall immediately be overlaid with top-layer plating. A prolonged exposure to air may result in reduced adhesion of the top-layer plating. Use of nickel plating shall be avoided where its magnetism is undesirable.

Tin plating has good solderability in the initial stage, but has large time deterioration.

5.3 Preparation for soldering

5.3.1 Parts and materials inspection

(1) Prior to parts mounting, PWB shall be examined for any of the following defects:

a. Conductor pattern containing blisters, creases, or scratches exposing base material surface, or conductor pattern separated from base laminate (including solder pad)

b. Base laminate containing interlayer delaminate, pits, or inclusions
c. Measling or crazing exceeding permissible value for substrate
d. Debris, oil, or any other contaminants on PWB
e. Lack of solder plating or coating on surfaces to be soldered

(2) To obtain good solder joints, surfaces to be soldered must be free of contamination with oil or residual salt from plating solution. These surfaces must be handled carefully to avoid contamination and shall be cleaned properly with an appropriate solvent prior to soldering. Insufficient cleaning will result in reduced solderability, formation of voids, and reduced solder bond strength. Due care shall be taken in use of ultrasonic cleaning that may cause damage to bonding wires inside parts. Ensure that cleaning is compatible with the solderability of the parts and materials used.

(3) PWB shall be checked for clean surfaces and non-moisture-absorbing surfaces before soldering. De-moisturizing for methods for PWB include long-term storage in dry air, heat drying, and vacuum drying at low temperatures.

The drying method, temperature, and time shall be specified according to the object and specified in the process specification, etc. (approximately 8 hours or less from drying to soldering). If the drying is insufficient, moisture absorbed by PWB causes malfunction.

As an example of drying temperature and time, 1 hour is typical at 130 °C. Check the relevant current applicable data sheet (JAXA-ADS).

(4) Prior to soldering, thermal resistance of the parts and other constraints shall be checked to avoid parts deterioration during soldering.

Example:
- Soldering temperature and time for feed through ceramic capacitors
- Soldering temperature and time for IC’s and transistors
- Soldering temperature and time for fuses
- Heating and cooling times for ceramic parts (preheating and avoidance of rapid cooling)

5.3.2 Tools inspection

(1) Tools shall be checked daily for appearances, operation, performance, etc.

(2) Each tip of soldering iron shall be checked daily and periodically for the following points:

a. Proper insertion
b. Mounting without loosening
c. Cleanliness
d. No oxidation scale between tip and heating element
e. Ground continuity
f. Prior tip size relative to work involved

g. Tip temperature

5.3.3 Wire preparation

(1) Insulation removal

Proper insulation stripping tools listed in Paragraph 5.1.3 shall be used.

(2) Damage to insulation

After insulation removal, the remaining insulation on the conductors to be used shall not be scratched, crushed, charred, or otherwise damaged in any way. Note, however, that slight discoloration, indentation or scraping on insulation termination ends from thermal or mechanical stripping, etc. are acceptable.

(3) Damage to conductor

After the removal of insulation, the conductors shall be free of cuts or scratches that expose the base material surface. No use shall be made of any conductors, such as part lead wires, which have been reduced in cross-section area.

(4) Wire lay

The lay of wire strands shall be restored as neatly as possible to the original lay if disturbed. The conductors shall be cleaned before restoring the strands back to the original condition.

(5) Electrical wire cutting

The ends of electrical wires shall be cut, immediately before soldering, with sufficient length left for proper stress relief.

(6) Splices

For splices, follow JERG-0-041.

5.3.4 Gold plating removal

All gold plating on surfaces to be soldered shall be removed by dipping into molten solder or by a mechanical process. Gold plating removal shall be followed by tinning. Where gold plating is removed during tinning, it is recommended to use separate solder pots for gold plating removal and for tinning.

- Note -

The contact time between gold plating and molten solder shall be sufficient to remove all gold from the conductor. Thin residual bands of gold-tin intermetallic compound can severely embrittle connections.

5.3.5 Tinning

(1) The portions of solid or stranded wires and part leads to be soldered shall be tinned.

(2) Preferred methods of tinning are ones that use solder pots or soldering irons.

(3) No conductors shall be dipped in the solder pot for more than 5 seconds.

(4) Liquid fluxes may be used. The flux shall be applied so that it does not flow under the insulation except for traces carried by solder wicking. Flux shall be removed carefully using a necessary minimum amount of cleaning solution to prevent it from flowing under the conductor insulation.

(5) Hot solder tinning on part leads shall not extend closer than 0.51 mm to part bodies, end seals, or insulation.

However, in the case that solder coating is permitted closer to the part bodies in the parts specifications, it can be allowed to extend closer than 0.51mm but the part bodies, end seals or insulation shall be checked after tinning for any damage.

(6) Tinning personnel shall check and ensure that the tinned surfaces exhibit at least 95 percent coverage. The contours of stranded conductors shall be visible.

(7) Rework of any tinning shall be conducted by repeating the above-described steps. If the rework fails to provide a sufficient coverage, the tinning shall be rejected and handled in accordance with the nonconformity handling procedures.

- Note -

"Nonwetting" or "de-wetting" observed after tinning shall be properly handled or prevented from recurring in accordance with the prescribed nonconformity handling procedures.

5.3.6 Solder pot control

(1) Tinning solder pots shall be analyzed on an established schedule, based on usage, to ensure that they meet the requirements of Table 5-1, and that the total of gold plus copper does not exceed 0.3 percent. Records of the analyses shall be kept. The solder pot may be dumped on an established schedule, based on usage, in lieu of analysis. When the solder produces a dull, frosty, or granular appearance on the work, the pot shall be immediately removed from use.

Table 5-1 Solder contaminant levels maximum allowable percent by weight of contaminant

Contaminant	Percent Allowed (wt%)
copper	0.25 *1
gole	0.20 *1
cadmium	0.005
zinc	0.005
aluminium	0.006
antimony	0.5
iron	0.02
arsenic	0.03
bismuth	0.25
silver	0.10
nickel	0.01

*1 The total of gold plus copper shall not exceed 0.3 wt%.

(2) The following instructions shall be complied with to maintain the solder pot purity at an appropriate level:

a. Dross shall be removed from the solder bath surface prior to soldering.

b. Dross shall be removed regularly during soldering to prevent dross adhesion to the solder workpieces.

(3) Tinning solder pots shall be maintained at required temperatures and monitored, as a minimum, before and after each tinning operation or 8 hours period of pot operation.

[Reference]

(1) Copper, gold, cadmium, zinc, and aluminum are metals most likely to be accidentally mixed in during soldering operations and shall be paid particular attention to.

(2) Contaminants likely to be found in a solder bath and their adverse effects are as follows:

a. Copper

Copper is a metal likely to be found on a surface to be soldered. Copper makes the soldered surface rough, and hard and brittle. The copper content of a solder bath shall be maintained at 0.25 wt percent or less.

b. Gold

Similarly to copper, gold is a metal likely to be found on a surface to be soldered. Inclusion of gold reduces solder flowability, thereby forming solder joints, each with a whitish surface. The gold content of a solder bath shall be maintained at 0.2 wt percent or less. The recommended control value is 0.08 wt percent.

c. Cadmium

Cadmium reduces solderability and gives a dull appearance to soldered surfaces.

d. Zinc

Adverse effects start to show in solder with its zinc content at 0.001 wt percent. A zinc content of approximately 0.005 wt percent will reduce solder flowability and wettability, thereby producing a dull-looking solder joints.

e. Aluminum

An aluminum content of 0.001 wt percent or more is high enough to cause accelerated solder surface oxidation. Consequently, soldered joints will have a porous, dull, granular-looking surface. When the solder contains an appropriate amount of antimony, an aluminum-antimony intermetallic compound will be produced, thereby suppressing the above-mentioned adverse effect.

f. Antimony

Solder with a high antimony content shows slightly reduced wettability and an increased electrical resistance, but exhibits improved mechanical strength and creep characteristics. Excessive antimony content in solder will reduce solder flowability and bondability, thereby producing hard, brittle, and corrosion-prone solder joints.

g. Iron

Iron increases the melting point of the solder, causes the formation of FeSn2 therein, and reduces the workability of the solder. A solder joint with an excessive iron content will show magnetism.

h. Arsenic

By adding arsenic, the solder undergoes mechanical property changes. More specifically, the solder becomes harder and more brittle. Solder containing it appears bubbly and produces intermetallic compound dendrites.

i. Bismuth

Solder containing bismuth has a lower melting point but produces brittle solder joints.

j. Silver

Silver contained in solder reduces leaching of silver plating.

k. Nickel

Nickel has a low solubility in solder. Solder containing nickel may result in rough-surfaced solder joints.

5.4 Parts mounting

5.4.1 General

Unless otherwise specified, JERG-0-042 shall apply. What follows presents soldering considerations requiring particular caution during parts mounting to PWB. Also presented below are some additional requirements. Dimensions presented herein provide inspection criteria for manufacturing purposes (for design dimensions, see JERG-0-042).

(1) Stress relief

Stress relief shall be incorporated, wherever possible, between any points of constraint to protect parts and solder joints from detrimental stresses arising from expansion or contraction caused by thermal variations or mechanical excursions. Excessive lead lengths or large loops between constraint points shall be avoided to prevent vibration damage or electronic performance problems. Leads shall not be temporarily constrained against spring-back force during solder solidification so that the joint is subject to residual stress. Examples of stress relief are shown in Figures throughout this document.

[Reference]

During soldering operations, metal materials such as lead wires often constrain PWBs or organic materials, e.g., conformal coating, that have a relatively high thermal expandability. Solder joints will fatigue while repeatedly exposed to thermal stresses during soldering and operational thermal cycles.

If a soldering operation causes an excessive amount of thermal stress or spring back force, the obtained solder joints will be exposed to continuous stresses, undergo rearrangement of crystal structure, and end up with creep ruptures.

Solder fatigue is the function of the thermal cycle stress and the number of cycles (time), while solder creep is the function of stress and time. Therefore, most of solder failures occur as a result of the combination of fatigue and creep.

For further information on these points, refer to JERG-0-039-TM001 Appendix: Technical Data 5 and Technical Data 7.

- Notes -

Extreme care shall be exercised in the handling of parts containing mechanically weak portions, such as glass encapsulated wet tantalum capacitors. The content inside a broken glass casing gradually deteriorates, and such deteriorations often fail to be detected in electrical testing performed immediately after soldering.

(2) Parts positioning

Parts, terminals, and conductors shall be mounted as follows:

a. Solder joint check

Parts shall be mounted so that terminations of other parts are not obscured. When this is not possible, interim assembly inspection shall occur to verify that the obscured solder joints meet the requirements herein.

b. Parts on conductive circuit

Parts having conductive cases mounted over printed conductors or which are in close proximity with other conductive materials shall be separated by insulation of suitable thickness. Insulation shall be accomplished so that part identification markings remain visible and legible.

(3) Visibility of markings

Where possible, parts shall be mounted in such a manner that markings pertaining to value, part type, etc., are visible. For parts marked in such a way that some of the marking will be hidden regardless of the orientation of the part, the following shall be the order of precedence for which markings shall be visible:

a. Polarity
b. Traceability code (if applicable)
c. Part number and characteristic value

(4) Parts mounted extending over mounting surface edges

Unless otherwise specified in the engineering documentation, parts shall be mounted on PWB, a terminal panel, or a chassis without extending over any edge of the mounting surface.

(5) Hookup wires

Hookup wire, solid or stranded, shall be supported by a means other than the solder connections or conformal coating if wire length exceeds 25mm.

(6) Glass encased parts

Glass encased parts such as diodes, thermistors, or resistors shall be covered with transparent resilient sleeve or other approved material when epoxy material is used for staking, conformal coating, or potting or where damage from other sources is likely. The epoxy material shall not be applied directly to glass.

- Notes -

When using heat shrinkable sleeves, extreme care shall be taken to prevent part damage due to sleeve shrinkage or excessive heat.

(7) Splice

When connecting a broken or damaged conductor such as part lead or PWB circuit, follow the contracted fault handling procedure. (Follow JERG-0-041 for solder splice.)

(8) Contact with solder terminations

Part bodies shall not be in contact with soldered terminations.

(9) Mechanical fasteners

Where a part body is fastened by a combination of mechanical fastening elements (screws, etc.) and soldering, the part body shall first be mechanically fastened according to the authorized method and then soldered to prevent application of any mechanical stress to the solder joint(s).

(Example)

- Soldering of L-shaped multi-polar connectors

An L-shaped multi-polar connector shall have its L-shaped lead soldered to the PWB after the screw fastening of the connector body to the counterpart with a correct tightening torque.

5.4.2 Lead cutting and bending

(1) During bending or cutting, part leads shall be supported on the body side to minimize stress and avoid damage to seals or internal bonds.

(2) The distance from the bend to the end seal shall be approximately equal at each end of the part.

(3) The distance from the part body to the start of the bend in a part lead shall be twice the lead diameter 0.76 mm minimum for round leads and twice the ribbon lead thickness 0.50 mm in minimum for ribbon leads. Where the lead is welded, the minimum distance is measured from the weld. The bending radius of the lead shall be greater than the lead diameter for round leads or than the ribbon lead thickness for ribbon leads (See Figure 5-4).

(4) The direction of the bend should not cause the identification markings on the mounted part to be obscured.

(5) Part leads shall be formed so that they may be installed into the holes in the PWB without excessive deformation that can stress the part body or end seals.

(6) All lead wires shall be formed and tinned before mounting the part.

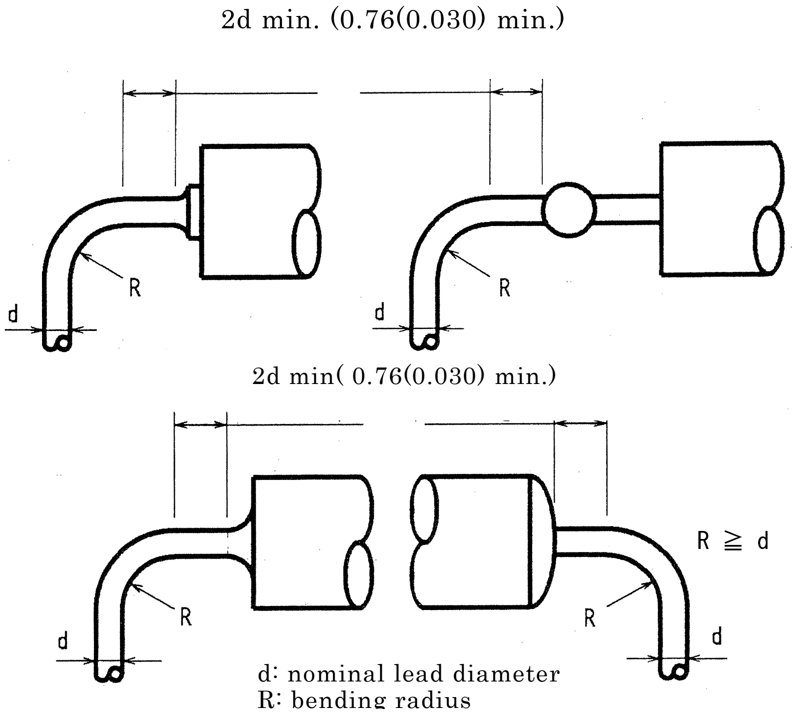
Where possible, part leads that are subject to stress corrosion cracking (e.g., Kovar leads), shall be preformed and trimmed prior to tinning.

(7) Whether formed manually or by machine, part leads shall not be mounted if they show evidence of nicks or deformations. Smooth impression marks resulting from tool holding forces shall not be cause for rejection.

(8) Tempered leads (sometimes referred to as pins) shall not be bent nor formed for mounting purposes since body seals and connections internal to the part may be damaged. Tempered leads or leads with a diameter of 1.27 mm (0.050 in) or more shall not be cut with nippers or other tools that impart shock to connections internal to the part.

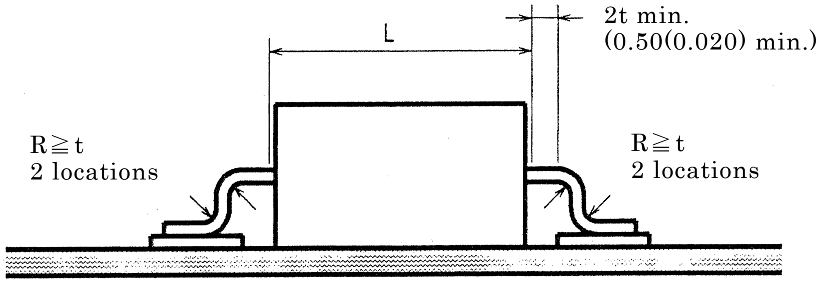
(9) Spring back resulting from lead wire clinching shall be acceptable.

(10) No solder joints shall be cut after soldering.



d: nominal lead diameter
R: bending radius

A. Typical round lead wire



t: nominal thickness of ribbon lead wire
R: Bending radius

Dimension in mm(in.)

B. Typical ribbon lead wire

- Notes -

It should be noted that the distance from the start of the bend in a part lead to the part body (2d min. in the above Figure) may be specified differently for some parts.

Figure 5-4 Distance from to the part body to the start of the bend in a lead

5.4.3 Mounting terminals

Use of terminals shall generally be restricted to situations where parts are expected to be removed and replaced five times or more, or where there are other compelling design requirements for their use.

(1) Terminals shall not be used as the interface connections in non-plated through holes (non-PTH's) in a double-sided PWB.

(2) Swage type terminals that are mounted in a plated through hole (PTH) shall be secured to the PTH by an elliptical funnel swage to allow full filling of the PTH with solder (See Figure 5-5). Terminals shall be swaged so that they can be rotated under finger force.

(3) When the seating of a swage type terminal that is mounted in a non-PTH is soldered to a PWB, a roll type swage shall be used for securing the terminal (See Figure 5-6).

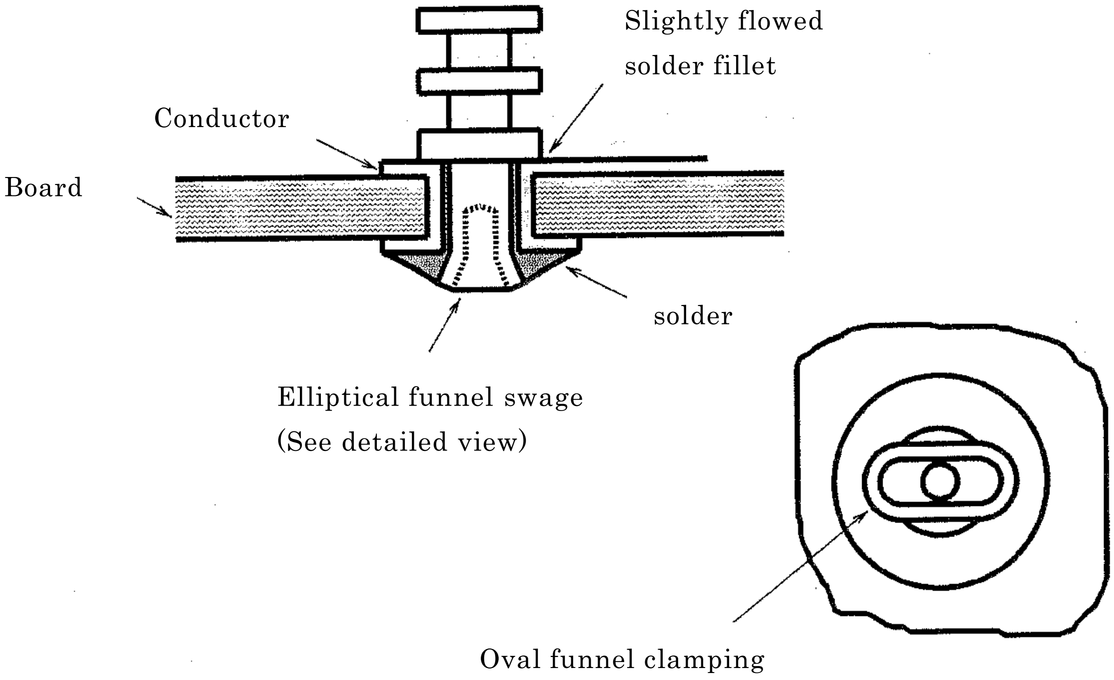
(4) PWB designs calling for soldering of the swaged end of the terminal to the printed wiring conductor on a single-sided PWB shall have the terminal secured with a V-funnel swage (See Figure 5-7).

(5) Swaging of terminals shall be performed in a way that does not damage the PWB.

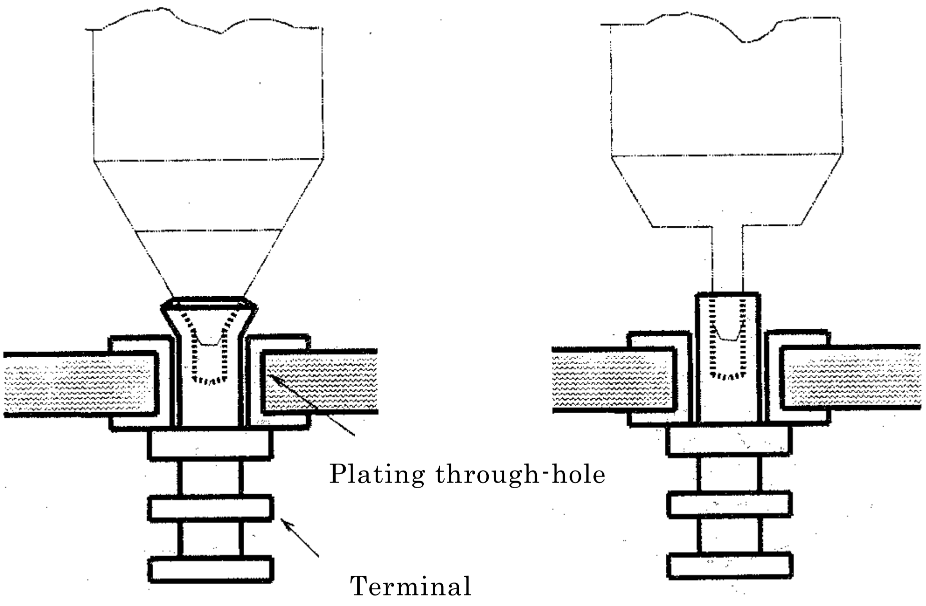
(6) After swaging, the rolled area shall be free of circumferential chips or cracks, but may have a maximum of three radial cracks, provided that the cracks are separated by at least 90° and do not extend beyond the rolled area of the terminal (See Figure 5-8)

[Reference]

Where terminals are required, bronze terminals are preferred. The bronze terminals shall be solder plated (fusing required unless otherwise instructed) or tin-lead coated. When the base metal contains zinc as its component, as is the case with brass, the zinc component will be diffused over the surface of the plating, thereby reducing the solderability. To prevent this from happening, the base metal shall be barrier-plated. A recommended barrier plating specification is copper plating with a minimum thickness of 0.003 mm (0.0001 in) (standardized in AMS 2418). Nickel plating may also be used where its magnetism and somewhat inferior solderability to copper barrier plating do not matter.



Detailed View



Front View

Side View

Figure 5-5 Terminal mounting by elliptical funnel type swage

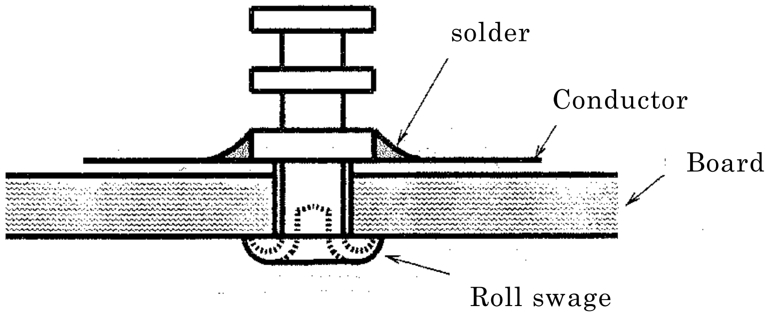


Figure 5-6 Roll flange terminal

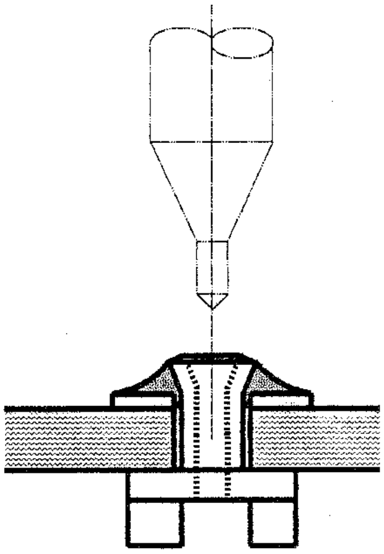
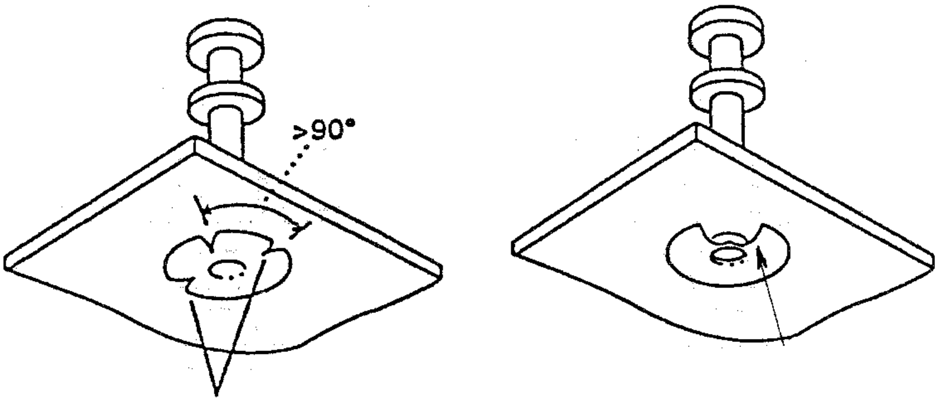


Figure 5-7 Terminal mounting by V-funnel swage



Radial cracks (3 max.)
Acceptable

Piece missing
Unacceptable

Figure 5-8 Terminal damage

5.4.4 Mounting of parts to terminals

(1) Parts shall be mounted parallel to, and in contact with, their mounting surface (See Figure 5-9). Slight angularity is permissible.

(2) The length of leads between parts and terminals should be approximately equal at both ends, except when special part shapes require staggering.

(3) Where parts are mounted between other terminal types, it is mandatory to put a stress relief bend in at least one lead. The part leads shall be formed into their final shape, unless otherwise instructed.

> - Notes -
>
> Care shall be exercised to assure that swaged solder connections are not mechanically stressed during parts mounting operations.

(4) Lead wires shall be wrapped around terminals as per Paragraph 5.5.

SR=Stress relief bend

CP=Constraing point

d=Nominal lead diameter

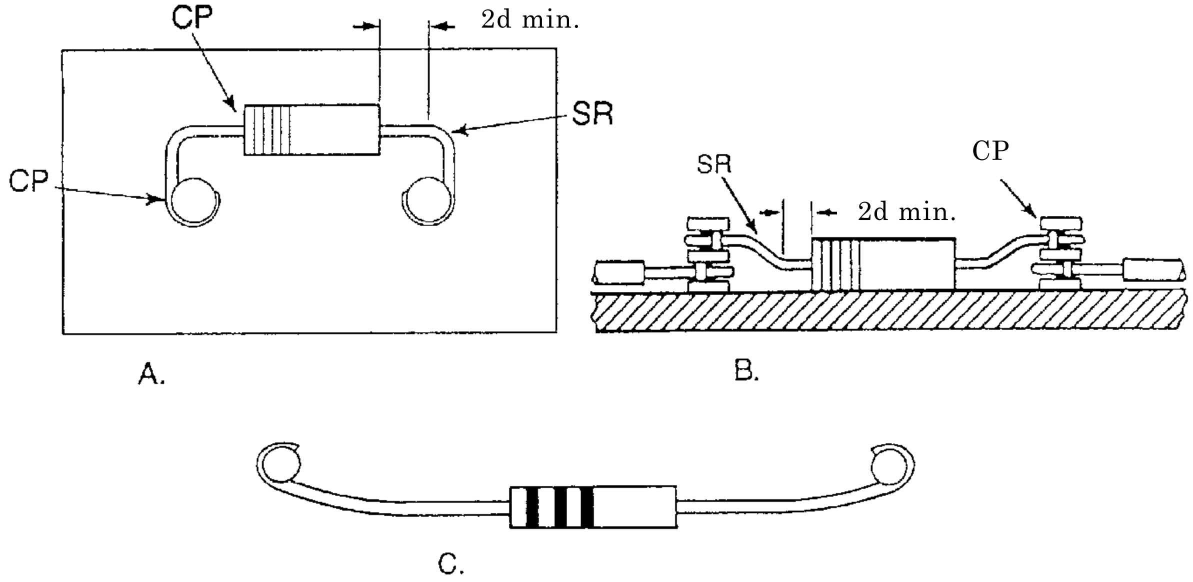


Figure 5-9 Stress relief example

5.4.5 Mounting leads and parts to PWBs

5.4.5.1 General

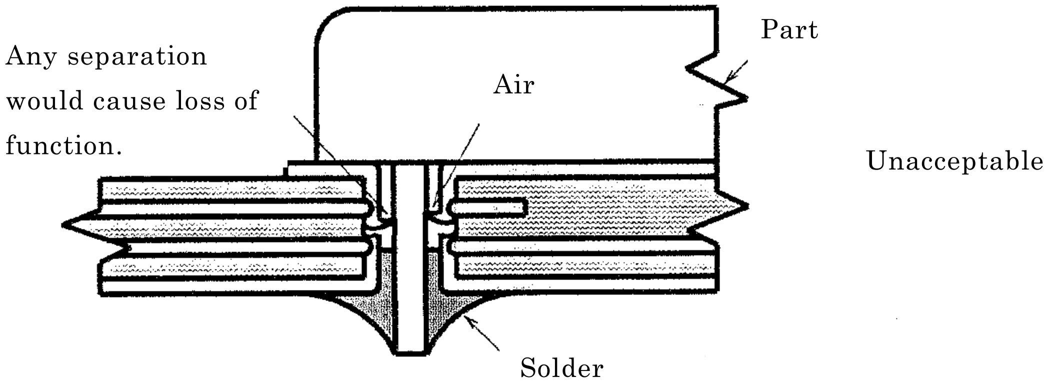
(1) The joints shall be tinned before soldering. The solder terminations shall be visible for inspection after soldering.

(2) If a part has lead wires insulated by the part manufacturer, Care shall be taken that the fillet at the end of the insulating coating does not enter the mounting hole or solder joint.

(3) Parts shall be mounted so that their bodies will not obstruct solder flow to the components side of plated through holes (See Figure 5-10).

(4) Lead connections shall be aligned, bent, or straight mounted in accordance with the technical documents. Only one lead wire or part lead shall be inserted into one hole.

(5) In the cases where visual inspection cannot be accomplished, a non-destructive method of inspection shall be performed (e.g., X-ray or fiberscope). The non-destructive method of inspection to be used shall be documented and approved by the JAXA prior to use.



Note: The solder is obstructed where the pressure of the air involved during soldering is equal to that of the molten solder.

Figure 5-10 Mounting hole obstruction

5.4.5.2 Horizontal mount of axial leaded parts

Axial leaded parts intended for horizontal mounting shall be parallel to, and in contact with, the mounting surface (See Figure 5-11). Slight angularity is permissible. When parts need to be bonded, slight spacing will be acceptable.

If a part body has a small diameter and the stress relief in its lead is filleted with solder, the part may be mounted slightly off the mounting surface.

If required to mount a part off the mounting surface, due consideration shall be given to the vibration-proofing of the part.

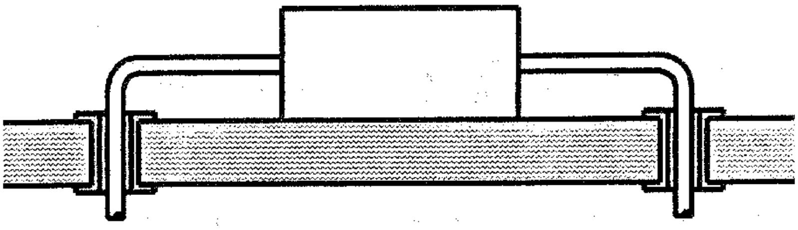


Figure 5-11 Horizontal mount

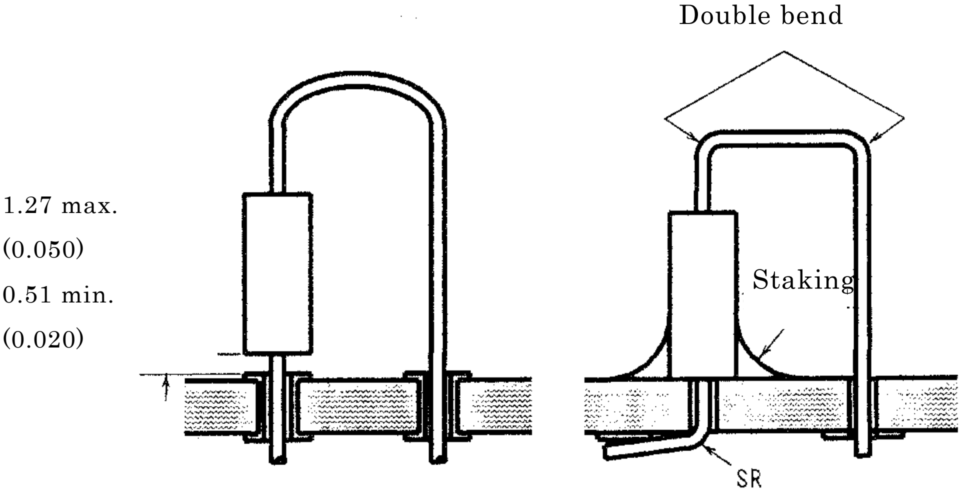
5.4.5.3 Vertical mount of axial leaded parts (See Figure 5-12)

(1) Plating through-hole

The end of the part body shall be mounted with at least 0.51 mm (0.020 in) to a maximum of 1.27 mm (0.050 in) clearance above the PWB surface or as specified on engineering documentation. The end of the part is defined to include any extensions such as cover fillet, solder seal, or weld bead.

(2) Non-plated-through hole

The end of the part body may be mounted flush with the PWB surface and shall be terminated with an off-the-pad-lap solder joint. The part shall be staked on the part side of the PWB. The opposite lead shall have two approximate right-angle bends.



A. Plated through hole

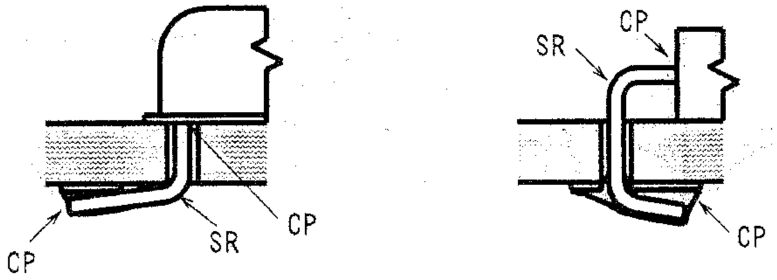
B. Non-plated through hole

Dimensions in mm(in.)

Figure 5-12 Vertical mount

5.4.5.4 Parts with leads terminating on opposite sides

Stress relief shall be provided in the part lead between the part body and solder terminations (See Figure 5-13). The leads may be terminated by clinch, straight-through, or off-the-pad-lap solder joint.



SR = Stress relief bend

CP = Constraint point

Figure 5-13 Stress relief part termination

5.4.5.5 Parts with leads terminating on the same side

Stress relief shall be provided by forming the part leads at a bend angle to the PWB of not more than 95°nor less than 45°. (See Figure 5-14).

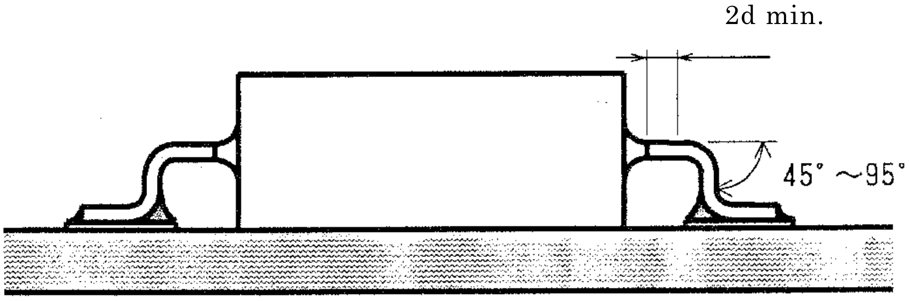


Figure 5-14 Bend angle

5.4.5.6 Parts with leads terminating on both sides

Stress relief shall always be provided in the part lead between the part body and solder termination. When the part lead is used to interconnect opposite sides of a PWB, stress relief or a plated through hole shall be provided (See Figure 5-15).

SR=Stress relief bend
CP=Constraint point

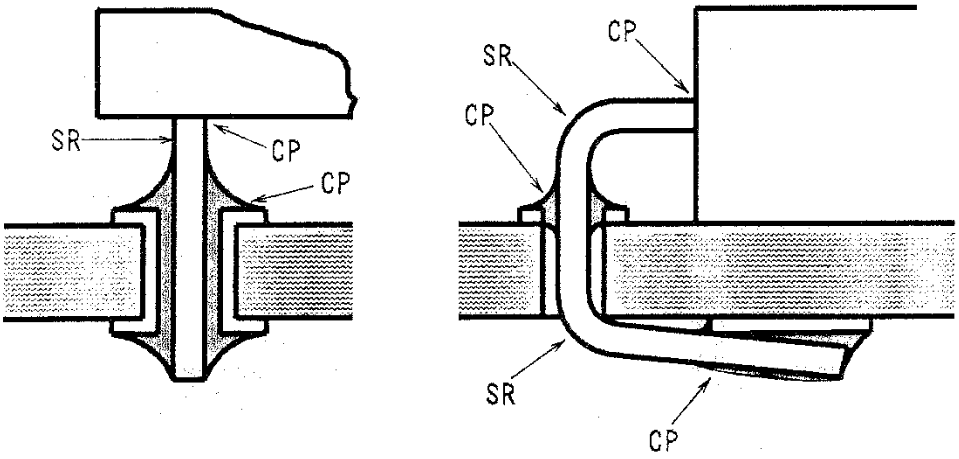
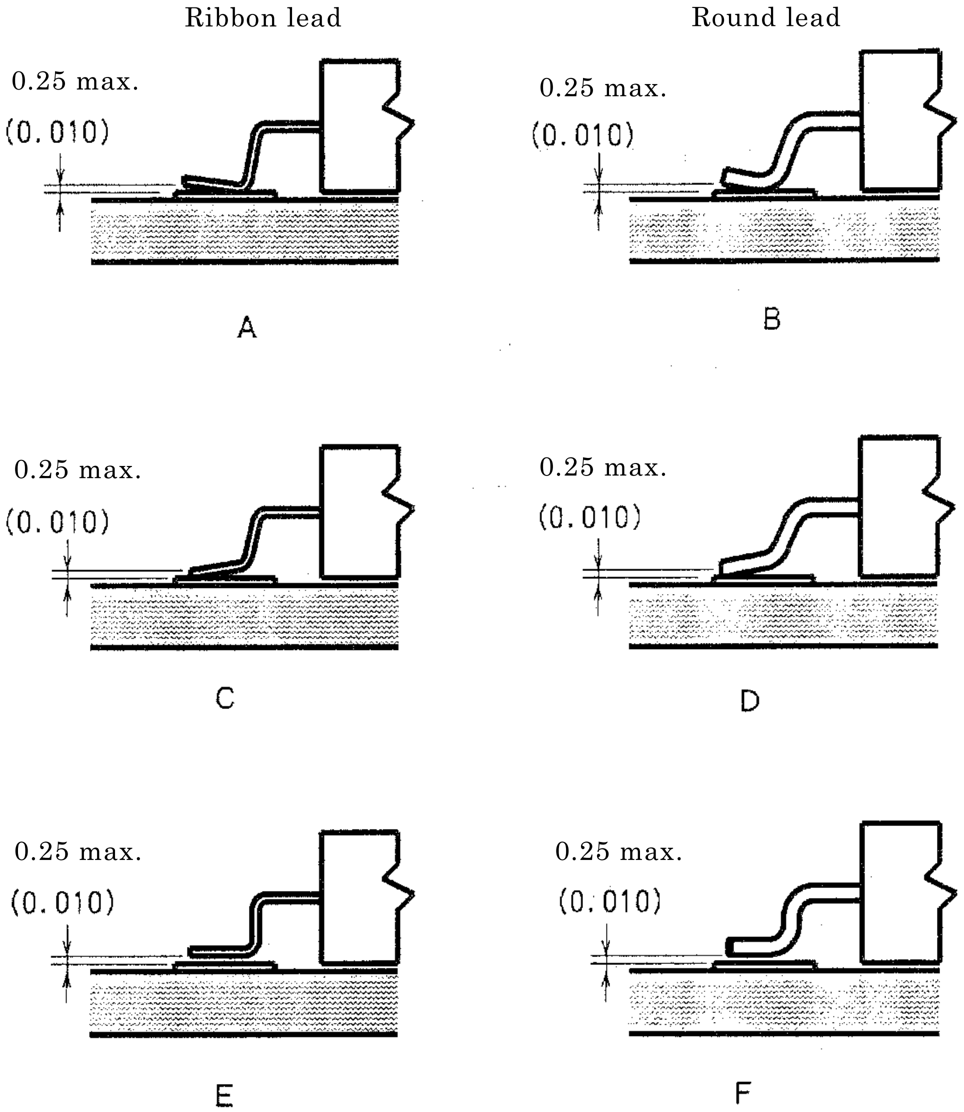


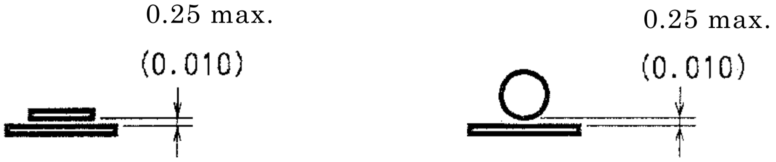
Figure 5-15 Conductors terminating on both sides

5.4.5.7 Lapped terminations

Lapped terminations consist of both round and flat ribbon leads. It is preferred that leads be seated in contact with the termination area for the full length of the foot. Separation between the foot of the lead and the surface of the termination area shall not exceed 0.25mm (0.010 inches)0.25 mm (0.010 in.) (See Figure 5-16).



Side View



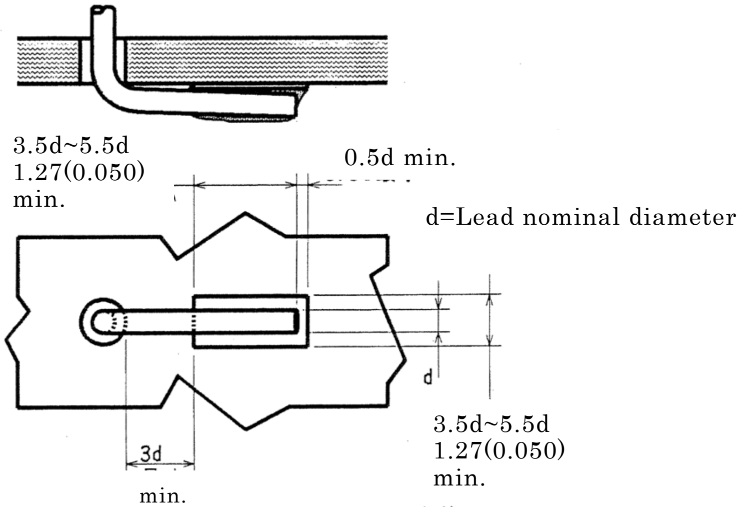
Front View

Dimension in mm (in)

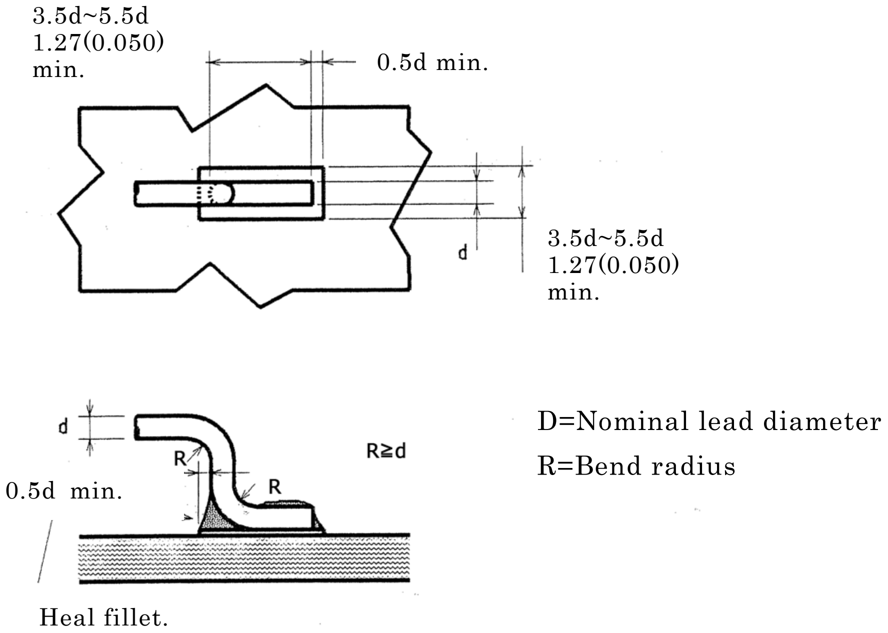
Figure 5-16 Lapped lead height above board

(1) Lapped round leads (See Figure 5-17.)

The round lead shall overlap the solder pad (i.e., land) a minimum of 3.5 times the lead diameter to a maximum of 5.5 times the lead diameter, but in no case shall the length be less than 1.27 mm. The cut-off end of the lead shall be no closer than half the lead diameter to the edge of the solder pad. Only that portion of the lead extending to the part body or to another soldered connection shall be beyond the solder pad. For lapped terminations where the part body is on the same side of the PWB as the solder pad, a heel fillet is mandatory.



A. Mounting along through-hole



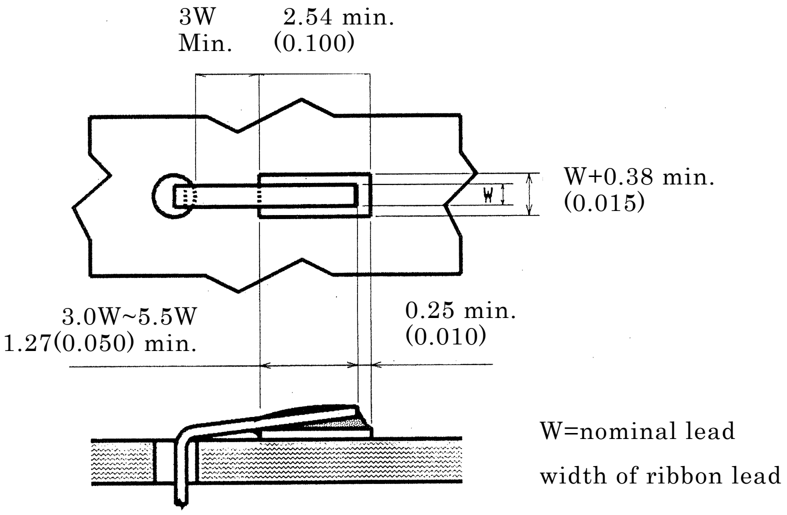
B. Surface mounting

Dimensions in mm (inch)

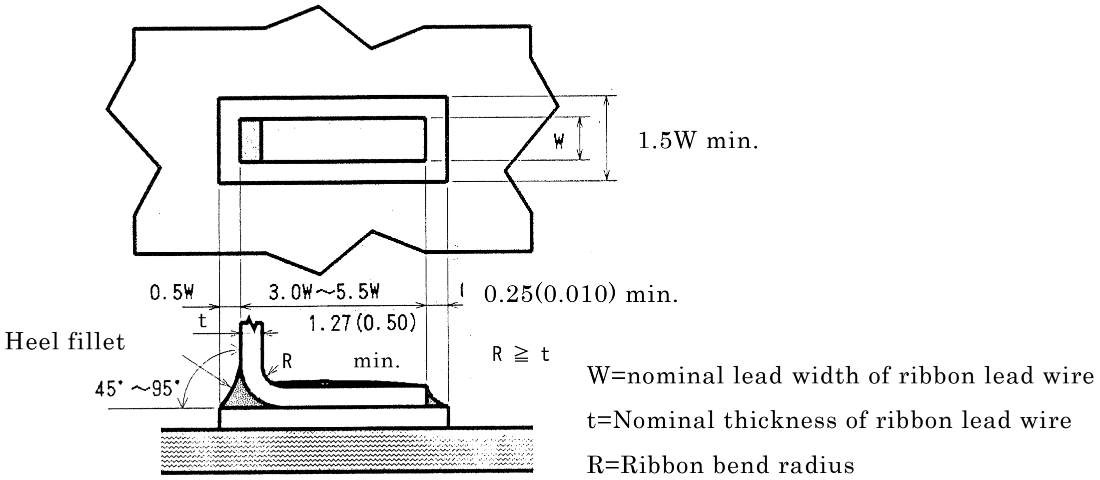
Figure 5-17 Lapped round termination

(2) Lapped ribbon leads (See Figure 5-18)

The ribbon lead shall overlap the solder pad (i.e., land) a minimum of 3.0 lead widths to a maximum of 5.5 lead widths. Only that portion of the lead extending to the part body shall be beyond the pad. The cut-off end of the lead shall be a minimum of 0.25 mm from the end of the pad. One edge of the lead may be flush with the edge of the solder pad. There shall be sufficient area around two of the three lead edges to accommodate solder filleting. If the ribbon lead width is less than 0.5mm, the length shall be 1.27 mm or more. For lapped terminations where the part body is on the same side of the PWB as the solder pad, a heel fillet is mandatory.



A. Mounting along through-hole



B. Single surface lapped termination

Dimensions in mm (inch)

Figure 5-18 Lapped ribbon lead

5.4.5.8 Clinched lead terminations (See Figure 5-19)

The length of the clinched portion of conductors and part leads shall be at least ½ the largest dimension of the solder pad or 0.78mm (0.031 inch), whichever is greater. Lead overhang shall not violate minimum electrical spacing requirements. The lead shall be bent in the direction of the longest dimension of the solder pad. If the pad dimensions are not sufficient, the lead shall be bent in the direction of the printed wire path. There shall be sufficient solder pad area extending beyond the sides of the lead to accommodate solder filleting. Fully clinched leads are defined as leads bent between 75°and 90° from a vertical line perpendicular to the PWB (See Figure 5-20). Non-bendable leads shall not be clinched.

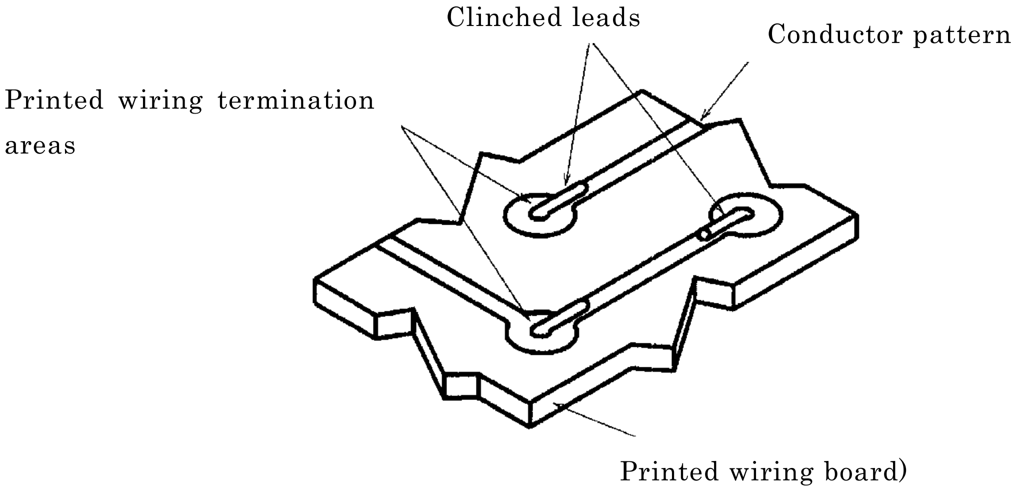


Figure 5-19 Clinched termination

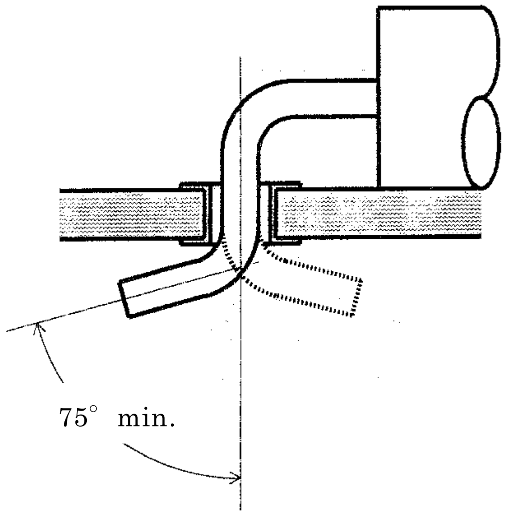


Figure 5-20 Lead bend

5.4.5.15 Straight-through lead terminations

Part leads terminated straight through the PWB shall extend a minimum of 0.5 mm and a maximum of 2.28 mm (See Figure 5-21). The minimum lead length shall be checked prior to soldering (actual measurement is not required except for referee purposes). Straight-through leads may be bent up to 30° from a vertical plane to retain parts during the soldering operation (See Figure 5-22). Non-bendable leads shall not be bent.

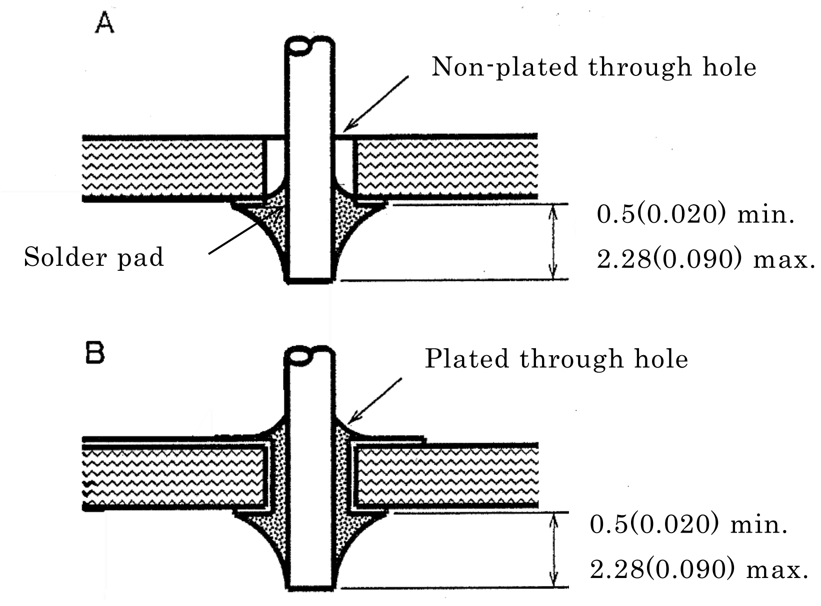


Figure 5-21 Straight-through termination

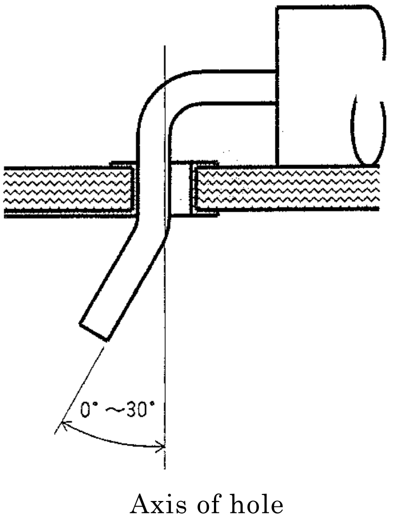


Figure 5-22 Straight-through lead retention

5.5 Attaching conductors to terminals

5.5.1 General

Part leads and wires shall be installed as follows.

(1) Minimum insulation coating clearance

The insulation shall not be imbedded in the solder joint. The contour of the conductor shall not be obscured at the termination end of the insulation.

(2) Maximum insulation clearance

The insulation clearance shall be less than two wire diameters, including insulation, but in no case shall permit shorting between adjacent conductors.

(3) Multiple parallel entry

The insulating coating clearance of the conductors mounted in parallel to one terminal may not be equal.

(4) Special cases

When characteristic impedance or other circuit parameters are affected, as in high-voltage circuits or coaxial line terminations, the insulation clearance requirements may be modified.

(5) Breakouts from wire harness

For multiple conductors routed from a common wire harness to equally spaced soldered terminals, the length of the conductor ends, including bend allowance, shall be uniform to prevent stress concentration on any one conductor.

(6) Mechanical support

Wire harnesses shall be supported so that the solder connections are not subjected to mechanical loads (See Figure 5-23). The methods, means, and location of this support shall be specified on the design engineering documentation.

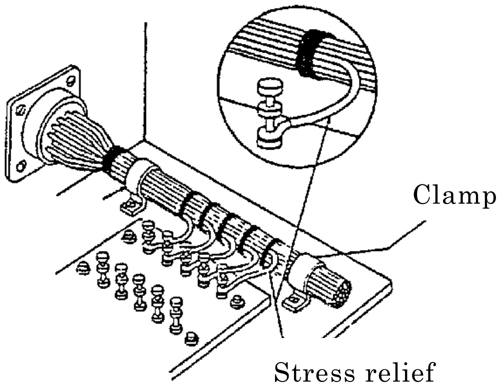


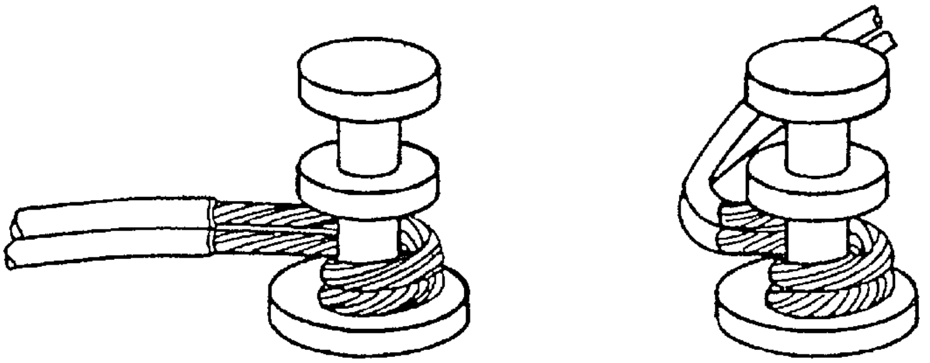
Figure 5-23 Attachment to wire harness terminals

(7) Stress relief

Conductors shall be provided with sufficient slack to preclude tension on the solder termination or conductor.

(8) Wrap orientation

Conductors may be wrapped clockwise or counterclockwise on the terminal. The conductor shall not interfere with the wrapping of other conductors on the terminal. The wrap orientation of a conductor shall be along the direction of the last point of contact between the conductor and the terminal to obtain as neat a finished wrap as possible (See Figure 5-24).



Acceptable

Unacceptable

Figure 5-24 Wrap orientation

(9) Terminal fill

Conductors and part leads shall be in full contact with the terminal. They shall not be wrapped onto each other or extend beyond the top of the terminal.

(10) Parts leads

Part leads shall not be used as terminals unless the part is designed for the lead to function as a terminal.

(11) Mounting of parts to terminals

The mounting of parts shall comply with the requirement of Paragraphs 5.4.4 and Paragraph 5.5.

(12) High-voltage lead wrap

High-voltage lead wraps shall be defined on the engineering documentation.

5.5.2 Turret and straight pin terminal

(1) Side route

The side route shall be connected as follows:

a. Conductors size larger than AWG 26 shall be wrapped a minimum of 180° to a maximum of 270° around the post (See Figure 5-25A).

b. Conductors size AWG 26 and smaller shall be wrapped a minimum of 180° but less than 360° around the post (See Figure 5-25B). However, AWG 30 or smaller conductors may be wrapped three times as a maximum.

The side insertion route shall be connected as follows.

a. Wires thicker than AWG26 shall be wound 180° to 270° around the terminal. (See Figure 5-25A)

b. AWG26 and smaller wires shall be wrapped 180° to 360° around the terminals (See Figure 5-25B).

However, AWG30 and smaller wires may be wrapped not more than three times.

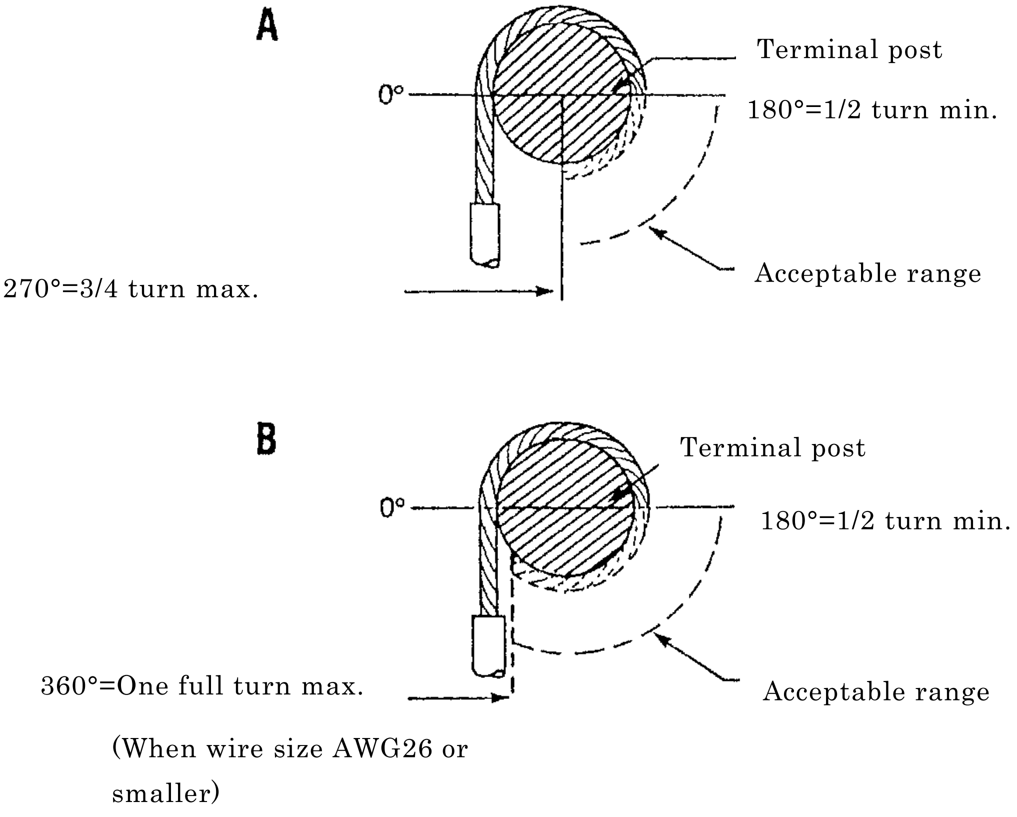


Figure 5-25 Conductor wrap

c. For turret terminals, all conductors shall be confined to the guide slots (See Figure 5-26A).

d. Conductors shall be maintained in contact with the terminal post for the full curvature of the wrap. The conductor ends shall not extend beyond the base of the terminal.

e. More than one conductor may be installed in a single slot of sufficient height. Conductors shall be attached to the flange in order of proximity to the flange. Lead wires shall be connected without having their insulation interfering with each other.

(2) Bottom route

The conductor shall enter the terminal from the bottom, be brought through the side slot at the top, and be wrapped as required for side route (See Figure 5-26B).

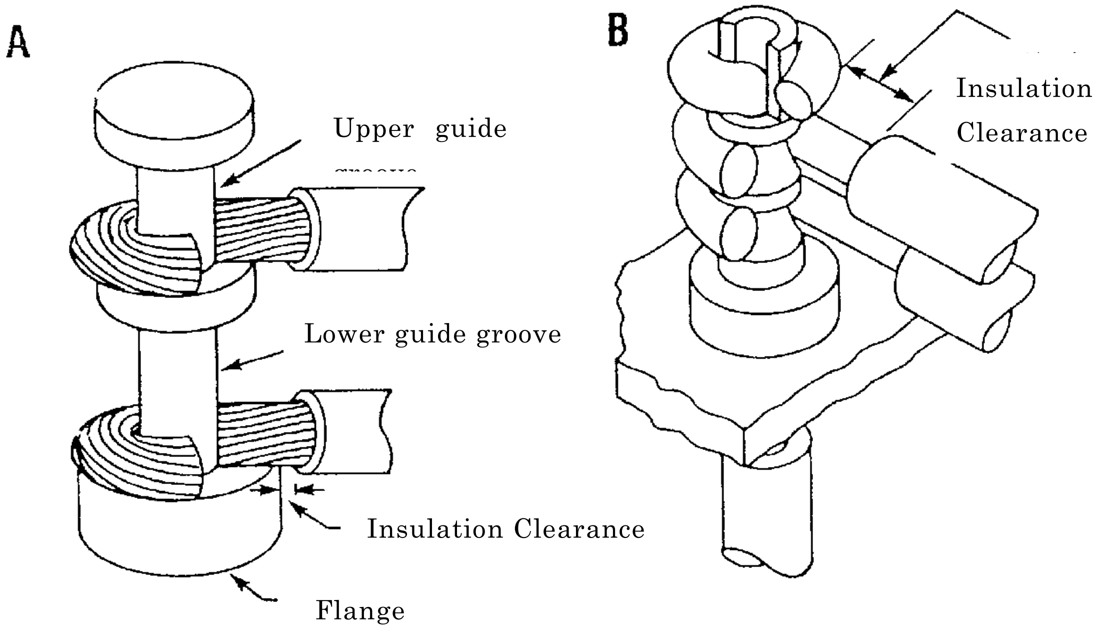


Figure 5-26 Turret terminal

(3) Continuous run wrapping

If three or more terminals in a row are to be connected, a solid jumper wire may be continued from terminal to terminal (See Figure 5-27). The wrap to the first and last terminal of the series shall conform to Paragraph 5.5.2 (1)a or (1)b, depending on the conductor size.

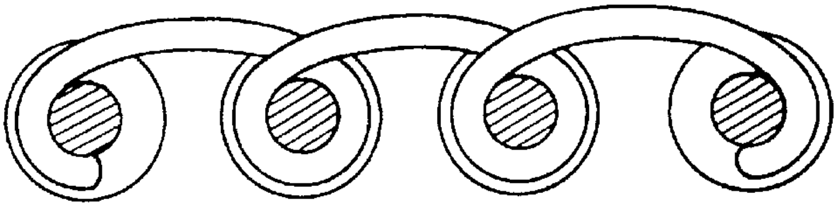


Figure 5-27 Continuous run wrapping - turret terminals

5.5.3 Bifurcated terminal

(1) Bottom route

The bottom route shall be connected as shown in Figure 5-28.

Conductors shall not extend beyond the diameter of the flange, except as shown in Figure 5-28(c), which is acceptable only when physical clearance is adequate for the intended environmental and electrical characteristics. When more than one conductor is to be attached, it shall be inserted at the same time but shall be wrapped alternately around separate posts.

(2) Side route

Side route shall be connected as shown in Figure 5-29.

a. The conductor shall enter the mounting slot perpendicular to the posts.

b. A conductor may lay straight through a terminal slot provided the conductor surface remains in contact with the terminal surface. Where conductors are wrapped on a terminal post, they shall wrap minimum of 90° to a maximum of 180°. (Figure 5-30).

c. Conductors shall be in full contact with the posts and flange.

d. When sufficient vertical space is available, more than one conductor may be installed on a single post provided each conductor is wrapped on the terminal post and not on another conductor. The direction of the bend of each additional conductor shall alternate (Figure 5-29B or D). The order of installation shall be from the side closest to the flange. When differently sized electrical wires are connected to one terminal, the wires shall be connected in the order of size with the thickest wire to the flange side.

e. Conductors shall not extend beyond the diameter of the base of the terminal except where physical clearance will not adversely affect environmental or electrical characteristics. (See Figure 5-29C)

(3) Side and bottom insertion route installation sequence

a. The bottom route shall be installed first as shown in Figure 5-28.

b. Then, the side route shall be installed as shown in Figure 5-29.

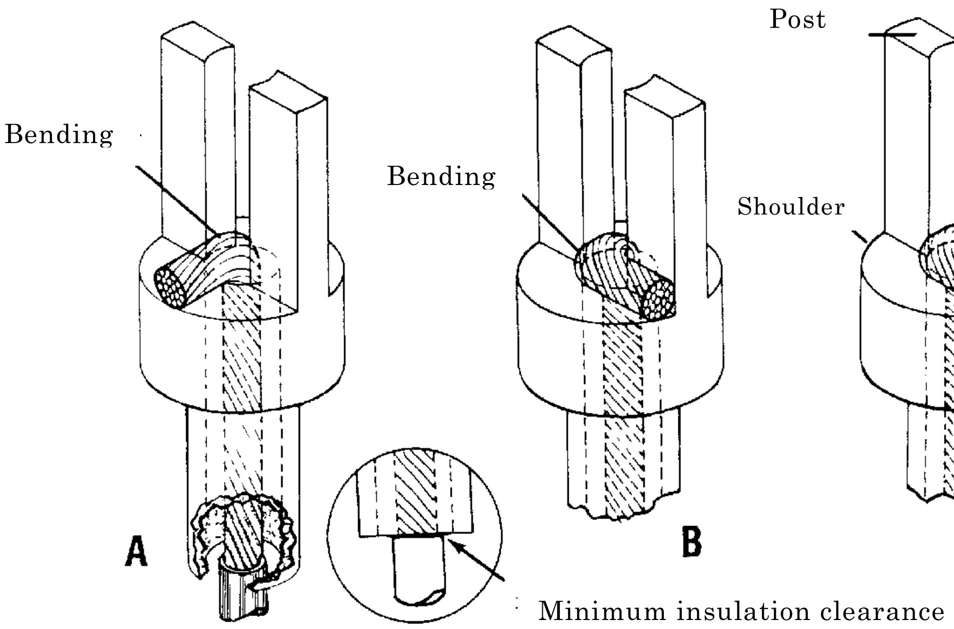


Figure 5-28 Bottom route connections to bifurcated terminals

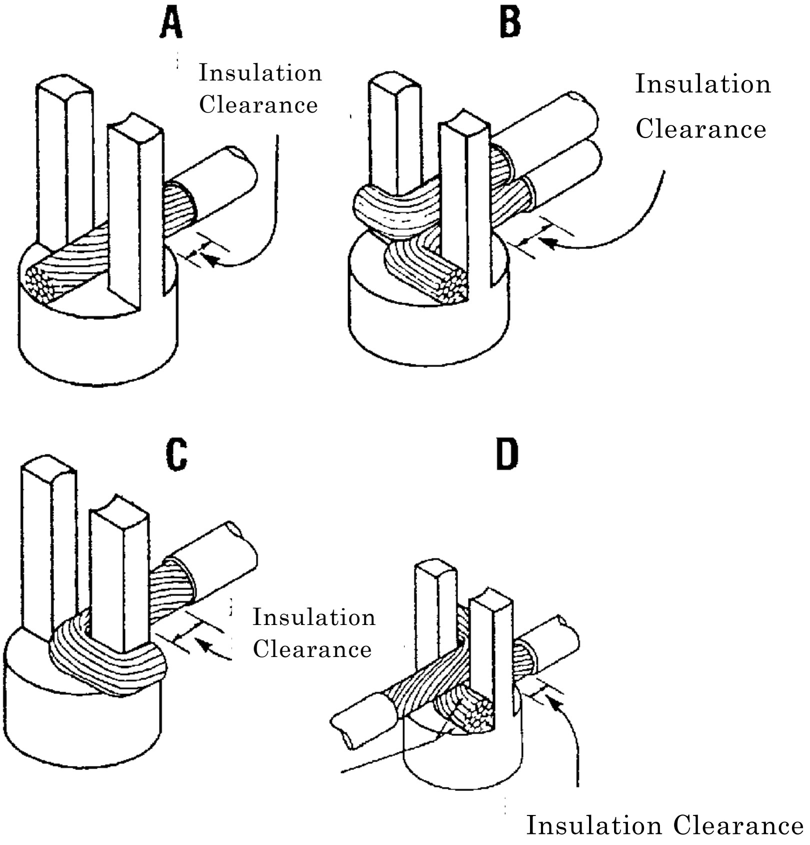


Figure 5-29 Side route connections to bifurcated terminals

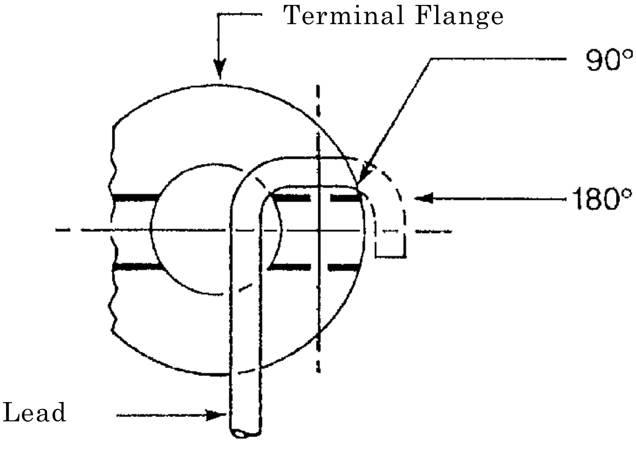


Figure 5-30 Lead wrap

(4) Continuous run connections

When a series of terminals are to be connected to each other, such interconnections shall be made with a solid wire in accordance with Figure 5-31 or 5-32. The wire shall be attached to the first and last terminal in accordance with Paragraph 5.5.3 (2).

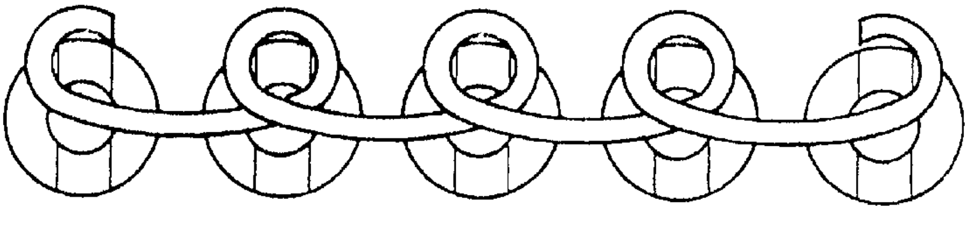


Figure 5-31 Continuous run wrapping/bifurcated terminals

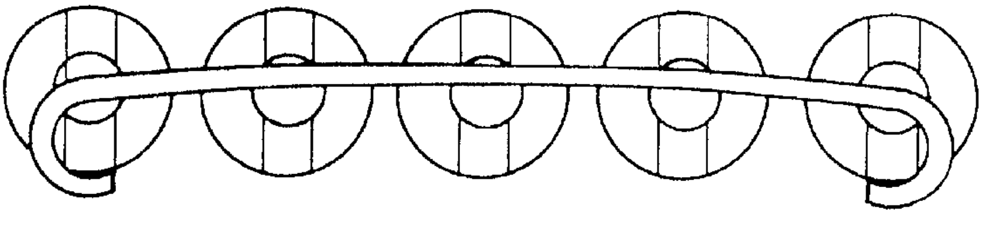
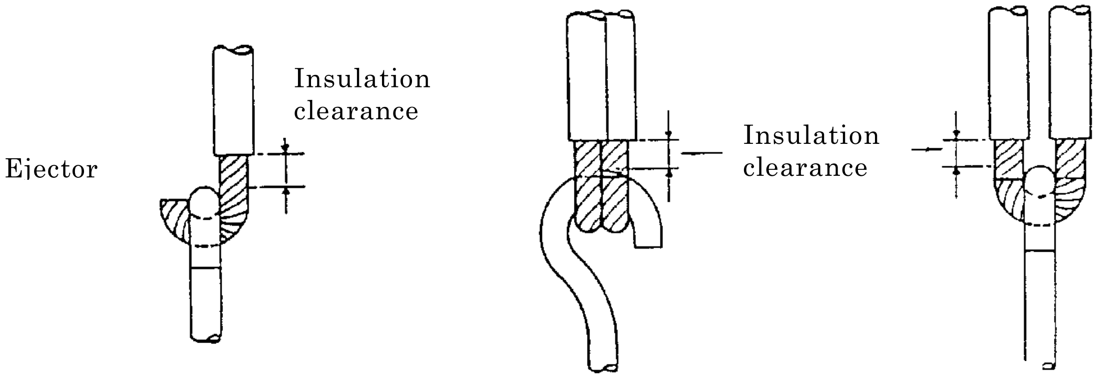


Figure 5-32 Continuous run wrapping /bifurcated terminals alternate procedure

5.5.4 Hook terminal

Connections to hook terminals shall be as shown in Figure 5-33. The bend to attach conductors to hook terminals shall be a minimum of a 1/2 turn (180°) to a maximum of a 3/4 turn (270°). Protrusion of the conductor ends shall be controlled to avoid damage to insulation sleeving. When more than one conductor is connected to the terminal, the direction of the bend of each additional conductor shall alternate. Conductor shall be wrapped directly around terminals, not over conductors.



A Single connection

B Multiple connections
(Winding direction may
be the same method)

Figure 5-33 Connections to hook terminals

5.5.5 Pierced terminals

Connection to pierced terminals shall be in accordance with Figure 5-34. When attaching a conductor to a pierced terminal, the bending shall be from a minimum of 1/4 turn (90°) to a maximum of 1/2 turn (180°). The insulation sleeve shall not be damaged by the protrusion of the wire.

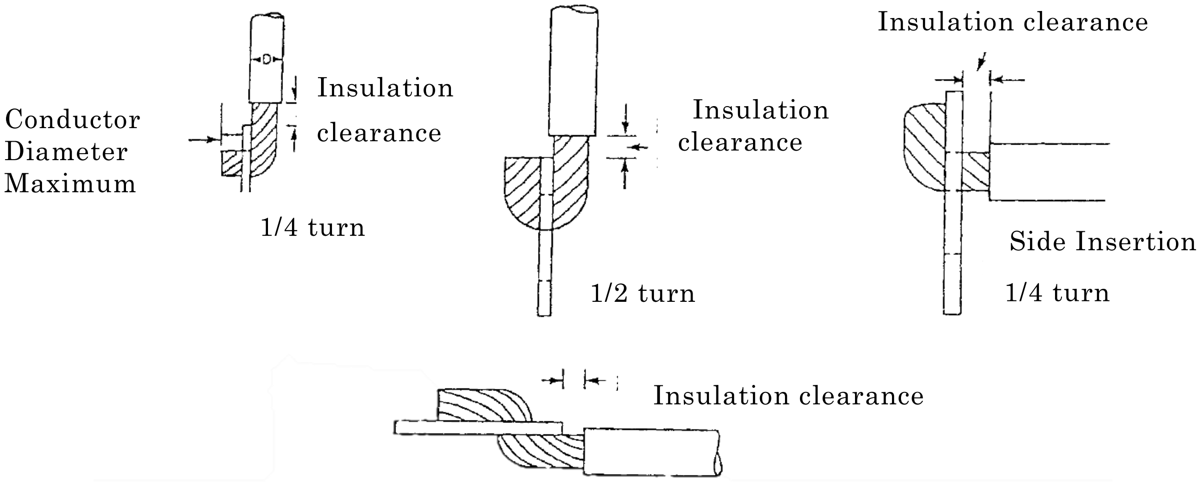


Figure 5-34 Connection to pierced terminals

5.5.6 Solder cup (connector type)

Conductors shall enter the solder cup (connector type) as shown in Figure 5-35. Conductors shall be bottomed in the cup and shall be in contact with the inner wall of the cup. The maximum number of conductors shall be limited to those that can be in contact with the full length of the inner wall of the cup.

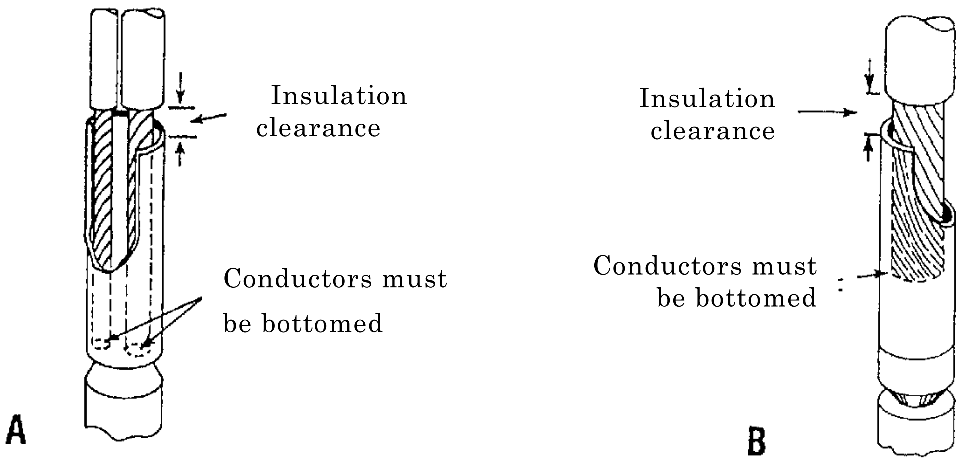
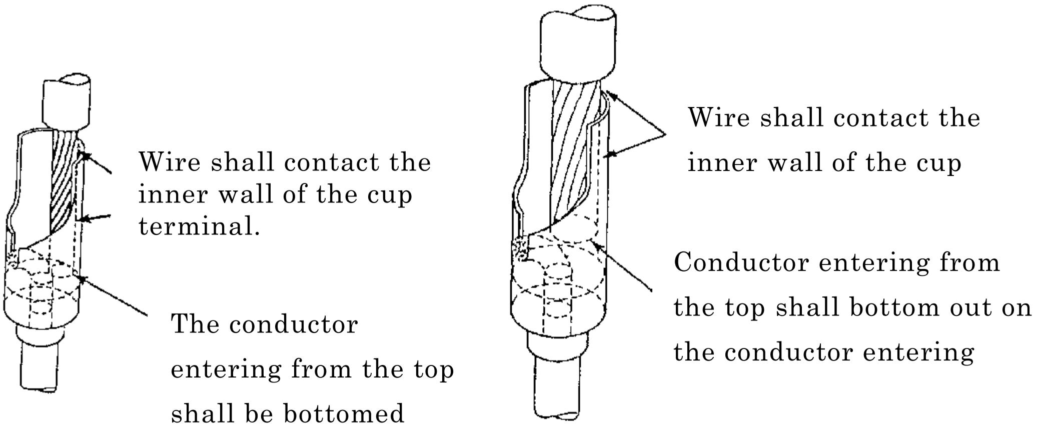


Figure 5-35 Connections to solder cups (connector type)

5.5.7 Solder cups (swaged type)

Connections to the solder cup (swaged type) shall be as shown in Figure 5-36. Conductors entering from the top shall be in contact with the inner wall of the cup and shall bottom in the cup or on the bottom conductor.



A When the top conductor is thin. B When the upper conductor is thick.

Figure 5-36 Connection to solder cups (swaged type)

5.5.8 Insulation sleeving application

All joints required to be covered by insulation sleeving shall be inspected prior and after sleeving. Heat shrinkable insulation sleeving shall be used for electrical insulation as appropriate.

For example, elements, such as hook terminals, solder cups, and bus wires, which are not protected by insulating grommets, potting, or conformal coating, shall be protected by insulation sleeving. Where a part covered by insulation sleeving requires mechanical support, measures shall be taken to ensure that the part is not free to move within the sleeving.

Material selection shall be specified on the engineering documentation. Sleeving shall not be pierced, split, charred, or otherwise damaged.

Whatever type of terminal connectors needs protection, insulation sleeving shall be fitted on conductors prior to soldering and shall only cover completed, cleaned, and inspected solder joints. When finished, both ends of the sleeving shall overlap the wire insulation by a length greater than the diameter of the wire.

- Notes -

1. Extreme care shall be taken to prevent damage to the assembly due to excessive heat while shrinking the sleeving.
2. The sleeving shall be shrunk without discoloration.

5.6 Hand soldering

5.6.1 General

(1) Securing conductors

There shall be no relative motion between conductors, terminals, and PWB termination areas during solder application and solidification. Conductors shall not be temporarily constrained against spring-back force during solder solidification that may produce residual stress in the joint.

(2) Heat shunts

Thermal shunts shall be used when heat applied during the soldering operations may degrade conductors, insulation, parts, or previously soldered connections.

(3) Inspection

Inspection criteria for inspection are listed Paragraph 5.8.4.

(4) Dip Soldering

Manual dip soldering of PWBs shall be prohibited.

(5) Pattern repair

Repair of damaged or broken conductor patterns on PWBs shall be prohibited.

(6) Cooling

Pressurized air shall not be used to cool solder joints. Connections shall be cooled at room temperature only.

(7) High voltage

High voltage connections where corona suppression is necessary shall be specified in the engineering documentation. Where soldering of high voltage connections is required, all elements of the connection shall be covered by a smooth fillet and free of discontinuity or severe change in contour.

(8) Soldering iron tip selection and temperature setting

Some parts that require soldering may have restrictions regarding heating temperature and heating time. Soldering iron tips and soldering temperature shall be selected as per the parts soldering requirements and the shape, material, and surface treatment requirements for solder joints.

(9) Soldering flat surfaces together

When a flat surface is soldered to another flat surface (e.g., PWB to ribbon lead), voids (residual air voids) often occur in the middle of the bonded interface. Appropriate measures, such as the following, shall be taken to prevent residual air void formation in the bonded interface:

- One-way solder application.
- The flat surfaces shall be slid (i.e., scrubbed) back and forth, left to right, to spread the solder all over before solder solidification.
- An air hole shall be opened in the middle of the flat conductor to be soldered.

5.6.2 Heat application

(1) A soldering iron tip shall be applied to the solder work surface so that the surface will reach the soldering temperature in the minimum required time.

(2) Soldering heat shall be applied carefully to prevent damage to the circuit, insulation, or adjacent parts. Thermal shunts shall be used where thermally sensitive parts may be affected by soldering heat.

- Notes -

Charred, molten, or burned parts shall be replaced.

(3) When a solder work surface has high thermal capacity, an appropriate supplementary heat source shall be used.

(4) A solder work surface shall be properly preheated prior to solder application.

5.6.3 Solder application

5.6.3.1 Soldering to terminals

(1) Solder fillets

A fillet of solder shall be formed between the terminal and each side of the conductor except when item a below applies:

a. Cup terminals

The solder shall form a fillet between the conductor and cup entry slot. The fillet shall follow the contour of the cup opening within the limits illustrated in Appendix II. Solder on the outside surface of the solder cup may be permissible to the extent that it approximates tinning and does not interfere with the function of the assembly or the connector.

b. Contacts (See Figure 5-37.)

There shall be good wettability between the electrical wire or the lead and the cup. Solder protruding from the outer surface of the solder cup shall take the form of thin film. The solder shall be visible through the inspection hole. The solder spillage shall be permissible to the extent that it has a slight rise from the inspection hole. The solder spillage shall not extend beyond the inspection hole to the side face of the cup.

(2) Solder joint-to-insulation clearance

Insulation shall not be embedded in the solder joint but shall be removed so that the insulation termination end does not interfere with visual access to the contour of the conductor. The clearance from the insulation termination end to the solder joint shall not exceed twice of the insulation diameter. The general rule of thumb is that the clearance shall be approximately equal to the outer diameter of the insulation. The conductor, however, shall not be short-circuited with other adjacent conductor.

(3) Wicking

Flow (wicking) of solder along the wire is permitted. Solder shall not make the presence of the individual wire strands indistinguishable. An increased flow (wicking) of solder along the wire increases the rigidity of the wire, making the solder prone to cracks due to bending.

(4) High temperature soldering

For soldering operations where terminals are to be subsequently reheated, the use of high temperature solder is permitted. The solder used shall conform to the requirements specified in Paragraph 5.2.1.

(5) High voltage connections

Where the engineering documentation requires the soldering of high voltage connections, the solder joints shall be spherical after normal soldering and inspection. Spherical solder joints shall have a smooth surface, free of discontinuities or abrupt changes in contour (See Figure 5-38).

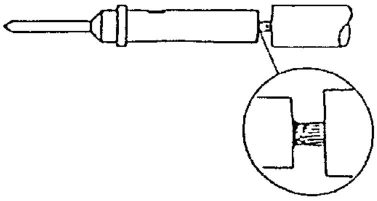
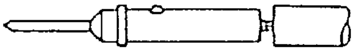
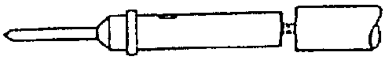
Accept	- Solder visible thru inspection hole - Good wetting between the wire or lead and cup - Thin film of solder spillage extending along the outside surface of cup	
	- Solder having a slight rise from the opening of the inspection hole - Good wetting between wire or lead and cup	
Reject	- Excessive solder spillage onto the outside surface - Non-wetting between wire or lead and cup	
	- Solder invisible thru the inspection hole - Non-wetting between wire or lead and cup	

Figure 5-37 Soldering of electrical wire and lead to contact

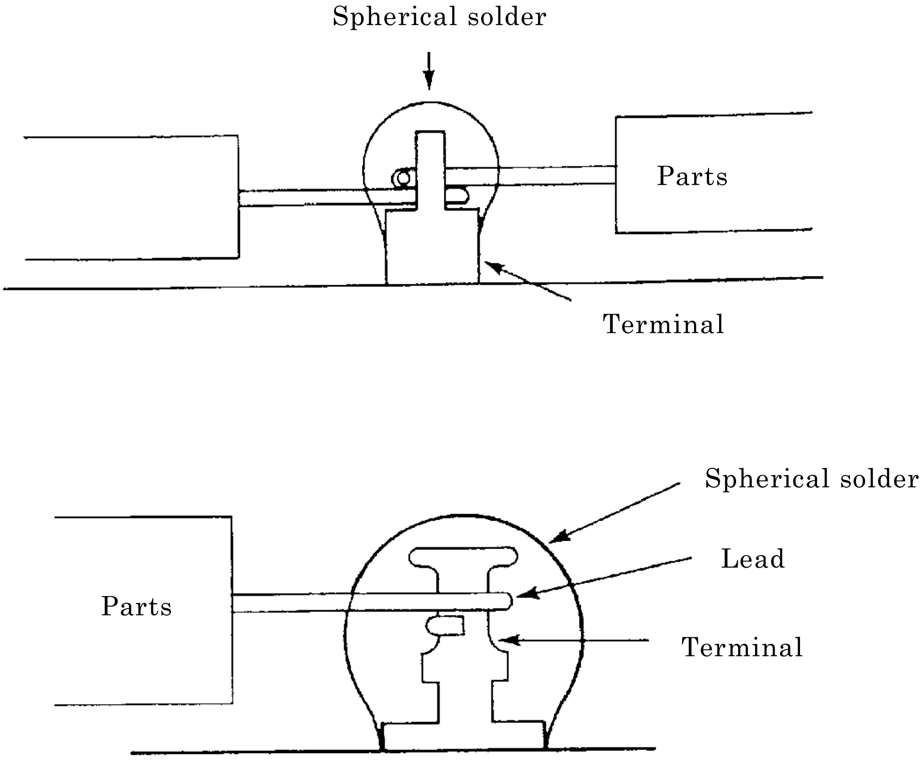


Figure 5-38 Solder-ball termination

5.6.3.2 Non-plated-through-hole soldering

Solder fillets shall be complete and as shown in Figures II-1 through 3 in Appendix II.

5.6.3.3 Plated-through-hole soldering

(1) In soldering a conductor into a PTH, heat may be applied to either or both sides of the PTH, but solder shall only be applied to one side.

(2) On the solder application side of PTH

The quantity of solder shall meet all requirements established by this document.

(3) For the connection on the PTH side opposite from the solder application

The solder quantity shall, as a minimum, exhibit flow-through and bonding of the lead or conductor to the solder pad; but not necessarily wetting out to or around the entire periphery of the solder pad. A slight recessing or shrinkback of the solder into the PTH below the solder pad shall be acceptable, providing the solder has obviously wetted the lead and solder pad and the shrinkback is slight enough that it cannot be construed to be a solder void or blow hole.

- Notes -

Great care shall be taken in soldering adjacent to a wide-area conductor pattern, e.g., ground plane, or a heat sink that absorbs heat from molten solder and obstructs solder flow.

5.6.3.4 Lap terminations

(1) A heel fillet is mandatory for all single surface lapped solder joints. The heel fillet shall have a thickness of "solder thickness + lead thickness" as a minimum and shall be continuous between the heel of the lead and the termination pad (land). The heel fillet shall extend beyond the lower bend radius but shall not extend into the upper bend radius (See Figure 5-39).

(2) Round lead lap terminations shall require a complete solder fillet around all sides of the lead (See Figure 5-40).

(3) On ribbon lead lap terminations where one side of a lead is allowed to be flush with the edge of the termination pad (land), a filet of solder shall be formed along the opposite side and the cut edge.

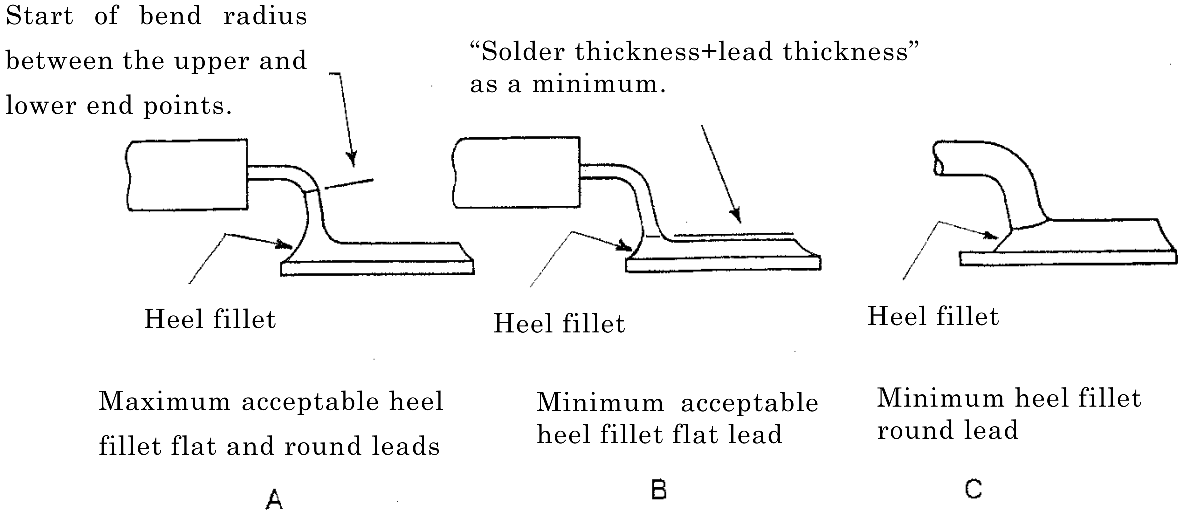


Figure 5-39 Heel fillet

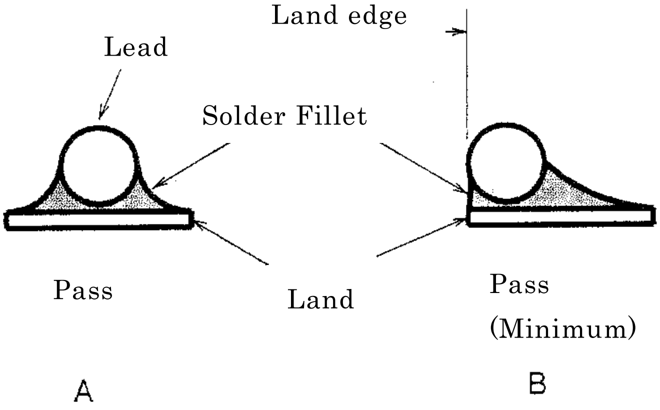


Figure 5-40 Round lead termination

5.6.4 Solder cleaning (after hand soldering)

(1) The process documentation shall specify appropriate cleaning methods and procedures.

(2) Interim cleaning

Soldering leaves residues, such as rosin solids contained in the flux. The residues shall be removed during interim cleaning within 30 minutes after soldering by applying an approved solvent as specified in paragraph 5.2.3. Solvents shall be applied in a manner that will minimize wicking of the solvent under conductor insulation and prevent its entry into the interior of parts.

(3) Final cleaning

Brushing may be used in conjunction with the solvents. The cleaning solvents and methods used shall have no deleterious effects on the parts, PWBs, or solder joints. Ultrasonic cleaning shall not be used for cleaning PWAs that contain IC's, diodes, transistors, and other electronic parts. After cleaning, there shall be no visible evidence of flux residue or other contamination when examined. Where the engineering documentation specifically prescribes high electrical insulation requirements, refer to JERG-0-039-TM001 Appendix: Technical Data 1.

(4) Cleaning of conformal coated assemblies

Conformal coated assemblies that require rework shall not be submerged in cleaning solvents. Cleaning shall be limited to the area of rework.

5.6.5 Rework

(1) Before removing a conductor, the solder joint shall be left to cool down to room temperature. Heat shall be applied without damaging the circuit, insulation, or adjacent parts. Parts shall be removed carefully without damaging PWBs.

(2) Solder shall be removed using wicking wires, etc. Use of vacuum solder removal

is not recommended. If use of vacuum solder removal is unavoidable, personnel shall be properly trained to be capable of solder removal using the correct procedures and appropriate tools.

(3) Flux residues shall be removed from solder joints by cleaning.

(4) Resoldering shall be performed as per the rules herein.

(5) Unless otherwise instructed, any soldered portions shall be repaired as per the nonconformity handling procedures compliant with the contract. For the repair method, refer to JERG-0-039-TM001 Appendix: Technical Data 8.

5.7 Wave soldering

5.7.1 Wave soldering process control

Where wave soldering is required, the process documentation shall specify the following items to ensure proper process control:

(1) Preheat temperature applied to PWB
(2) Temperature of solder in solder bath
(3) PWB transfer conveyor speed and angle
(4) Solder-wave height
(5) Flux density
(6) Flux height
(7) Depth of PWA in wave
(8) Control of dross inhibitors
(9) Allowable contaminants when the solder bath is analyzed
(10) Frequency of maintenance and of analysis
(11) Other factors affecting the quality of the connections in the end product. Maintenance and calibration data shall be made available for inspection.

5.7.2 Materials

Materials to be used for wave soldering shall conform to the following requirements:

(1) Solder

Solder to be used shall have the composition indicated in paragraph 5.2.1 and conform to J-STD-006 Type O (equivalent to Type S) or JIS Z 3282 or equivalents.

(2) Flux

Liquid flux to be used shall be liquid rosin flux meeting the requirements per paragraph 5.2.2. Normally, isopropyl alcohol shall be used as a thinner solution and shall be compatible with the specifications of the liquid rosin flux.

(3) Solvents

PWAs shall be cleaned using solvents or cleaners per paragraph 5.2.3. The use of wetting agents shall be followed by thorough deionized water rinsing and drying. PWAs shall then be kept dry until conformally coated.

5.7.3 Preparation and assembly

(1) Only electroplated solder coated and fused conductor patterns or solder coated conductor patterns shall be used in wave soldering of PWB. Part leads shall be tinned.

(2) Parts shall be mounted to meet the requirements per paragraph 5.4. Due caution shall be exercised in parts mounting to prevent relative motion between the part and board during solder solidification. If temporary clamping is used, it shall not result in residual solder joint stresses from lead spring-back forces.

(3) PWB's shall be cleaned and de-moisturized prior to wave soldering. The drying time and temperature shall be set as appropriate for the PWAs to be dried and shall be specified in the process documentation. The drying shall be performed within eight hours after wave soldering. Drying time and temperature, and the time in and out of the oven or chamber shall be recorded. . PWB's may be stored for longer periods of time in a controlled moisture free atmosphere.

(4) Metal surfaces that are not to be soldered shall be masked or coated with solder resist prior to loading onto the carrier.

5.7.4 Process condition settings

(1) Samples to be used for condition parameter setting

The wave soldering parameters listed above in Paragraph 5.7.1 shall be set prior to wave soldering of products. These condition parameters shall be set using samples equivalent to the PWAs used in the products.

(2) Flux application

Liquid flux shall be applied by dipping, spraying, brushing, rolling, or wave or foam flux application to form a thin coating layer on the surface. The concentration of the flux shall be specified in the process documentation and shall be periodically measured and controlled within the permissible range.

(3) Preheating of PWB

PWB shall be preheated appropriately within the range of 71°C to 107°C. The preheating temperature shall be measured at points preselected appropriately for the types of the PWBs.

- Note –

To prevent molten solder from scattering, flux shall be dried prior to wave soldering until tacky-dry.

(4) Conveyor speed

The conveyor speed shall be controlled to a preselected rate, which shall not vary more than 25 mm per minute. An improperly set conveyor speed will lead to overheating or insufficient heating, thereby resulting in solder spikes or bridges, a reduced solder bond strength, or degradation of parts.

(5) Solder temperature

The temperature of molten solder for wave soldering shall be controlled so that the solder in the wave making contact with the PWB falls within the range of 230°C ± 3°C to 280°C ± 3°C. The temperature shall be set optimally for the conveyor speed.

(6) Solder wave height

The height of the solder wave shall be controlled to a constant preselected height. A variable solder wave height will result in variations in solder dip time, thereby affecting the solder bond strength.

(7) Contaminants in solder bath

The solder bath shall be controlled on an established schedule, based on usage, to ensure it meets the requirements of Table 5-1. Anytime the solder produces a dull, frosty, or granular appearance on the work, the bath shall be immediately removed from use.

(8) Process log

Before feeding the product into the wave soldering machine, the wave soldering conditions for each type of product shall be checked and set properly for operation. A wave soldering log shall be recorded showing the preheating temperature, conveyor speed, solder temperature range, wave height, and room temperature for each PWB type. The log shall also be used to document results of periodical analyses prescribed above in paragraphs 5.7.4 (2) and (7).

(9) Other

The solder bath shall be electrically grounded.

5.7.5 Solder cleaning (after wave soldering)

(1) The process documentation shall specify appropriate cleaning methods and procedures.

(2) As soon as possible after soldering, the flux, dross inhibitor, temporary solder resist, and other contaminants shall be removed by cleaning with solvents, etc. The cleaning shall not damage the hardware or make part markings illegible. Evidence shall be left if markings other than indelible ink may disappear.

This shall be accomplished by use of an appropriate solvent meeting the requirements per paragraph 5.2.3, followed by rinsing with clean solvent to ensure complete removal of the residues.

(3) To verify the adequacy of cleanliness after the final rinsing, a periodic inspection

interval shall be determined according to which the resistivity or the degree of NaCl equivalent ionic contamination shall be monitored. The inspection interval shall be set as appropriate for the size and quantity of the PWBs. Refer to JERG-0-039-TM001 Appendix: Technical Data 1 for the evaluation method and criteria for the cleaning.

5.7.6 Rework

Rework and other reprocessing after wave soldering shall be performed as per paragraph 5.6.5.

5.8 Quality assurance

5.8.1 Document control

Ensure that the required documents are maintained to the latest version and implemented.

(1) Incorporation of the requirements herein into the design standard, process specifications, work procedures, inspection procedures, etc. (paragraph 4.1)
(2) Training and certification of operators and inspectors (paragraph 4.2)
(3) In-process handling and storage (paragraph 4.5.2 (1))
(4) Electrostatic discharge control program (paragraph 4.5.3)
(5) Tool and equipment operating procedures (paragraph 5.1.1 (3))
(6) Calibration system (paragraph 5.1.1 (4))
(7) Use of supplementary heat sources (paragraph 5.1.2 (5))
(8) Flux usage (paragraph 5.2.2 (4))
(9) De-moisturizing of PWB (and PWA) (paragraphs 5.3.1 (3) and 5.7.3 (3))
(10) Wave soldering procedures (paragraph 5.7.1)
(11) Cleaning procedures (paragraphs 5.6.4 (1) and 5.7.5 (1))

5.8.2 Records

Ensure that the required records are properly maintained.

(1) Results of the vision examination (paragraph 4.2)
(2) Temperature and humidity monitoring (paragraph 4.5.1 (2))
(3) Tools and equipment calibration (paragraph 5.1.1 (4))
(4) De-moisturizing of PWB (and PWA) (paragraphs 5.3.1 (3) and 5.7.3 (3))
(5) Special inspection of nonconforming proximity of tinning to part bodies (paragraph 5.3.5 (5))
(6) Solder pot and bath analyses (paragraphs 5.3.6 and 5.7.4 (7))
(7) Wave soldering log (paragraph 5.7.4 (8))
(8) Monitoring of resistivity or NaCl equivalent ionic contamination (paragraph 5.7.5 (3))

5.8.3 Verification of tools, equipment, and materials

(1) Tools and equipment

All tools and equipment shall be verified for conformance to the applicable requirements as found in paragraph 5.1.

(2) Materials

All materials shall conform to the requirements of paragraph 5.2. Material controls shall be implemented to ensure that only conforming materials are used. Materials not conforming or not required for the operations involved shall be removed from the work area or tagged non-usable.

5.8.4 Inspection

5.8.4.1 General

Inspection for acceptability shall be performed on all solder connections, parts mounting and conditions, conductor routing, and PWB features. Parts and conductors shall not be physically disturbed to aid inspection. Visual inspection of all soldered connections and adjacent areas shall be performed using magnification of 4x to 10x (10x wherever suspicious). Depending on the nature of the suspicion, JAXA shall be consulted for use of additional magnification (Note, however, that additional magnification shall not be overused at the expense of inspection of the entire solder joint and adjacent area.) Inspection optics shall conform to the requirements of paragraph 5.1.5.

Where visual inspection is not possible, other appropriate nondestructive means (e.g., laminography, microfocus X-ray, fiberscope optics) shall be used.

The accept/reject criteria for the appearance of solder joints shall be as per paragraphs 5.3 through 5.7 and the paragraphs to follow. Appendix II shows the boundary samples of typical solder joints.

5.8.4.2 Acceptance criteria

(1) The appearance of the solder joint surface shall be smooth and shall have a finish that may vary from satin to bright depending on the type of solder used.

(2) Solder shall wet all elements of the connection, except as noted item (5) below. The solder shall fillet between connection elements over the complete periphery of the connection as shown in the figures in Appendix II.

(3) A heel fillet is mandatory for all lapped solder joints.

(4) The lead contour shall be visible (except for high-voltage connections. See paragraph 5.6.3.1 (5)).

(5) PTH soldering:

a. On the solder application, the quantity of solder shall meet the requirements established by this document.

b. On the side opposite from the solder application, the solder quantity shall, as a minimum, exhibit flow through and bonding of the lead or conductor to the solder pad. However, the following cases are acceptable.

- A slight recessing or shrink-back of the solder into the plated through-hole (except for those regarded as caused by voids or blow holes)
- Slight de-wetting of the solder around the periphery of the pad on the part side of the PWB

(6) Support for wires as identified on the engineering documentation.

(7) The presence of stress relief in leads or conductors to provide freedom of motion between points of constraint.

(8) Support for parts as identified on the engineering documentation.

(9) Part markings visible and legible, or evidence available.

(10) Exposed ends of leads on straight-through terminations after soldering shall not be cause for rejection if the PWB is to be conformally coated.

(11) Absence of defects listed in Paragraph 5.8.4.3.

5.8.4.3 Rejection criteria

The following are some characteristics of unsatisfactory condition for solder joints, any of which are cause for rejection:

(1) Conductors and parts

a. Nicks, cuts (rubbing or slight indentation of the coating terminal by mechanical stripper, etc. is acceptable), or charring of insulation (slight discoloration from thermal stripping is acceptable).

b. Improper insulation clearance.

c. Improper tinning of part leads or conductors.

d. Separation of wire strands (bird caging).

e. Part improperly supported or positioned (polarity, centering, planarity).

f. Improper vertical mount of component (clearance)

g. Cut, nicked, stretched, or scraped leads or wires exposing the base metal (except smooth impression marks resulting from bending tool holding forces)

h. Flux residue or other contaminants

Trace flux residues shall be acceptable if evaluation data obtained from a electrochemical migration resistance test provide objective engineering evidence demonstrating that the flux residues produce no adverse effects.

i. Improper wrap or stress relief.

j. Epoxy on un-sleeved glass parts.

k. Unsupported hookup wires in excess of 25 mm length. (See Appendix I)

l. Swaging not in accordance with paragraph 5.4.3.

m. Improper lead bending or cutting.
n. Splices used to repair broken or damaged conductor.
o. Breakout of conductors from wire bundles not in accordance with paragraph 5.5.1 (5)
p. Part leads used as terminals (except when designed as a terminal)
q. Terminals or wires modified to fit.
r. Improper clinch length.
s. Improper lead protrusion through PWB.
t. Gaps between part leads and solder pads on lapped terminations.
u. A part obscuring the solder termination of another part (unless interim inspection was performed)

(2) Solder connections

a. Cold solder connection.
b. Overheated solder connection.
c. Fractured or disturbed solder connection.
d. Poor wetting.
e. Blowholes, pinholes, and voids (except pits defined in Appendix I)
f. Excessive solder (solder in the bend radius of axial leaded parts in PTHs is not cause for rejection, provided that the lead is properly formed, the topside bend radius is discernible, and the solder does not extend to within one lead diameter of the part body or end seal).
g. Insufficient solder.
h. Splattering of flux or solder on adjacent areas
i. Rosin solder joint
j. Contamination (e.g., lint, flux, dirt).

Unless otherwise specifically instructed on foreign substance, immovable foreign substance (that immovable with application of a small external force via, e.g., a bamboo skewer) may be made tolerable by coating if the minimum pattern interval minus diameter of the foreign substance meets the required minimum conductor interval.

k. De-wetting
l. Non-wetting
m. Part body (meniscus) in solder joint

(3) Printed wiring board

a. Separation of the conductor pattern from substrate
b. Burns on substrate

c. Discoloration that bridges uncommon conductors (e.g., measling, halo effect).

d. Solder peaks, icicles, and bridging on conductor patterns.

e. Cut, nicked, gouged, or scraped printed wiring conductor that exposes base metal.

f. Cut, nicked, gouged, or scraped substrate that exposes PWBs glass fibers.

g. Delamination of the PWB substrate.

h. Solder mask tackiness, flaking, or separation from the substrate or conductors. Necessity of repair (touch-up) on the peeled solder resist shall be determined as per Table 5-2. Note, however, that neither of the following shall be considered nonconforming: a solder-coated resist with slight peeling*1 that occurred around a soldered land during soldering or a printed wiring assembly to be conformally coated. If extending between patterns and exposing the conductor underneath, a solder resist peeling area shall be touched up upon detection, small or not or conformally coated or not.

i. Repaired or damaged printed wiring conductor pattern.

j. Blisters

Table 5-2 Necessity of touch-up of peeled solder resist

Location of peeling	Slight peeling*1	Non-slight peeling*1
On Conductor	Necessary*2	Necessary
Outside conductor	Unnecessary	Necessary
Scratched conductor	Reject	Reject

*1 : Slight peeling (of permissible size) means partial peeling occurring within 1 mm around the perimeter of the land.

*2: No touch-up necessary if conformally coated.

6. NOTES

(1) For Primary data of evaluation test regarding soldering process, and Study of the test results, refer to JERG-0-039-TM001 Appendix: Technical Data 2~11.

(2) Relevant referenced documents are listed in Appendix III.

Appendix I Terms and definitions

The terms and definitions used in this standard are as follows.

A

Axial leaded part

A part with leads extending from both axial end surfaces.

B

Bifurcated (split) solder terminal

A terminal with a slot or split opening in which conductors are placed before soldering.

Birdcage

A defect in stranded wire where the strands in the stripped portion between the covering of an insulated conductor and a soldered connection (or an end-pretinned lead) have separated from the normal lay of the strands.

Blister

A raised area on the surface of the laminate caused by the pressure of volatile substances entrapped within the laminate.

Blow hole

A cavity in the solder surface whose opening has an irregular and jagged form, without a smooth surface. (A defect caused by blowout of gas, associated with an excessive gap between soldered parts, moisture absorption by the PWB, or improper cleaning after plating.)

Bridging

A buildup of solder between parts, part leads, or PWB conductors that forms an undesired conductive path.

C

Cold solder connection

A solder joint exhibiting poor wetting and a grayish, porous appearance due to insufficient heat, inadequate cleaning prior to soldering, or excessive impurities in the solder.

Conformal coating

A thin electrically nonconductive protective coating applied to parts-mounted PWBs or

PWAs for the purpose of moisture-proofing or insulation.

Contaminant

An impurity or foreign substance present in a material that affects one or more properties of the material. A contaminant may be either ionic or nonionic. An ionic, or polar, compound forms free ions when dissolved in water, making the water a more conductive path. A nonionic substance does not form free ions, nor increase the water's conductivity. Ionic contaminants are usually processing residue such as flux activators, fingerprints, and etching or plating solutions.

Crazing

An internal condition occurring in the laminate base material in which the glass fibers are separated from the resin.

Cup terminal

A cylindrical terminal (e.g., solder-type connector) that is hollow half way through to accommodate one or more conductors to be electrically connected.

D

Delamination

A separation between plies within a PWB base material or any planar separation within a multilayer PWB.

Dewetting

A condition where molten solder at least adheres to a surface, but the appearance of fillets seems to suggest insufficient wetting, which is usually weak in adhesion.

Disturbed solder joint

Unsatisfactory solder connection that results from relative motion between the conductor and termination during solidification of the solder and usually has a wrinkled surface.

Dross

Oxide and other contaminants that form on the surface of molten solder.

E

Excessive solder joint

Unsatisfactory connection wherein the solder obscures the configuration of the connection.

F

Fillet

A smooth concave buildup of material between two surfaces (e.g., a fillet of solder between a conductor and a solder pad or terminal, or a fillet of conformal coating between a component and a PWB).

Fractured solder joint

A joint showing evidence of cracking, resulting from relative movement between the conductor and termination, after solidification of the solder.

H

Haloing

Mechanically induced fracturing or delaminating on or below the surface of the base PWB material; it is usually exhibited by a light area around holes, other machined areas, or both.

Hook terminal

A terminal formed in a hook shape.

I

Insufficient solder joint

A solder connection characterized by incomplete coverage of one or more of the metal surfaces being joined or by incomplete solder fillets.

J

Jumper Wire

Connections between plated-through holes, terminals, conductor lands, and component leads on printed wiring boards where there are no connections on the printed circuit.

L

Land

A portion of a conductive pattern usually, but not exclusively, used for connection or attachment, or both, of parts.

M

Measling

Discrete white spots below the surface of the insulated base material, usually caused by moisture, pressure, and/or thermally induced stress.

N

Nonwetting

A condition whereby molten solder has wet a metal surface only partially or not at all; the base metal remains exposed.

O

Orange peel

A solder surface condition characterized by rough, noticeably irregular, or granular texture, or streaks.

Overheated solder joint

An unsatisfactory solder joint, the surface of which is roughened (dull, whitish, granular, and porous or pitted) due to overheating.

P

Pierced (perforated) terminal

A terminal containing a hole through which leads or wires are placed before soldering.

Pinhole

A solder connection with a small hole penetrating from the surface of the solder to a void of unknown size within the solder connection.

Pit

A relatively small recess in the solder surface, the bottom of which is visible from all angles of vision.

R

Radial leaded part

A part with lead wires extending from its side (e.g., transistors, ceramic capacitors). Synonymous with “non-axial leaded part.”

Repair

Operations performed on a nonconforming article to place it in usable condition. Repair is distinguished from rework in that alternate processes based on new engineering instructions for configurations different than normal are employed instead of reprocessing.

Rework

The reprocessing of articles or material that will make it conform to drawings, specifications, and contract.

Reflow soldering

A process in which the solder pre-applied to a PWB with parts mounted in place is heated and melted, and then left to cool in order to join the parts by solder to the board.

Rosin solder connection

An unsatisfactory solder joint that has a film of rosin flux entrapped between conductors (between a terminal and an electrical wire, or a pattern and a lead wire, etc.), resulting in incomplete electrical connection.

S

Solder

A nonferrous, fusible metallic alloy (consisting usually of tin and lead) used to join metallic surfaces. Low in electrical resistance. Hence often used to join electrical wiring connections.

Soldering

A process of joining metallic surfaces through the use of solder without direct fusion of the base metals.

Solderability

The property of a surface that allows it to be wet by molten solder.

Solder connection

An electrical/mechanical connection that employs solder for the joining of two or more metal surfaces.

Solder mask/resist

Coating material used in automatic soldering to prevent adherence of solder to selected areas of a pattern.

Solder pad

See “land.”

Solder spatter

Irregularly shaped solder fragments detached from a solder joint.

Solder spike

A cone shaped peak or sharp point of solder usually formed by the premature cooling and solidification of solder on removal of the heat source. Synonymous with “icicle” or “peak.”

Staking

The process or condition in which parts or components mechanically mounted or soldered to PWB’s are bonded and secured by means of electrically nonconductive adhesive for enhanced support.

Stress relief

Bends formed in conductors to minimize stresses acting between connections.

T

Turret terminal

A round post-type grooved stud around which conductors are fastened before soldering.

V

Void

A space enclosed on all sides by the solder.

W

Wave soldering

A method of soldering complete PWAs where the PWB, with parts mounted, is passed through one or more waves of molten solder, which is continuously moving to maintain fresh solder in contact with the PWB.

Wicking

A flow of molten solder or cleaning solution by capillary action.

Wetting

A condition whereby molten solder has spread all over and adhered to a solid metal surface.

Appendix II Samples of solder joints

This Appendix contains photographs of boundary samples showing the permissible maximum and minimum amounts of solder used to form typical solder joints, as well as photographs of defect samples. These photographs can be used as visual standards for workmanship inspection.
Paragraph 5.8 shall be consulted for individual inspection criteria.

Minimum Maximum

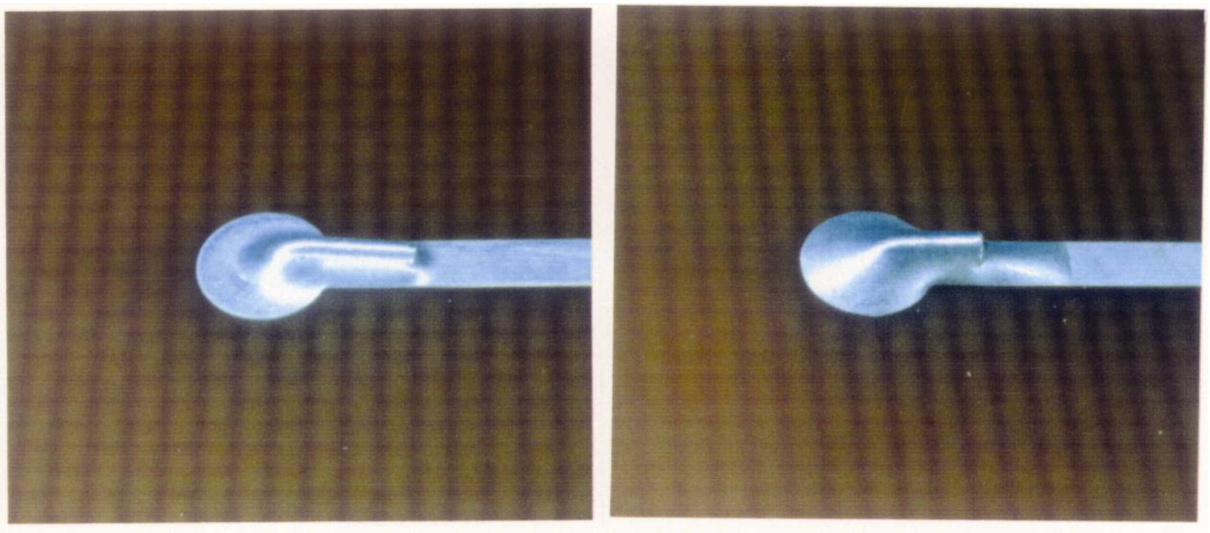


Figure II-1: PWB clinched termination
(Round lead soldered to circular pad)

Minimum Maximum

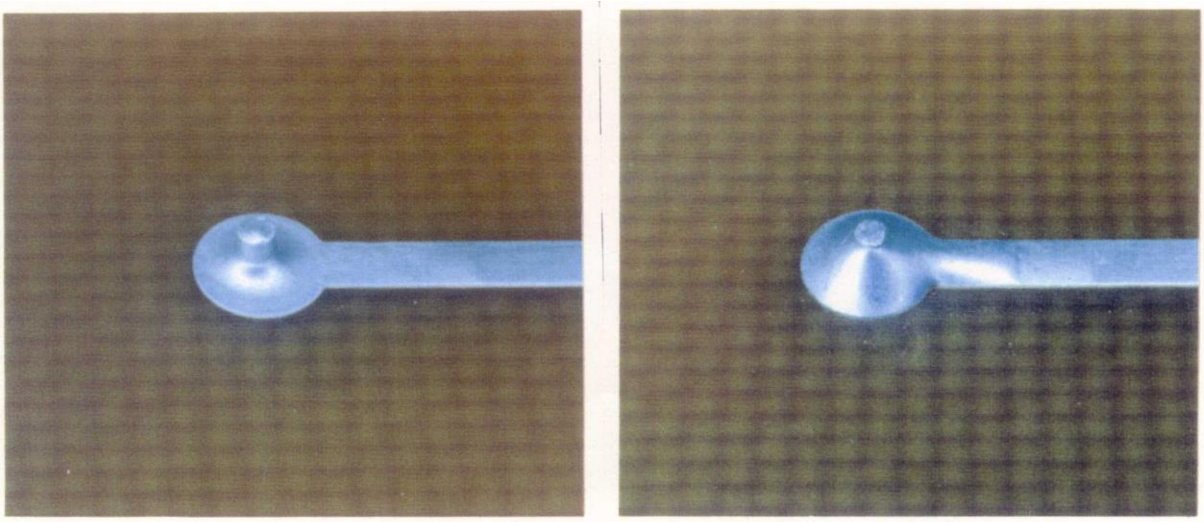
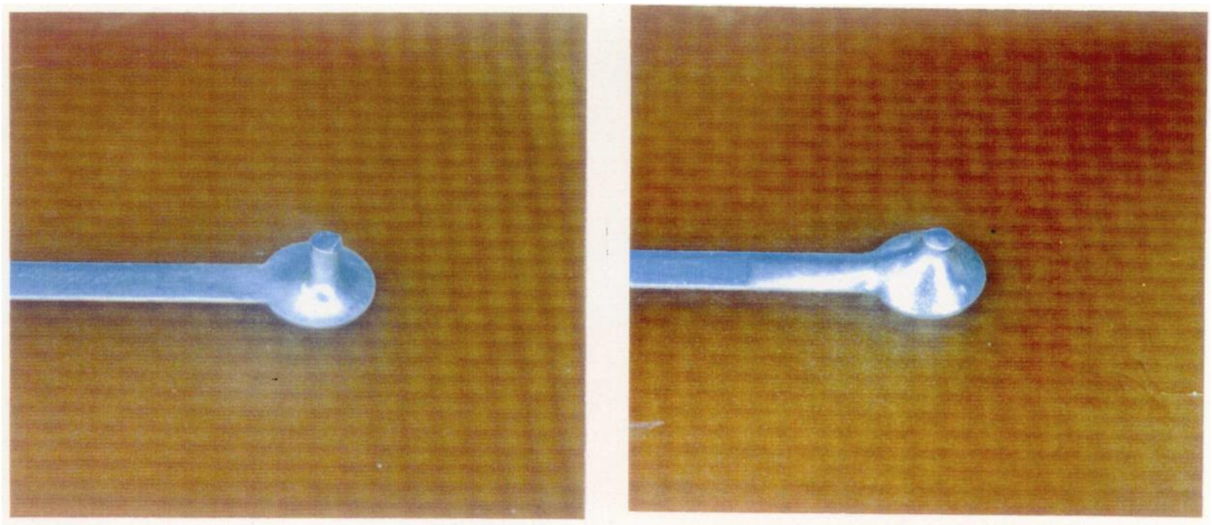


Figure II-2: PWB stud termination - Type 1
Lead protrusion = 0.8 mm (0.03 in.)

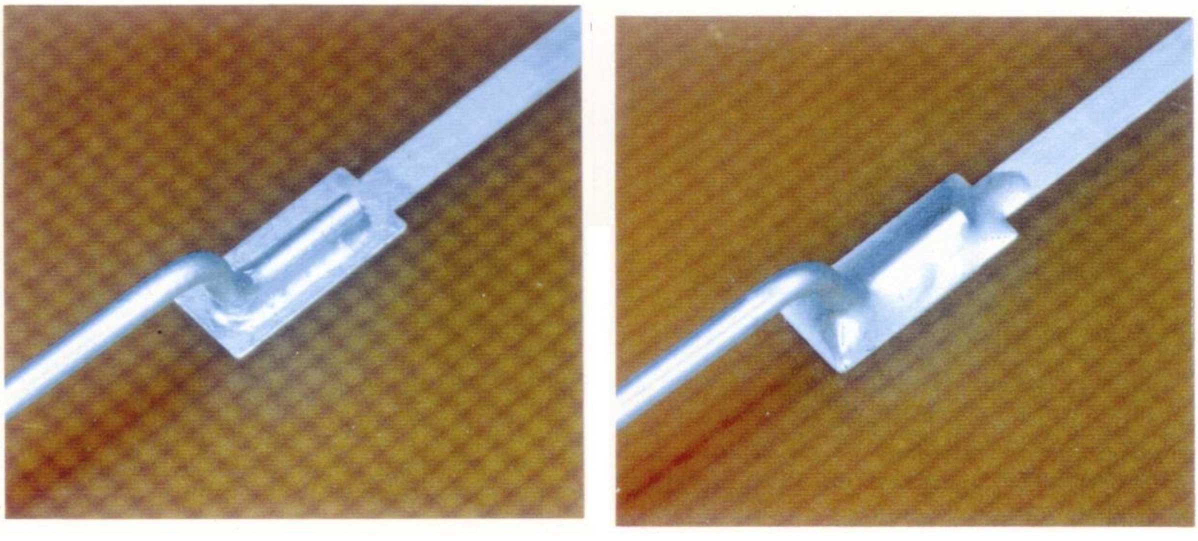


Minimum

Maximum

Figure II-3: PWB stud termination - Type 2

Lead protrusion = 2.3 mm (0.09 in.)

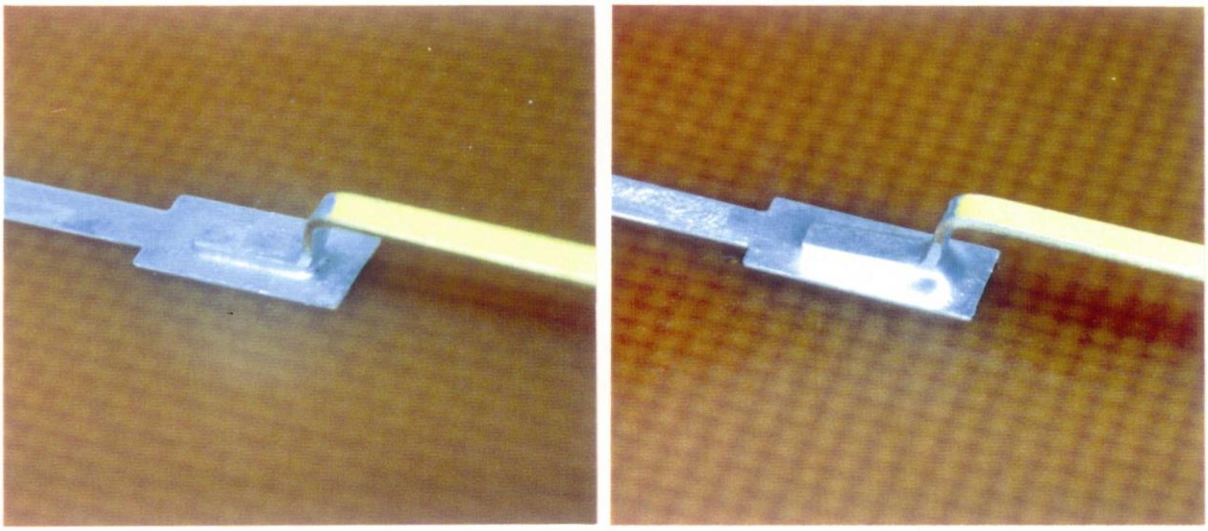


Minimum

Maximum

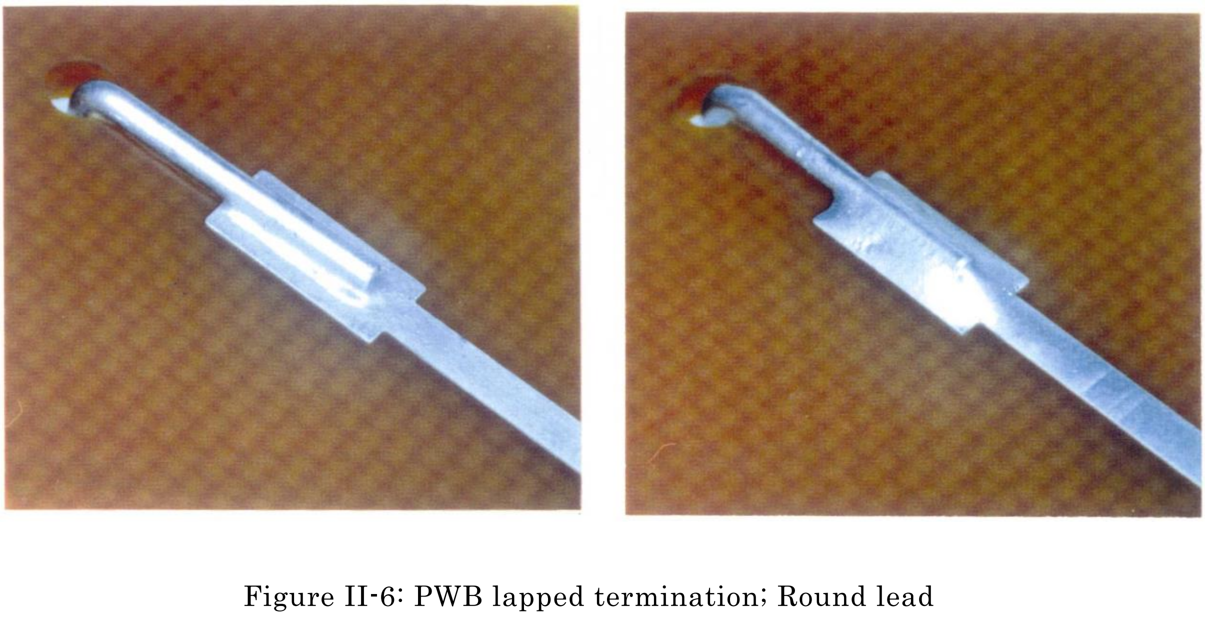
Figure II-4: PWB lapped termination; Round lead

(Lead terminated on rectangular pad on same side as part)



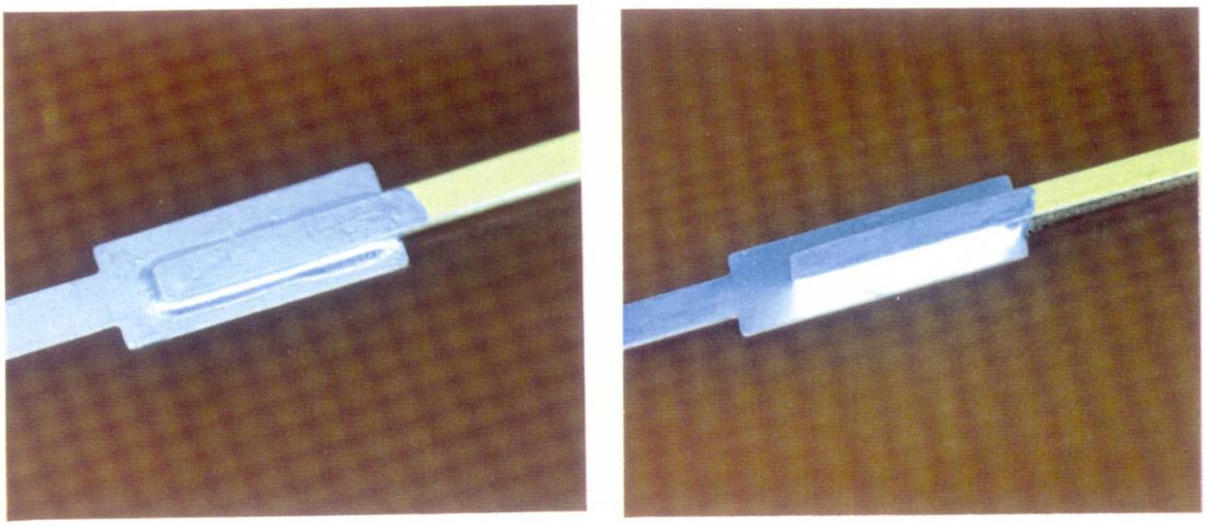
Minimum Maximum

Figure II-5: PWB lapped termination; Ribbon lead
(Lead terminated on rectangular pad on same side as part)



Minimum Maximum

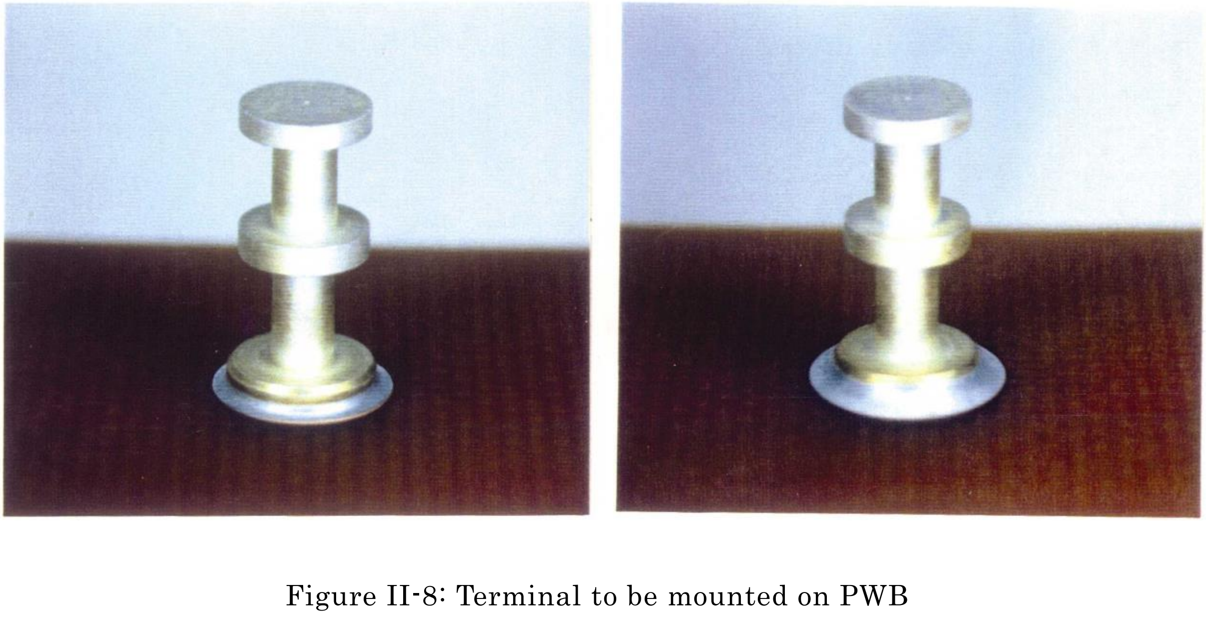
Figure II-6: PWB lapped termination; Round lead
(Lead terminated on rectangular pad on side opposite to part)



Minimum

Maximum

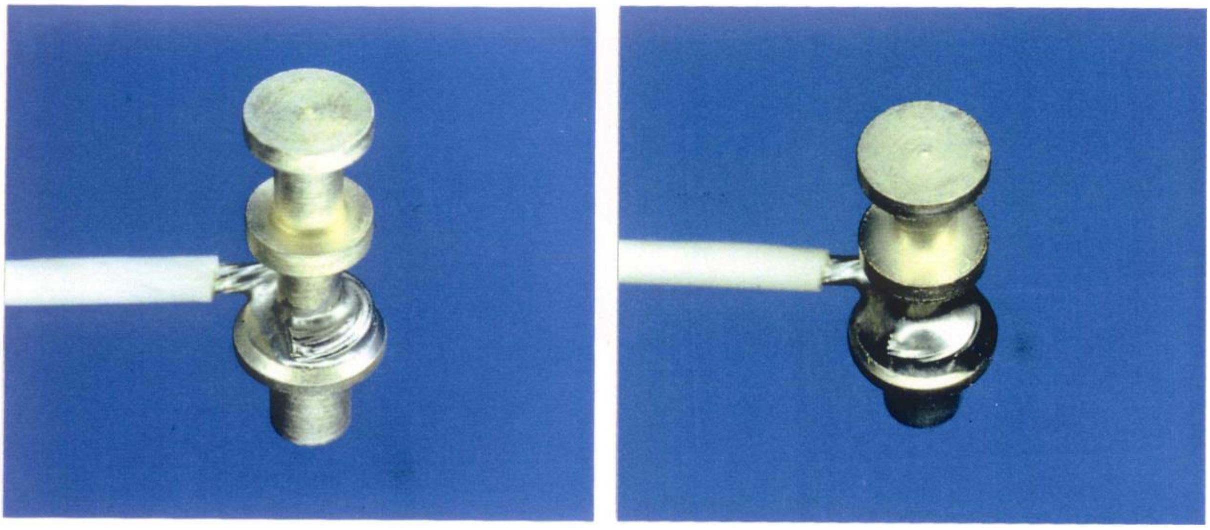
Figure II-7: PWB lapped termination; Ribbon lead
(Lead terminated on rectangular pad on side opposite to part)



Minimum

Maximum

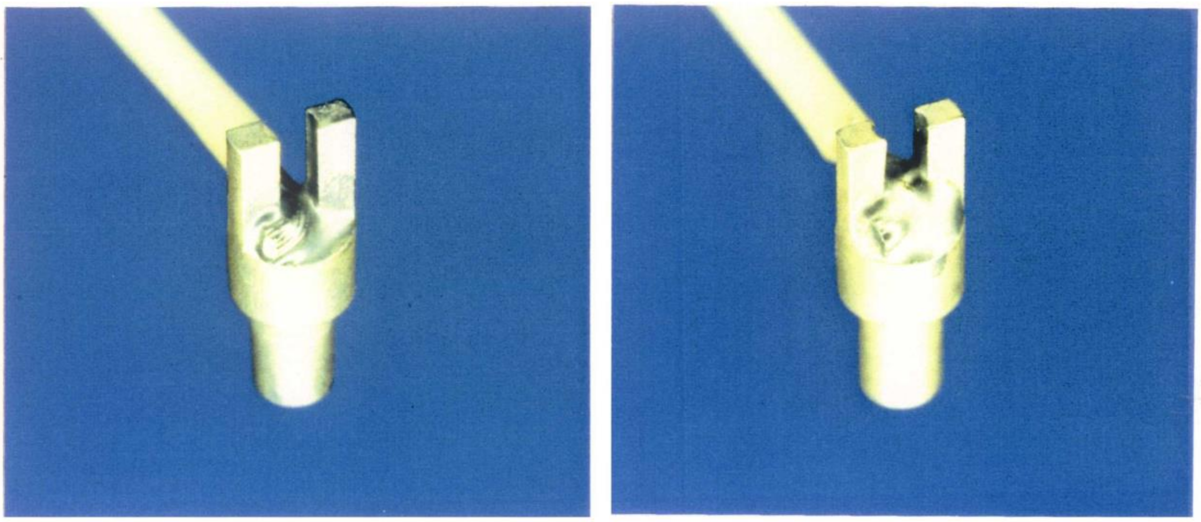
Figure II-8: Terminal to be mounted on PWB
(Turret terminal soldered to mounting pad)



Minimum

Maximum

Figure II-9: Conductor wrapped around turret terminal - single wire



Minimum

Maximum

Figure II-10: Conductor wrapped around bifurcated terminal - single wire

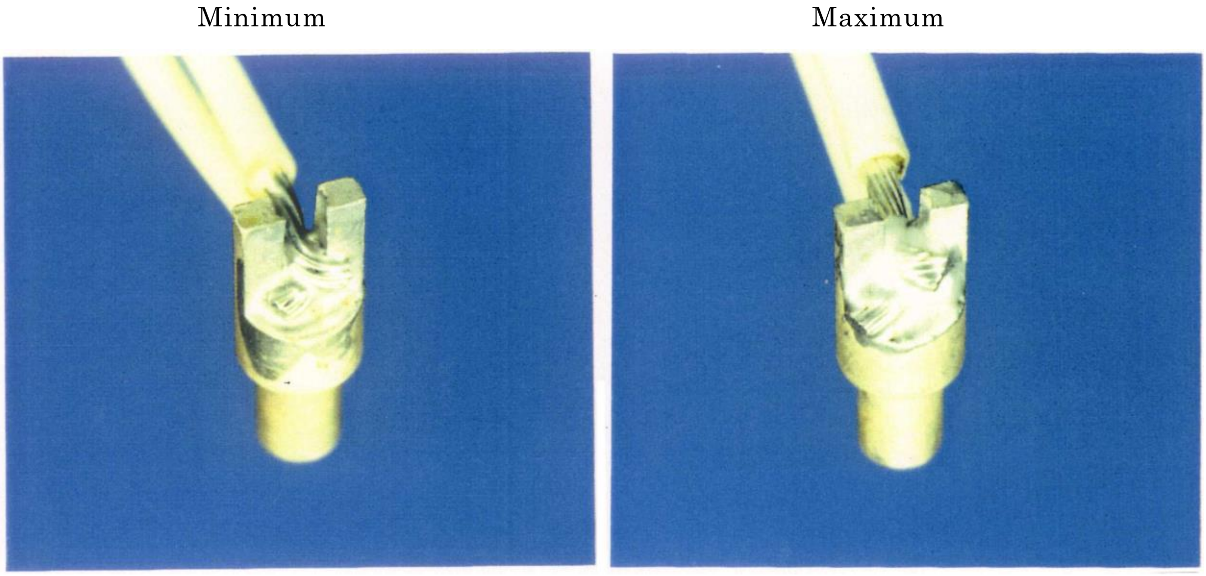


Figure II-11: Conductor wrapped around bifurcated terminal - two wires

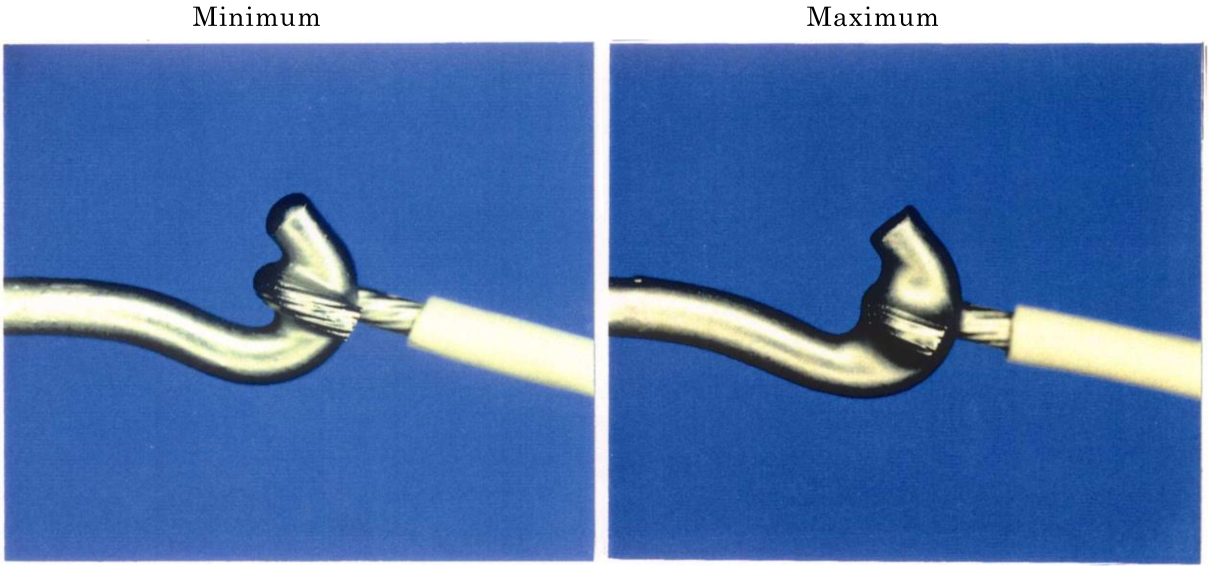
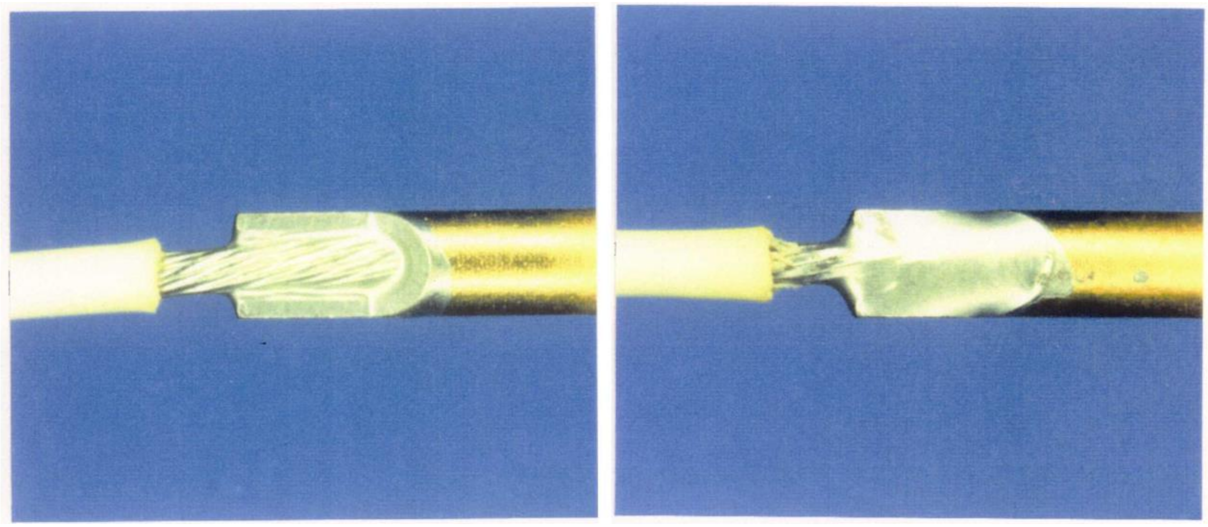


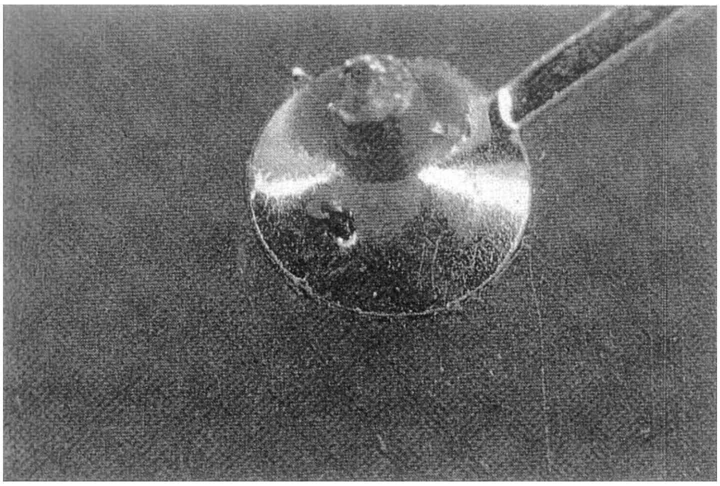
Figure II-12: Conductor wrapped around hook terminal - single wire



Minimum

Maximum

Figure II-13: Conductor insertion into cup terminal - connector type



(Source: I.T.R.I. reference material)

Figure II-14: Blowhole

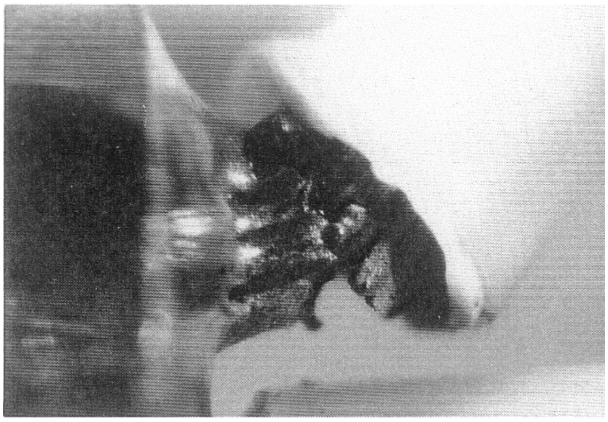
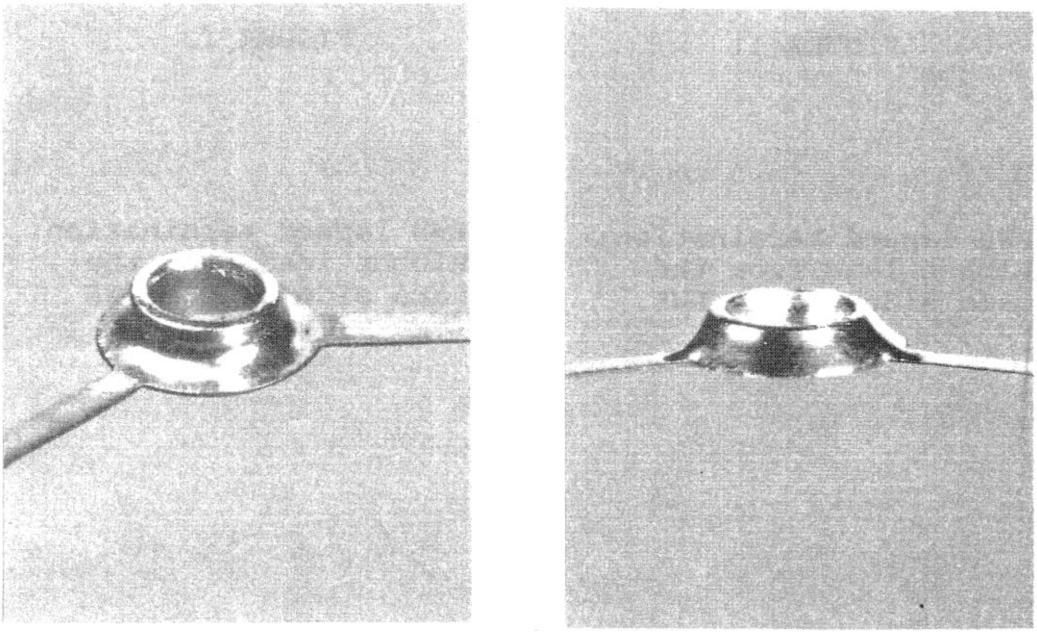


Figure II-15: Damaged conductor

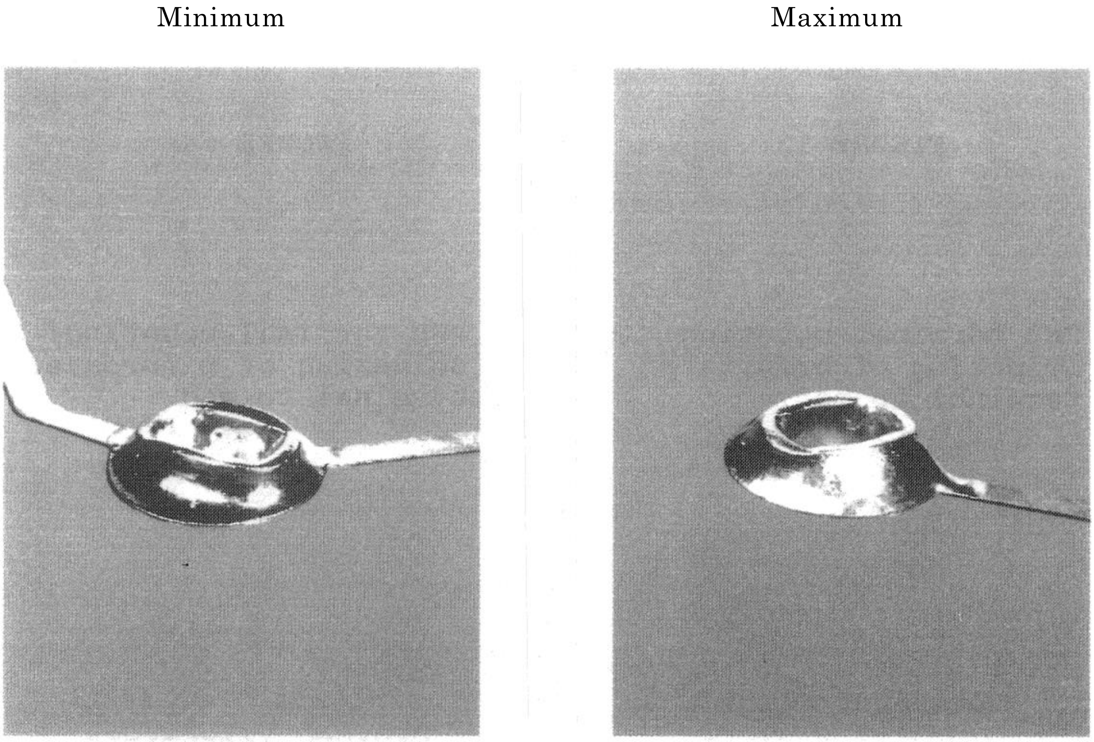
Conductor broken due to bending in solder wicking



Minimum

Maximum

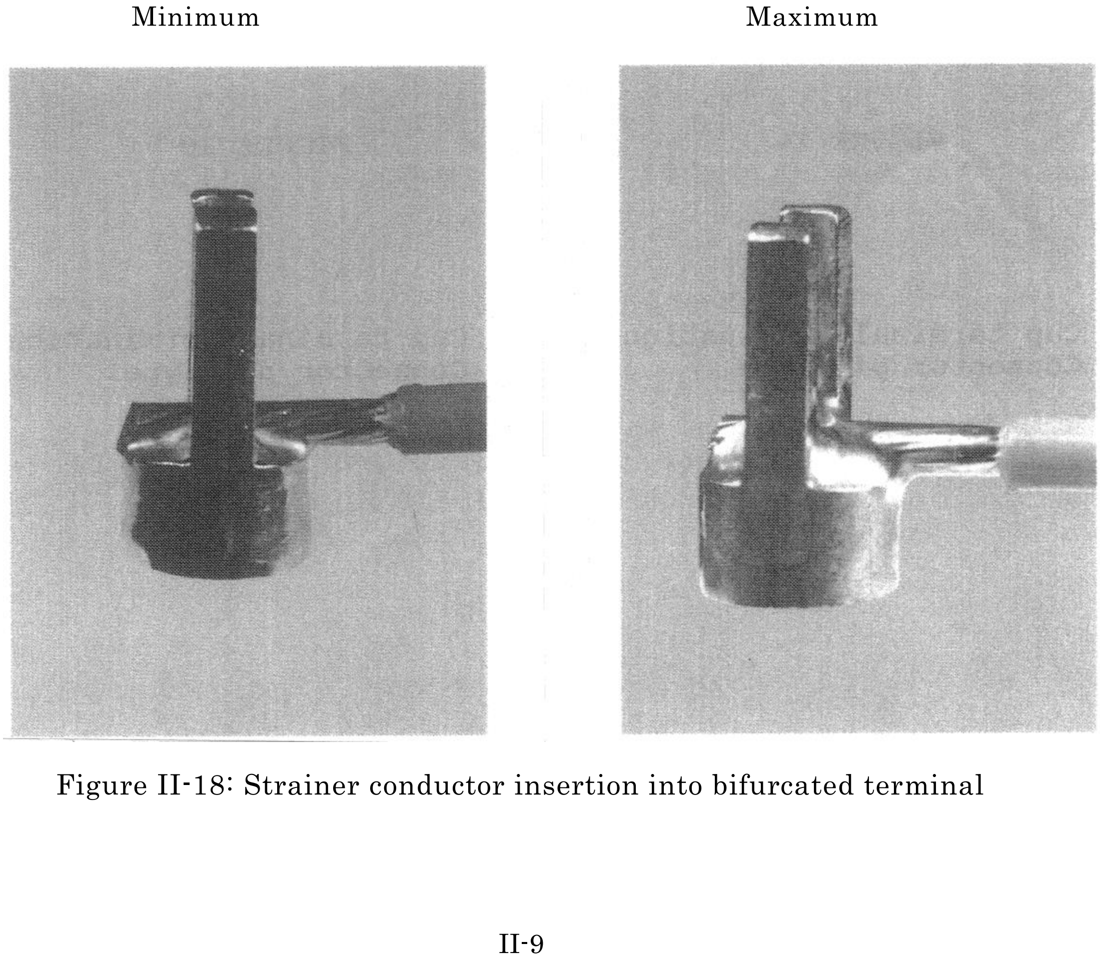
Figure II-16: Terminal to be secured to PWB with V-funnel swage



Minimum

Maximum

Figure II-17: Terminal to be secured to PWB with elliptical funnel swage



Minimum

Maximum

Figure II-18: Strainer conductor insertion into bifurcated terminal