ECSS-Q-70-08A
6 August 1999

EUROPEAN COOPERATION
ECSS
FOR SPACE STANDARDIZATION

Space product assurance

The manual soldering of high-reliability electrical connections

ECSS Secretariat
ESA-ESTEC
Requirements & Standards Division
Noordwijk, The Netherlands

Published by: ESA Publications Division
ESTEC, P.O. Box 299,
2200 AG Noordwijk,
The Netherlands

ISSN: 1028–396X

Price: DFl 50

Printed in The Netherlands

Foreword

This Standard is one of the series of ECSS Standards intended to be applied together for the management, engineering and product assurance in space projects and applications. ECSS is a cooperative effort of the European Space Agency, National Space Agencies and European industry associations for the purpose of developing and maintaining common standards.

Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to perform the necessary work.

This Standard has been prepared by the ECSS-Q-70-08 Working Group and is based on ESA PSS-01-708 and NASA-STD-8739.3. It has been reviewed by the ECSS Technical Panel and approved by the ECSS Steering Board.

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Contents list

Foreword 3

Introduction 11

1 Scope 13

2 Normative references 15

3 Terms, definitions and abbreviated terms 17

3.1 Terms and definitions 17
3.2 Abbreviated terms 24

4 Principles and prerequisites of reliable soldered connections 25

4.1 Principles 25
4.2 Prerequisites 25

5 Preparatory conditions 27

5.1 Facility cleanliness 27
5.2 Environmental conditions 27
5.3 Precautions against static charges 28

5.4 Lighting requirements 28
5.5 Equipment and tools 28

6 Materials selection 33

6.1 Solder 33
6.2 Flux 33
6.3 Solvents 35
6.4 Flexible insulation materials 35
6.5 Terminals 35
6.6 Wires 36
6.7 PCBs 36
6.8 Conformal coating, staking compounds and potting materials 36

7 Preparation for soldering 39

7.1 Preparation of conductors, terminals and solder cups 39
7.2 Preparation of the soldering bit 41
7.3 Maintenance of resistance-type soldering electrodes 42
7.4 Handling (work station) 42
7.5 Storage (work station) 42
7.6 Baking of PCBs 42

8 Mounting of components 43

8.1 General requirements 43
8.2 Lead bending requirements 45
8.3 Mounting of terminals to PCB 47
8.4 Lead attachment to PCBs 48
8.5 Mounting of components to terminals 54
8.6 Cordwood modules 54
8.7 Mounting of connectors to PCBs 55

9 Attachment of conductors to terminals, solder cups and cables. 57

9.1 General 57
9.2 Wire termination 57
9.3 Turret and straight pin terminals 58
9.4 Bifurcated terminals 60
9.5 Hook terminals 62
9.6 Pierced terminals 62
9.7 Solder cups (connector type) 64

9.8 Insulation tubing application 64
9.9 Wire and cable interconnections 64
9.10 Connection of stranded wires to PCBs 67

10 Soldering to terminals and PCBs 69

10.1 General 69
10.2 Solder application to terminals 69
10.3 Solder application to PCB 70
10.4 Wicking 70
10.5 Solder rework 71

11 Cleaning of PCB assemblies 73

11.1 General 73
11.2 Ultrasonic cleaning 73
11.3 Monitoring for cleanliness 73

12 Final inspection 75

12.1 General 75
12.2 Acceptance criteria 75
12.3 Rejection criteria 75

13 Verification 77

13.1 General 77
13.2 Temperature cycling 77
13.3 Vibration 77

14 Quality assurance 79

14.1 General 79
14.2 Data 79
14.3 Nonconformance 79
14.4 Calibration 79
14.5 Traceability 79
14.6 Workmanship standards 80
14.7 Inspection 80
14.8 Operator and inspector training and certification 80

Annex A (informative) Typical satisfactory and unsatisfactory solder connections 81

Figures

Figure 1: Profiles of correct and incorrect cutters for trimming leads 29
Figure 2: Non-approved types of mechanical strippers 30
Figure 3: Stress relieved component terminations on PCB 44
Figure 4: Minimum lead bend 46
Figure 5: Component and solder termination on the same side 46
Figure 6: Leads with solder termination on both sides 47
Figure 7: Types of terminal swaging 48
Figure 8: Clinched-lead terminations - unsupported holes 49
Figure 9: Clinched lead terminations - plated through-holes 49
Figure 10: Stud terminations 51
Figure 11: Through-hole lapped terminations 52
Figure 12: Design dimensions for single-surface lapped terminations (not all can be measured after soldering). 53
Figure 13: Method of stress relieving parts attached to terminals 54
Figure 14: Side- and bottom-route connections to turret terminals 59
Figure 15: Bottom-route connections to bifurcated terminal 60
Figure 16: Side-route connection to bifurcated terminal 61
Figure 17: Top-route connection to bifurcated terminal 62
Figure 18: Connections to hook terminals 63
Figure 19: Connections to pierced terminals 63
Figure 20: Connections to solder cups (connector type) 64
Figure 21: Methods for securing wires 66
Figure 22: Stranded wires to PCBs 67
Figure A-1: Soldered clinched terminals 82
Figure A-2: Soldered stud terminals 83
Figure A-3: Soldered turret terminals 84
Figure A-4: Soldered turret terminals 85
Figure A-5: Soldered bifurcated terminals 86
Figure A-6: Soldered hook terminals 87
Figure A-7: Soldered cup terminals 88
Figure A-8: Hand-soldered wire to shielded cable interconnections 89
Figure A-9: Hand-soldered wire to shielded wire interconnections 90
Figure A-10: Hand-soldered wire interconnections – details of defects 91

Tables

Table 1: Chemical composition of spacecraft solders 34
Table 2: Guide to choice of solder types 34
Table 3: Insulation clearance 40
Table 4: Dimensions for Figure 22 67
Table 5: Cleanliness test values 74
Table 6: Minimum severity for vibration testing 78

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Introduction

The main part of this Standard is based on recommendations from the National Aeronautics and Space Administration, and European soldering technology experts. Modifications have been incorporated into the text to provide for the specific requirement of low-outgassing electrical systems which are required by scientific and application satellites. Other additions have been made in the light of recent technological advances and results of metallurgical test programmes. The methods and workmanship contained in this document are considered to be fully approved for normal spacecraft requirements.

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1 Scope

This Standard defines the technical requirements and quality assurance provisions for the manual soldering of high-reliability electrical connections intended for use in spacecraft and associated equipment.

The rigorous requirements set by this Standard ensure the high reliability of hand-soldered electrical connections intended to withstand normal terrestrial conditions and the vibrational G-loads and environment imposed by space flight. The proper tools, correct materials, design and workmanship are covered by this Standard. Acceptance and rejection criteria are stated and some workmanship standards are included to permit discrimination between proper and improper work.

Wave-soldering processes and surface mount technologies are specified in separate documents, and those processes require to be verified as prescribed in the respective standard.

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2

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

ECSS-P-001	Glossary of terms
ECSS-Q-20	Space product assurance - Quality assurance
ECSS-Q-20-09	Space product assurance - Nonconformance control system
ECSS-Q-70	Space product assurance - Materials, mechanical parts and processes
ECSS-Q-70-01	Space product assurance - Cleanliness and contamination control (to be published)
ECSS-Q-70-02	Space product assurance - Thermal vacuum outgassing test for the screening of space materials (to be published)
ECSS-Q-70-04	Space product assurance - Thermal cycling test for the screening of space materials and processes (to be published)
ECSS-Q-70-10	Space product assurance - Qualification and procurement of multilayer printed-circuit boards (gold-plated or tin-lead finish) (to be published)
ECSS-Q-70-28	Space product assurance - Repair and modification of printed-circuit board assemblies (to be published)
ECSS-Q-70-38	Space product assurance - High-reliability soldering for surface-mount and mixed technology printed-circuit boards (to be published)
ECSS-Q-70-48	Space product assurance - Requirements for approved skills training and certification (electronic assembly techniques) (to be published)
ECSS-Q-70-71	Space product assurance - Data for the selection of space materials (to be published)
ISO-9453	Solder, tin alloy, lead

ISO-EN 29454	Flux specification
J-STD-004	Requirements for soldering fluxes
EN 100015-1:1992	Protection of electrostatic sensitive devices – Part 1: General requirements

3

Terms, definitions and abbreviated terms

3.1 Terms and definitions

The following terms and definitions are specific to this Standard in the sense that they are complementary or additional with respect to those contained in ECSS-P-001.

3.1.1 Base laminate

See "Substrate".

3.1.2 Bifurcated (split) terminal

A terminal containing a slot or split in which wires or leads are placed before soldering.

3.1.3 Bit

The removable heat store of a soldering iron.

3.1.4 Blister

Delamination in a distinct local area or areas.

3.1.5 Bridging

A build-up of solder or conformal coating between parts, component leads and/or base substrate forming an elevated path (see "Fillet").

3.1.6 Cable

Two or more insulated conductors, solid or stranded, of equal length, contained in a common covering; or two or more insulated conductors, of equal length, twisted or moulded together without common covering; or one insulated conductor with a metallic covering shield or outer conductor (shielded cable or coaxial cable).

3.1.7 Chipped lead seal

Cracked glass-to-metal component package seal. (Often caused during lead forming operations.)

3.1.8 Clinched termination

A conductor or component lead which passes through a printed circuit board and is then bent to make contact with the printed circuit board pad. The clinched portion should not be forced to lie flat on the pad and some innate spring back is desirable before this form of termination is soldered.

3.1.9 Cold solder joint

A joint in which the solder has a blocky, wrinkled or piled-up appearance and shows signs of improper flow or wetting action. It can appear either shiny or dull, but not granular. The joint normally has abrupt lines of demarcation rather than a smooth, continuing fillet between the solder and the surfaces being joined. These lines are caused by either insufficient application of heat or the failure of an area of the surfaces being joined to reach soldering temperature.

3.1.10 Colophony

See “Rosin”.

3.1.11 Component

A device which performs an electronic, electrical or electromechanical function and consists of one or more elements joined together and which cannot normally be disassembled without destruction. The terms component and part may be interchanged. Typical examples of components are transistors, integrated circuits, hybrids, capacitors.

3.1.12 Component lead

A solid wire which extends from and serves as a connection to a component.

3.1.13 Conduction soldering

Method of soldering which employs a soldering iron for transfer of heat to the soldering area.

3.1.14 Conductor

A lead or wire, solid or stranded, or printed circuit patch serving as an electrical interconnection between terminations.

3.1.15 Conformal coating

A thin protective coating which conforms to the configuration of the covered assembly.

3.1.16 Connection

An electrical termination.

3.1.17 Contact angle

The angle enclosed between half-planes, tangent to a liquid surface and a solid-liquid interface at their intersection. In particular, the contact angle of liquid solder in contact with a solid metal surface. An approximate value for this can be determined by shadow projection or other means, by measuring after the solder has solidified. Note that the contact angle is always the angle inside the liquid.

3.1.18 Contamination

Particles, liquids, gases, materials and micro-organisms which by their presence can disturb the performance of an item.

3.1.19 Cordwood construction

Circuitry in which components are mounted between, and perpendicular to, two printed circuit or conductive networks.

3.1.20 Corrosion

The deterioration of a metal by chemical or electrochemical reaction with its environment.

3.1.21 Cracked solder joint

A soldered connection which has fractured or broken within the solder.

3.1.22 Crazing

A condition existing in the base laminate of a printed circuit board in the form of connected white spots or "crosses" on or below the surface of the base laminate, reflecting the separation of fibres in the glass cloth and connecting weave intersections, usually related to mechanically induced stress.

3.1.23 Delamination

A distinct separation of printed circuit board layers (resin from glass) originating from or extending to the edges of a hole or edge of the board.

3.1.24 Dewetting

The condition in a soldered area in which the liquid solder has not adhered intimately, characterized by an abrupt boundary between solder and conductor, or solder and terminal/termination area (often seen as a dull surface with islands of thicker shiny solder).

3.1.25 Discrete component

Any individually packaged electronic device, either active or passive (e.g. resistors, capacitors, inductors, diodes, transistors).

3.1.26 Disturbed solder joint

Unsatisfactory connection resulting from relative motion between the conductor and termination during solidification of the solder.

3.1.27 Dross

The scum that forms on the surface of molten metal (on liquid solder it may comprise impurity elements or oxidation products).

3.1.28 Electrical connection

Conductive connection in electrical or electronic circuits.

3.1.29 Encapsulating compound

An electrically non-conductive compound used for environmental protection which completely encloses and fills in voids between electrical components.

3.1.30 Eutectic alloy

An alloy of two or more metals that has one distinct melting point. One eutectic solder is a tin-lead alloy containing 63 % Sn and 37 % Pb which melts at 183 °C.

3.1.31 Excessive solder joint

Unsatisfactory connection wherein the solder obscures the configuration of the connection, or prevents assessment of the true wetting angle.

3.1.32 Eyelet

A tubular metal part inserted into a printed circuit board and having both ends headed or rolled over.

3.1.33 Fillet

A smooth concave build-up of material between two surfaces, e.g. a fillet of solder between a component lead and a solder pad or terminal, or a fillet of conformal coating material between a component and printed circuit board.

3.1.34 Flatpack (flat package)

A term used to describe the appearance of an integrated circuit which has been hermetically sealed within a thin, rectangular enclosure, with flat coplanar leads protruding from the periphery.

3.1.35 Flux

A material which, during soldering, removes the oxide film, protects the surface from oxidation, and permits the solder to wet the surfaces to be joined.

3.1.36 Flux activity

The property of a flux which allows the smallest contact angle between molten solder and a solid surface (see also "Rosin").

3.1.37 Flux particle

A tiny fragment of flux residue of yellow or sometimes whitish translucent appearance. Usually appears whitish green under ultraviolet light.

3.1.38 Fractured joint

A soldered connection which has fractured or broken within the solder. See "Cracked solder joint".

3.1.39 Glass meniscus

The glass fillet of a lead seal which occurs where an external lead leaves the package body.

3.1.40 Haloing

A condition existing in the base laminate of a printed circuit board in the form of a light area around holes and/or other machined areas on or below the surface of the laminate. Limited delamination.

3.1.41 Hermetic seal

A seal which protects an enclosed circuit from corrosion by preventing the entry of such contaminants as water vapour.

3.1.42 Hook terminal

A terminal formed in a hook shape.

3.1.43 Hybrid microcircuit

A component performing an electronic circuit function which consists of a thick- or thin-film network on a substrate which supports active and/or passive chip components connected to it.

3.1.44 Icicles

See "Solder Icicle".

3.1.45 Integrated-circuit component

An individually packaged functional circuit formed by depositing an active or passive electronic element on to a substrate.

3.1.46 Interfacial connection

A conductor which connects conductive patterns between opposite sides of a printed circuit board. Normally a plated-through hole.

3.1.47 Lap joint

Joining or fusing of two overlapping metal surfaces with solder without use of any other mechanical attachment or support.

3.1.48 Measling/measles

A condition existing in the base laminate of printed circuit board in the form of discrete white spots or "crosses" below the surface of the base laminate, reflecting a separation of fibres in the glass cloth at the weave intersection. During soldering this can be caused by excessive heat.

3.1.49 Multi-layer circuit board

A product consisting of alternate laminates of printed circuit substrates and insulators, bonded together by simultaneous application of heat and pressure prior to drilling and plating holes for interconnections. See also "printed circuit board".

3.1.50 Overheated solder joint

A joint in which the solder can appear either shiny or dull, but which also has a crystalline appearance and shows evidence of a grain structure caused by excessive dwell time of a solder iron, too great a heat source, or repeated rework.

3.1.51 Pad

The termination of a conducting surface on a printed circuit board to which leads are soldered to form an electrical connection. These can be described as either functional, where an active track is terminated, or non-functional, where the pad is isolated

3.1.52 Pin hole

A small hole in solder.

3.1.53 Pits

Small holes or sharp depressions in the surface of solder. Can be caused by flux blow-out due to entrapment or overheating.

3.1.54 Plated-through hole

A plated-through hole is one formed by a deposition of metal on the inside surface of a hole. Also known as a supported hole. The configuration is used to provide additional mechanical strength to the soldered termination or to provide an electrical interconnection on a double-sided or multi-layer printed circuit board.

3.1.55 Porous solder joint

A joint with many pits having a grainy or gritty surface (due to overheating).

3.1.56 Potting compound

A compound, usually electrically non-conductive, used to encapsulate or as a filler between components, conductors or assemblies.

3.1.57 Printed circuit board (PCB)

A product resulting from the process of selectively etching unwanted copper from one or both surfaces of a copper-clad insulating substrate to form a desired circuitry pattern which is subsequently solder- or gold-plated. The term printed circuit board covers the following families:

- single sided;
- double sided, rigid or flexible;
- multilayer, rigid or flex-rigid.

3.1.58 Repair

An action taken on a nonconforming product so that it will fulfil the intended usage requirements although it will not conform to the originally specified requirements (ISO 8402:1994).

NOTE 1 Repair is one type of disposition of a nonconforming product.

NOTE 2 Repair includes remedial action taken to restore, for usage, a once conforming but now nonconforming product, for example, as part of maintenance.

3.1.59 Resin

Natural substance that is usually transparent or translucent and yellowish to brown. Resins are formed in plant secretions and are soluble in organic solvents, but not water. This is a generic term, rosin being the specific term with regard to soldering.

3.1.60 Resistance soldering

Method of soldering by passing a current between two electrodes through the area to be soldered.

3.1.61 Rework

An action taken on a nonconforming product so that it will fulfil the specified requirements (ISO 8402:1994).

NOTE Rework is one type of disposition of a nonconforming product.

3.1.62 Rosin

A natural resin obtained as the residue after removal of turpentine from the oleoresin of the pine tree, consisting mainly of abietic acid and related resin acids, the remainder being resin acid esters. It is non-corrosive and electrically non-conducting.

Rosin is the basic constituent of the rosin flux family (see ISO EN 29454).

3.1.63 Rosin-soldered joint

Unsatisfactory connection which has entrapped rosin flux.

3.1.64 Shield

A metallic sheath surrounding one or more wires, cables, cable assemblies, or a combination of wires and cables that is used to prevent or reduce the transmission of electromagnetic energy to or from the enclosed conductors. The shield also includes an insulating jacket that may cover the metallic sheath.

3.1.65 Solder

A non-ferrous fusible metallic alloy of two or more metals (usually tin and lead) used when melted to join or fuse metallic surfaces together and to provide a low resistance electrical path.

3.1.66 Solderability

The property of a surface which allows it to be wetted by molten solder.

NOTE Standard tests exist to assess the solderability of conductors. Surfaces are considered to have a “good solderability” if, following the procedures of this standard, solder wetting can be achieved within 3 seconds and dewetting does not occur before 8 seconds.

3.1.67 Solder coating

A surface coated with a thin, uniform layer of solder.

3.1.68 Solder-cup terminal

A hollow, cylindrical terminal closed at one end to accommodate one or more conductors.

3.1.69 Solder icicle

A conical peak or sharp point of solder usually formed by the premature cooling and solidification of solder upon removal of the heat sources.

3.1.70 Solder pad

Termination area on a printed circuit conductor.

3.1.71 Soldering

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

3.1.72 Soldering time

The time required for a surface to be wetted by solder under specified conditions.

3.1.73 Staking compound (cement)

An electrically non-conductive adhesive material used to anchor a component or item in place.

3.1.74 Stress lines

Two forms of stress lines can appear on a finished solder fillet:

a. Lines or folds running parallel to the mounting surface usually denote excessive soldering times or temperatures and also rework. They are probably caused during soldering by differential expansions, i.e. between the printed circuit board substrate which expands a far greater distance than the metallic material of the joint.

b. Lines running perpendicular to the mounting surface are commonly caused when the soldering iron bit is removed too slowly from a liquid solder joint.

3.1.75 Stress relief

Method or means to minimize stresses to the soldered termination or component. Generally in the form of a bend or service loop in a component lead, solid or stranded wire to provide relief from stress between terminations, as that caused, for instance by movement or thermal expansion.

3.1.76 Stud termination

An upright conductor termination through a printed circuit board.

3.1.77 Substrate

The supporting dielectric material upon which the elements of a circuit are deposited or installed.

3.1.78 Tack solder

The use of solder for the purpose of temporarily connecting a lead to a termination point.

3.1.79 Termination/terminal area

A conductive surface on a printed circuit board used for making electrical connections (also referred to as printed circuit pad, solder pad).

3.1.80 Thermal shunt

A device with good heat-dissipation characteristics used to conduct heat away from an article being soldered.

3.1.81 Tinning

The coating of a surface with a uniform layer of solder before it is used in a soldered connection.

3.1.82 Tip

The application surface at the end of the soldering-iron bit.

3.1.83 Turret terminal

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

3.1.84 Unaided eye

Normal Snellen 6/6 (metric) vision including eye glasses required to correct defective vision to 6/6 (metric) equivalent. Does not include microscopes, eye loupes or any other magnifying device.

3.1.85 Weave exposure

A surface condition of a printed circuit board laminate in which the unbroken woven-glass cloth is not uniformly covered by resin.

3.1.86 Wetting

Flow and adhesion of a liquid to a solid surface, characterized by smooth, even edges and low contact angle.

3.1.87 Wicking

A flow of molten solder or cleaning solution by capillary action. Occurs when joining stranded wire; solder is drawn within the strands, but normally not visible on outer surface of strands. Wicking can also occur within the stress relief bend of a component lead.

3.1.88 Wire

A single metallic conductor of solid, or stranded, construction, designed to carry current in an electric circuit, but which does not have a metallic covering, sheath or shield. For this standard, "wire" refers to "insulated electric wire".

3.2 Abbreviated terms

The following abbreviated terms are defined and used within this Standard.

Abbreviation	Meaning
AWG	American Wire Gauge
FEP	Fluorinated Ethylene Propylene Copolymer
MOS	Metal-Oxide Semiconductor
PCB	Printed Circuit Board
PTFE	Polytetrafluoroethylene
RF	Radio Frequency
RMA	Rosin, Mildly Activated (old term now defined by J-STD-004 Type L1: Rosin, low activation with less than 0,5 % halide)
r.m.s.	root-mean-square

4

Principles and prerequisites of reliable soldered connections

4.1 Principles

a. Reliable soldered connections result from proper design, control of tools, materials and work environments, and careful workmanship.

b. The basic design concepts to ensure reliable connections and to prevent solder-joint failure are:

- Stress relief shall be inherent in the design, so that detrimental thermal and mechanical stresses on the solder connections are avoided.
- Where adequate stress relief is not possible, a method of solder-joint reinforcement is necessary.
- Materials shall be so selected that the mismatch of thermal expansion coefficients is minimal at the constraint points in the part-mounting configuration.
- Materials and processes which allow the formation of brittle intermetallics shall be avoided.
- The design shall permit ready inspection of soldered connections.

4.2 Prerequisites

a. Each contractor is responsible for maintaining a documented soldering programme which meets the requirements of this Standard and ECSS-Q-70-48 for the types of soldered connections employed in the articles involved. The soldering programme shall include procedures for training, certification, maintenance of certified status, recertification and revocation of certified status for soldering and inspection personnel. The contractor shall also prepare and have readily available workmanship standards consisting of satisfactory work samples or visual aids which clearly illustrate the quality characteristics for all soldered connections involved. Also, the applicable illustrations in this Standard, supplemented as necessary, shall be utilized for visual standards.

b. Records shall be kept to provide identification between the finished product and the operator. Records shall also be maintained of the training, testing and certification status of soldering operators. Records shall be retained for at least ten years, or in accordance with project contract requirements.

c. Equipment and tools shall be verified or calibrated periodically for proper operation, and records of tool calibration shall be maintained.

d. For soldering requirements not covered in this Standard, the contractor shall submit a process procedure including all pertinent quality requirements to the relevant final customer for approval in accordance with ECSS-Q-70.

e. The methods for preparing and assembling the components to be joined by soldering, and the selection and use of tools shall conform to this Standard.

f. Components, terminals and conductors shall be mounted and supported as prescribed herein. These requirements apply to assemblies designed to operate within the temperature limits from -55 °C to +80 °C. More extreme temperatures or other unusual environmental applications will require special design measures to provide necessary environmental survival capability.

g. Solder-joint configurations not shown in this Standard shall be verification tested (see clause 13) by means of fully representative samples, before acceptance for flight equipment.

h. Operator and inspector training and certification is a prerequisite.

5

Preparatory conditions

5.1 Facility cleanliness

a. Unless classified as a clean room, the areas in which soldering is to be carried out shall be maintained in a neat orderly fashion with no loose material (such as dirt, dust, solder particles, oils, clipped wires) that can cause contamination of the soldered connection. Furniture shall be kept to a minimum in the work areas and be arranged to allow easy and thorough cleaning of the floor.

b. A washroom and eating, drinking and smoking facilities shall be located in a separate room close to, but outside, the soldering areas.

c. Working surfaces shall be covered with an easily cleaned hard top or have a replaceable surface of clean, non-corrosive silicone-free paper.

d. Tools to be used in the soldering operation shall be clean; excess lubricants shall be removed before soldering starts.

e. Before assembly, wire, terminal and connector contacts shall be visually examined for cleanliness, absence of oil films and freedom from tarnish or corrosion.

f. Handling and storage of, for instance, electronic components shall be in accordance with subsections 7.4 and 7.5.

5.2 Environmental conditions

The soldering area shall have a controlled environment which limits entry of contamination. The following environmental conditions in the area shall be continuously maintained:

- room temperature: (22 ± 3) °C;
- relative humidity at room temperature: (55 ± 10) %.

The work stations shall not be exposed to draught. Fresh air shall be supplied to the room through a filtering system and, so that there is a positive pressure difference with respect to adjacent rooms, the exhaust air shall be suitably restricted.

5.3 Precautions against static charges

See also EN 100015-1. Where devices susceptible to static charges (e.g. MOS devices, microwave semiconductors, precision voltage regulators) are to be soldered, the following measures shall be taken during component preparation, mounting, soldering and cleaning. The main point is to prevent the build-up of static charges and to avoid potential differences by keeping personnel, equipment and device leads at the same potential, i.e. ground.

- The working bench shall be provided with a static dissipative top, which shall be connected to ground. The resistance between the bench top and ground shall be greater than 50 kΩ and less than 2 MΩ. A grounded wrist strap shall be worn when handling sensitive items. The strap shall be connected to ground via a resistor of 1 MΩ.
- The working chair shall be provided with a cover of cotton or a conductive material.
- Powered equipment at the work station shall be safely grounded. A ground-fault circuit interrupter shall be installed.
- Protective clothing and gloves made from treated (conducting) synthetic fibres shall be worn.
- Where possible all tools, such as mounting aids, shall be conductive. Static charges on non-conductive parts may be neutralized with ionized air.
- The soldering bit shall be grounded.
- Devices shall be kept as shipped (in e.g. conductive sticks, foam) as long as possible. Individual packaging shall only be removed at the work station. Containers shall be labelled as containing devices sensitive to static electric charges.

5.4 Lighting requirements

The lighting intensity shall be a minimum of 1080 lux on the work surface. At least 90 % of the work area shall be shadowless and without severe reflections.

5.5 Equipment and tools

5.5.1 Brushes

Medium-stiff natural or synthetic bristle brushes may be used for cleaning provided that they do not scratch the metal surface to be cleaned or damage adjacent materials beyond their visual inspection requirements. Such brushes should not be affected by the various PCB cleaning solvents. These brushes shall be regularly cleaned in a solvent prescribed in subclause 6.3.1. Wire brushes shall not be used.

5.5.2 Files

Files for dressing plated copper soldering-iron tips shall not be used. Files shall not be kept within the work area.

5.5.3 Cutters and pliers

In order to prevent the transmission of shock to delicate parts the cutter used for trimming conductor wire and component leads shall shear sharply, and consistently produce a clean, flat, smooth-cut surface along the entire cutting edge. There shall be no twisting action during this cutting operation. The suitable cutting edge profile and application are shown in Figure 1. The cutting edges of pliers shall be regularly checked for damage and maintained in a sharp condition. Smooth, long-nose pliers or tweezers may be used for attaching or removing conductor wire and component leads.

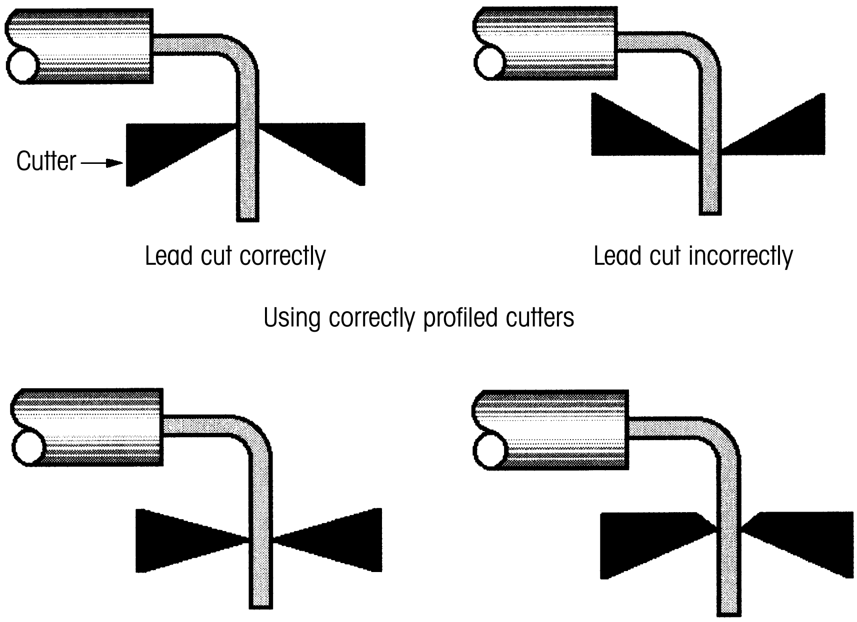

Figure 1: Profiles of correct and incorrect cutters for trimming leads

5.5.4 Bending tools

Bending and shaping of bare component leads shall be accomplished with appropriate tools, including automatic bending tools, which do not cut, nick or in any way damage the leads or insulation. Care shall be taken to avoid any damage or excessive straining on encapsulated components (see also subclause 8.2). Where semiconductor components in flatpack housings are required special tools defined by the contractor shall be used to shape the leads. These tools shall have no sharp edges and shall have a brilliant polished finish, preferably of hard chromium.

5.5.5 Clinching tools

Clinching tools shall be designed to minimize the likelihood of damage to the surfaces of printed-circuit conductors, components or component leads.

5.5.6 Insulation strippers

a. **Thermal strippers**. Thermal-type insulation strippers may be used on types of wire insulation for which they are suited; they are preferred for use with AWG 22 and smaller wire size where there is a possibility of wire stretching if a mechanical stripper is used. The heat of the stripper shall be controlled to prevent blistering and excessive melting of insulation. Local extraction units are required if thermal stripping is employed, in order to avoid component contamination or health hazards due to resultant fumes.

b. **Precision mechanical cutting-type strippers**. Automatic power-driven strippers with precision, factory-set, non-adjustable cutting and stripping dies and wire guards may be used. Precision-type hand strippers with accurately machined and factory-preset cutting heads may be used. The die openings for wire sizes other than that being used, should be masked off. The conductor shall not be twisted, ringed, nicked, cut or scored by this operation. Refer to Figure 2 for non-approved mechanical strippers.

c. **Calibration of stripping tools**. Both thermal and mechanical stripping tools require periodic calibration or sample evaluation during a production run.

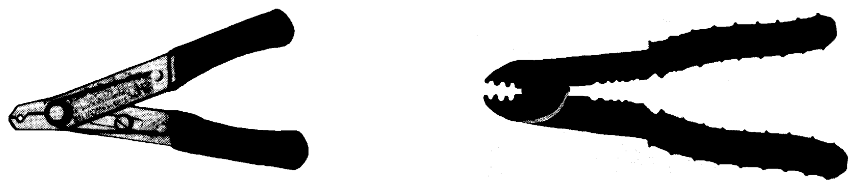

Figure 2: Non‐approved types of mechanical strippers

5.5.7 Soldering irons and resistance soldering equipment

a. **Selection of soldering irons**. The size and shape of the soldering iron and bit shall permit soldering with maximum ease and control without causing damage to adjacent areas or connections. Temperature‐controlled irons shall be used and they shall be calibrated at regular intervals. The tip shape, such as spade, chisel or pyramid, shall be appropriate for the workpiece and an assortment of spare bits shall be kept. The soldering iron or resistance‐heating electrode shall heat the joint area to the solder liquidus temperature in a time between 1 and 2 seconds and maintain proper soldering temperature at the joint throughout the soldering operation. For normal soldering of electronic components a soldering‐bit temperature of 280 °C is recommended, but it shall in no instance exceed 330 °C. For specific purposes a soldering‐bit temperature of 360 °C is permitted (e.g. presence of heat sinks or large PCB ground planes). Soldering equipment shall not produce magnetic fields that induce detrimental electrical energy in the item being soldered.

b. **Soldering‐iron holder**. A soldering‐iron holder satisfactory for the soldering iron used shall be provided. A cage‐type holder that leaves the soldering‐iron tip unsupported is preferred when temperature control is used (variable power control, properly adjusted).

5.5.8 Non‐contact heat sources

When heat is applied by a jet of heated gases, or by radiant‐energy beams, the user shall demonstrate the production of joints to the workmanship standard of this standard. The high reliability of the joints shall be proven by means of a test programme, which shall include verification testing as detailed in clause 13. The equipment shall be maintained by an established, documented procedure.

5.5.9 Soldering tools

Tools shall not cut, nick or in any way damage leads. Forked tools generally referred to as “soldering aids” may be used, provided they are made of a material which cannot be tinned under the soldering conditions employed.

a. **Thermal shunts**. Thermal shunts or heat sinks, when required, shall be of such size and shape that adequate thermal protection and minimum mechanical interference is afforded to the parts during soldering operations. The shunts should be easily applied and removed. They may be held in place by friction, spring tension, or any other suitable means that does not damage finish or insulation. An effective clamp‐type thermal shunt can be constructed by sweating small copper bars into the jaws of an alligator clip. Thermal shunts shall be used for the de‐golding, pre‐tinning and soldering of temperature‐sensitive components or whenever it is not certain whether the maximum temperature rating or insulation temperatures indicated by the manufacturer can be maintained.

b. **Anti‐wicking tools.** Appropriate anti‐wicking tools, marked with conductor gauge sizes, shall be used when required for the pre‐tinning of standard wires.

c. **Lead‐holding tool.** A suitable lead‐holding tool can be constructed. The tool shall be designed to avoid damage to the leads.

5.5.10 Defective or uncalibrated equipment or tools

Defective or uncalibrated equipment or tools shall be promptly removed from the work areas and replaced.

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6

Materials selection

6.1 Solder

6.1.1 Form

Solder ribbon, wire and preforms may be used provided that the alloy and flux meet the requirements of this standard. Alloy for use in solder baths shall be supplied as ingots (without flux).

6.1.2 Composition

Except under special circumstances, dependent on material compatibility or thermal constraints which shall be specified, the solder alloy shall have a composition prescribed in Table 1, see ISO 9453 for details. The solder alloy chosen shall be dependent upon how it will be used and Table 2 should be consulted as a guide.

6.1.3 Melting temperatures and choice

See Table 2.

6.2 Flux

6.2.1 Rosin-based fluxes

- **Pre-tinning**. Mildly activated rosin-based fluxes should be used (e.g. J-STD-004 Type L1) for the pre-tinning of component leads, metallized terminations and terminal posts. Fully activated rosin-based fluxes (e.g. J-STD-004 Type H1) may be used in cases of poor solderability.
- **Assembly**. Only pure rosin flux should be used for assembly (e.g. ISO-EN 29454 Type 1.1.1 or J-STD-004 Type L0). If mildly activated rosin flux is utilized for assembly, the effectiveness of subsequent cleaning operations shall be monitored (see subclause 11.3).
- **Flux application**. When an external liquid flux is used in conjunction with flux cored solders, the fluxes shall be compatible. If used, liquid flux shall be applied to the surfaces to be joined prior to the application of heat. The use of excess flux shall be avoided. When cored solder is used, it shall be placed in a position that allows the flux to flow and cover the connection elements as the solder melts.

6.2.2 Corrosive acid fluxes

When rosin-based fluxes are inadequate for the **pre-tinning** of component leads or terminal posts, then corrosive water-soluble acid fluxes may be used. Because these fluxes have residues that promote stress-corrosion cracking and general surface corrosion, they shall be completely removed immediately after use and before any further soldering operation (see also clause 11).

These activated fluxes shall not be used when their vapours or residues of spattered flux can come into contact with electrical insulation material. They shall be stored separately in accordance with the stipulations set out in subclause 7.5.3.

Table 1: Chemical composition of spacecraft solders

Designation		**63 tin solder (eutectic)**	**62 tin silver-loaded solder**	**60 tin solder**	**96 tin silver solder (eutectic)**
Tin (Sn)	Min %	62,5	61,5	59,5	remainder
	Max %	63,5	62,5	61,5	
Lead (Pb)	Max %	remainder	remainder	remainder	0,10
Antimony (Sb)	Max %	0,05	0,05	0,05	0,12
Silver (Ag)	Min %	–	1,8	–	3,5
	Max %	–	2,2	–	4,0
Bismuth (Bi)	Max %	0,10	0,10	0,10	0,10
Copper (Cu)	Max %	0,05	0,05	0,05	0,05
Iron (Fe)	Max %	0,02	0,02	0,02	0,02
Aluminium (Al)	Max %	0,001	0,001	0,001	0,001
Zinc (Zn)	Max %	0,001	0,001	0,001	0,001
Arsenic (As)	Max %	0,03	0,03	0,03	0,03
Cadmium (Cd)	Max %	0,002	0,002	0,002	0,002
Others	Max %	0,08	0,08	0,08	0,08

Table 2: Guide to choice of solder types

Solder Type	**Melting range (°C)**		**Uses**
	Solidus	**Liquidus**	
63 tin solder (eutectic)	183	183	Soldering PCBs where temperature limitations are critical and in applications where an extremely short melting range is required.
62 tin silver loaded	175	189	Soldering of components having silver-plated or ‘paint’ (i.e. ceramic capacitor) finish. This solder composition is saturated with silver and prevents the scavenging of silver surfaces.
60 tin solder	183	188	Soldering electrical wire/cable harnesses or terminal connections and for coating or pre-tinning metals
96 tin silver (eutectic)	221	221	May be used for special applications such as soldering terminal posts.

6.3 Solvents

6.3.1 Acceptable solvents

The solvents which may be used for the removal of grease, oil, dirt, flux and flux residues shall be non-conductive and non-corrosive, and shall not dissolve or degrade the quality of parts or materials or remove their identification markings. Solvents shall be properly labelled and maintained in a clean and uncontaminated condition. Those showing evidence of contamination or decomposition shall not be used.

Solvents shall not be used in any manner which will carry, dissolved flux residue onto contact surfaces such as those in switches, potentiometers or connectors.

The following solvents are acceptable when properly used for cleaning in soldering operations (see clause 11):

- ethyl alcohol, 99,5 % or 95 % pure by volume;
- isopropyl alcohol, best commercial grade, 99 % pure;
- deionized water at 40 °C maximum may be used for certain fluxes. Items shall be thoroughly dried directly after the use of deionized water;
- any mixture of the above.

6.3.2 Drying

All solvents shall be selected such that they can be completely dried.

6.4 Flexible insulation materials

Flexible insulation materials shall be suitable for use in a space environment. They shall have low outgassing properties, conforming to ECSS-Q-70-02.

Recommended materials include FEP and PTFE.

Other suitable materials include irradiated polyethylene, fluorinated resins and polyimide.

Care shall be taken that PTFE is not heated above 250 °C, as small amounts of poisonous gases are then generated.

6.5 Terminals

6.5.1 Preferred terminals

Terminals fabricated from bronze (copper/tin) alloys are preferred. Terminals made of brass (copper/zinc) alloys shall not be employed unless they have been correctly plated with a 3 μm–10 μm barrier layer of copper (nickel is also acceptable but it is magnetic and may have a poor solderability). The requirement for a barrier layer on brass items is necessary to prevent the diffusion, then surface oxidation, of zinc. The thickness of such barrier layers may be controlled on sampling basis by microsection.

Hot-dipped, tin/lead-coated, or electro-deposited and reflowed tin/lead terminals shall be used. Terminals with coatings on the mounting surface shall be rejected if they loosen in subsequent soldering operations.

6.5.2 Tin-, silver- and gold-plated terminals

Tin-, silver- and gold-plated terminals on PCBs shall not be used. These finishes may be removed by the methods prescribed in subclause 7.1.6 in order to achieve an approved tin-lead finish.

6.5.3 Shape of terminals

The bifurcated and turret terminals shall be provided with ledges or grooves of suitable dimensions to permit the adequate location of connecting wires and to facilitate the flow of solder.

6.6 Wires

Wire should be made of high-purity copper or copper alloy. Tinned and silver-coated wires should be used. Wires shall be stripped of their insulation in the manner described in subclause 7.1.

Special single strand wires, such as enamelled winding wires, shall be stripped by a special method.

6.7 PCBs

6.7.1 Boards

The basic insulation board shall be fabricated from woven-glass-reinforced dielectric material. Types G10, G11, FR4, FR5 and polyimide should be used. Compressed layers with organic fillers shall not be used. PCBs shall be procured from a supplier who has demonstrated that his products satisfy the requirements specified in ECSS-Q-70-10.

6.7.2 Plated-through holes

Plated-through holes should be used. Holes may be used unaided (i.e. without proper copperwire support) as electrical connection between conductor patterns on double-sided or multi-layer boards when procured from a qualified source. PCBs having a high coefficient of expansion shall require an aided hole, (i.e. PCB materials not listed in subclause 6.7.1).

For non-plated-through holes interfacial connections shall be made according to subclause 8.2.4.

6.7.3 Tin/lead finish on conductors

The copper conducting patterns shall be protected from corrosion or tarnishing by a suitable plating finish. Tin/lead electroplated and reflowed finishes shall be employed on PCBs requiring hand soldering. Finishes 10 μm-15 μm thick should be used, and the chemical composition shall conform to ECSS-Q-70-10.

6.7.4 Gold finish on conductors

Gold finishes in instances where components are to be welded onto the conducting pattern are not compatible with the surface-finish requirements for soldering and shall be avoided. Soldering directly to gold plating shall not be used. Degolding procedures are detailed in subclause 7.1. RF circuits which require gold finishes may have their conductors selectively plated so that the terminal pads to be soldered have a tin-lead finish.

6.8 Conformal coating, staking compounds and potting materials

Staking compound, conformal coatings, cementing, or encapsulation shall be used where to provide mechanical support and protection against contamination. The types of materials and related procedures to provide mechanical support shall be specified. Material shall be selected to conform to the requirements of ECSS-Q-70-02. The selection shall also be dependent on electrical requirement and anticipated service environment. Important electrical properties shall include dielectric constant, insulation resistance and corona suppression. Special consideration shall also be given to factors resulting from processing methods; these shall include cure temperature as well as exothermic heat of reaction.

Shrinkage of resin during cure and repair shall not degrade articles which are to be coated. No compounds that emit acetic acid, ammonia, amines, hydrochloric acid and other acids shall be used, as they can cause stress-corrosion cracking of part leads. Stress relief, as detailed in subclause 8.1.5, shall not be impeded by the improper selection of potting, encapsulating or conformal-coating material; particularly at low service temperatures where some materials become hard and brittle.

All materials contained in this subclause shall be individually assessed when flammability requirements are applicable.

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7

Preparation for soldering

7.1 Preparation of conductors, terminals and solder cups

7.1.1 Insulation removal

Stripping tools or machines used shall be of the correct size for the wire conductor (see subclause 5.5.6) and marked to indicate adjustment or calibration status. The conductor shall not be twisted, ringed, nicked, cut or scored by this operation. There shall be no charring of the insulation although discoloration of the insulation associated with normal thermal stripping methods is no cause for rejection.

7.1.2 Damage to insulation

After insulation removal, the remaining conductor insulation shall not exhibit any damage such as nicks, cuts, crushing, or charring. Slight pressure markings caused by mechanical stripping tools shall not be a cause for rejection. Conductors with damaged insulation shall not be used. Slight discoloration from thermal stripping is acceptable.

7.1.3 Damage to conductors

After removal of the conductor insulation, the conductor shall not be nicked, cut, scraped, or otherwise damaged. Part leads and other conductors which have been reduced in cross-sectional area shall not be used. Damaged wires where the base material is exposed shall not be used.

7.1.4 Insulation clearance

Maximum insulation clearance from the solder joint shall be as stated in Table 3. Exceptions may be made for the assembly of coil winding wires.

Minimum insulation 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.

Table 3: Insulation clearance

Wire diameter American Wire Gauge (AWG)	Conductor diameter (D) (mm)	Insulation clearance (max)
32 - 24	0,200 - 0,510	4 × D
22 - 12	0,636 - 2,030	3 × D
≥ 10	≥ 2,565	2 × D

7.1.5 Surface to be soldered

a. **Cleaning**. All conducting surfaces to be soldered shall be clean before the soldering operation. Cleaning solvents are specified in subclause 6.3.1. Unauthorized abrasives, including pumice and emery paper, shall not be used for surface preparation. Gold plating having a thickness of 1 μm or less on printed circuits shall be removed in the manner laid down in subclause 7.1.5 c. Under no conditions shall soldering directly to gold plating be permitted.

b. **Wire lay**. The lay of the wire strands shall be restored if disturbed, without using bare fingers.

c. **Removal of gold from a PCB conductor**. This shall be carried out by means of a special pencil-style white typewriter eraser. The operation shall not damage the substrate materials or reduce the solderability of the conductor area or reduce the thickness of the copper leads. This method is only suitable for removing gold plating less than 1 μm thick.

d. **Terminals and solder cups**. Terminals and solder cups shall not be modified to accommodate improper conductor sizes.

7.1.6 De-golding and pre-tinning of conductors

a. **Stranded wires**. The stripped ends of stranded wires shall be tinned to confirm solderability and prevent untwisting and separation of wire strands. This operation may be carried out by lightly fluxing the strand ends with pure rosin flux, then dipping the required length of bared wire into a bath of molten tin/lead solder (see subclause 6.1.2). Immersion should be for about 2–3 seconds at a bath temperature of between 210 °C and 260 °C. Before dip tinning, the bath surface shall be freshly skimmed to remove surface impurities, such as oxides. Pre-tinning may also be accomplished by applying solder onto the wire with the aid of a heated soldering-iron tip (see subclause 5.5.7). Solder shall penetrate to the inner strands of stranded wire. The insulation shall not be damaged and flow of solder (wicking) along the conductors shall be kept to a minimum. When possible, anti-wicking tools shall be employed (see subclause 5.5.9). Solder shall not obscure the wire contour at the termination end of the insulation. Flux shall be removed by means of a cleaning solvent. This shall be applied with lint-free cloth so that its flow under the conductor insulation is minimal.

b. **Component leads/solid-wire conductors**. Component leads or solid wires shall be pre-tinned by dipping into a solder bath for 2–8 seconds (see notes below) as described in subclause 7.1.6 a. These conductors shall not be reduced in cross-sectional area by dissolution into the molten solder bath. Withdrawal of component leads from the bath should be slow, vertical and without pausing, resulting in a solder coat more than 2 μm deep. When possible, components having glass-to-metal lead seals shall be preformed according to subclause 5.5.4 before pre-tinning. The tinning shall not approach closer than 0,75 mm to any lead-to-glass seal of the component package. In instances of poor solderability, activated fluxes may be used, but they shall be immediately cleaned off with a solvent, as specified in subclauses 6.2 and 6.3.

- The immersion period should be 3–4 seconds. However, the maximum period shall be no greater than 8 seconds.
- In no instance shall a component body, or its glass meniscus, be immersed in or become wetted by liquid solder. Many components have limited pre-tinning distances.

c. **De-golding of gold-plated leads and terminals**. Gold shall be removed from component leads and terminals by dipping the leads into a solder bath (bath 1) held at 250 °C to 280 °C for 2–3 seconds. After gold dissolution the leads shall be pre-tinned (in bath 2) as described in subclause 7.1.6 b. During this process regular analyses of baths 1 and 2 shall be made. Alternatively the solder within these baths may be regularly replaced, (the replacing frequency shall be justified). The gold shall not exceed 1 % by weight in bath 1. Bath 2 shall not be contaminated with copper in excess of 0,25 % by weight or gold in excess of 0,2 %, the total gold plus copper not exceeding 0,3 %. Contamination with zinc, aluminium or iron shall be carefully avoided. When the solder produces a dull, frosty or granular appearance on the work, the bath shall be removed from use. Alternatively, a short length of solder wire may be melted within a solder cup to dissolve gold plate; the liquid solder can then be wicked-out with stranded wire. Moreover, the following special constraints shall apply:

- on no account shall pre-tinning be carried out in the solder which has been used for gold dissolution;
- suitable thermal shunts, as specified in subclause 5.5.9, shall be used;
- on no account shall the absolute maximum soldering rating of the component be exceeded.

7.2 Preparation of the soldering bit

7.2.1 Inspection

Frequent checks shall be made to ensure that the bit fits well into the soldering tool.

7.2.2 Maintenance

Oxidation products shall be removed from the bit at regular intervals to ensure the tip's ability to readily transfer heat.

7.2.3 Copper bits for special soldering applications

Copper bits for special soldering applications may be filed (subclause 5.5.2) to the correct shape when cold. After filing, the tip shall be dipped into flux and then into a solder bath maintained at 300 °C. Hot bits may be cleaned with a damp natural or synthetic sponge.

7.2.4 Plated bits

Plated bits may be cleaned with a moist sponge, or if necessary abrasive paper (grain size 600). A file shall not be used. Any solder covering and obscuring the plated bit shall be removed prior to examination by wiping the bit, when the iron is hot, with a lint-free sponge material. The plated tip shall then be carefully examined for cracking. Cracked platings shall be immediately rejected and removed from the soldering area as they allow the liquid solder to alloy with and erode the plated copper bit, forming an excessive amount of intermetallics which reduce heat transfer and produce unacceptable joints.

7.2.5 Tip in operation

The application surface of the tip shall always be coated with a thin continuous layer of solder in order to avoid oxidation. Pre-tinning of the tip may be carried out according to subclause 7.1.6 a.

7.3 Maintenance of resistance-type soldering electrodes

The surfaces of electrodes shall be kept free of contamination and corrosion.

7.4 Handling (work station)

Component leads, terminals, wire ends and PCB termination areas shall not be touched with the bare hands. Persons who work with cleaned PCB assemblies should wear clean lint-free gloves or finger cots. If metal surfaces are handled with bare hands or otherwise become contaminated, they shall be immediately cleaned with a solvent specified in subclause 6.3.1.

Components susceptible to static-electric charges require special precautions; see subclause 5.3.

7.5 Storage (work station)

7.5.1 Components

Adequate storage facilities which protect components from contamination and damage shall be available. Containers for handling components sensitive to static-electric charges shall be labelled as such and shall be made of a conductive material.

7.5.2 PCBs

PCBs shall be stored in a moisture-free container situated in the proximity of the work area.

7.5.3 Materials requiring segregation

Materials requiring segregation shall include solders of unauthorized composition, corrosive acid fluxes or other corrosive fluxes and solvents containing impurities such as inorganic acids, and shall be removed from the work area.

7.5.4 Traceability

Visible evidence of traceability of all items and materials shall be recorded during their use and storage in the soldering fabrication area.

7.6 Baking of PCBs

PCBs shall be cleaned and demoisturized within 8 hours prior to their initial exposure to soldering temperatures. The PCBs may be stored for longer periods of time in a controlled moisture-free atmosphere. Demoisturization may be accomplished by an oven bake at 90 °C to 120 °C (depending upon the laminate material), for a minimum of 4 hours, or by a vacuum bake at a lower temperature.

8

Mounting of components

8.1 General requirements

8.1.1 Introduction

Components shall all be mounted parallel to the mounting surface, preferably in contact with it and in any case not more than 1 mm above it. Exceptions to this requirement are detailed in the following subclauses.

8.1.2 Heavy components

Components heavier than 5 grams shall be given additional support. Approved adhesives or mechanical means may be used. The method used shall not produce stresses causing functional degradation or damage to the part or assembly. Care shall be exercised to avoid negating the stress relief designed into the assembly or introducing additional stresses.

8.1.3 Metal-case components

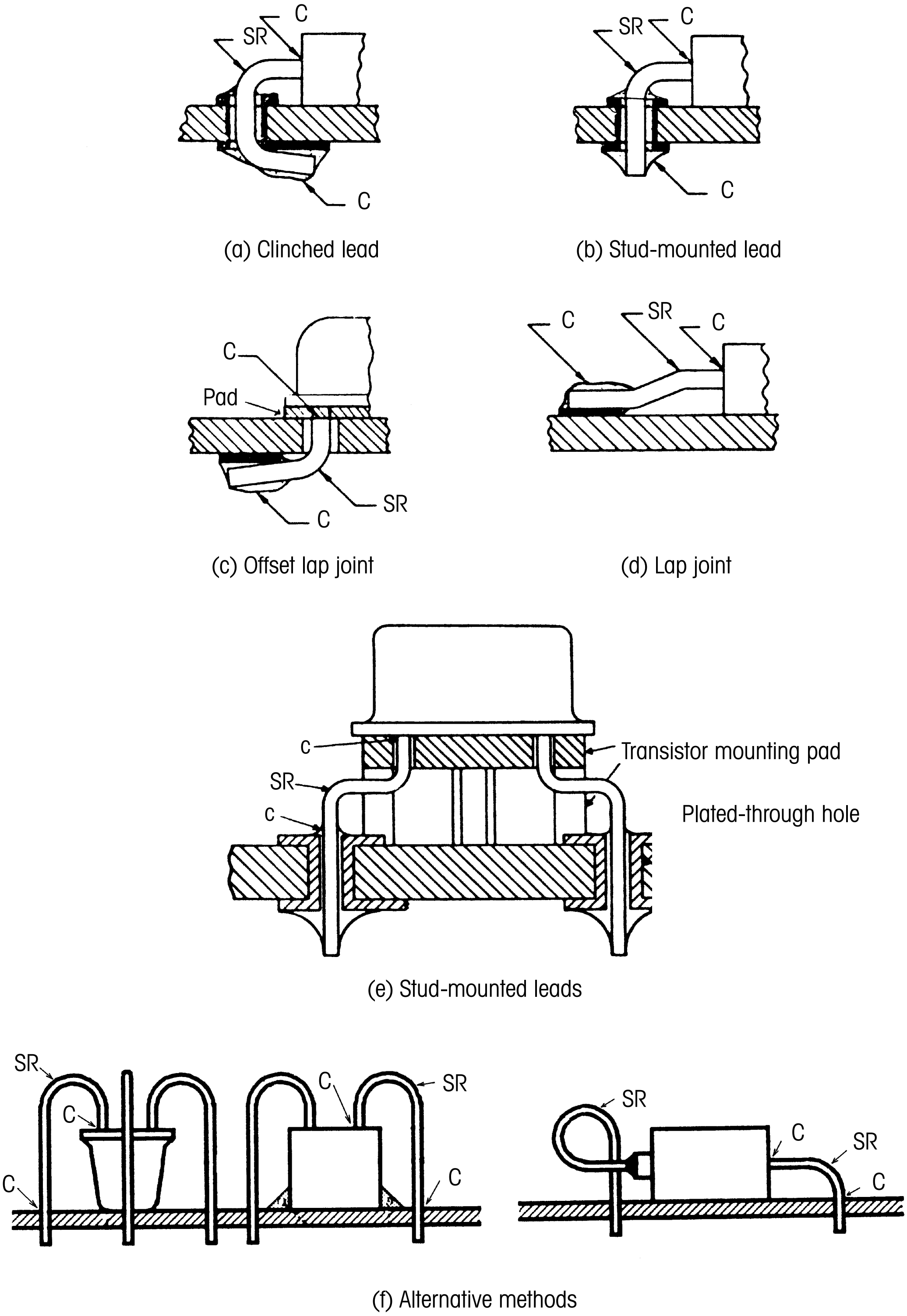
Metal-case components that are mounted over printed conductors or come into contact with each other or with other conductive material shall be encased in or supported by an insulating space-qualified material. Such components shall not be mounted over soldered connections. Where part identification marks (such as serial numbers on components) are covered, transparent insulators should be used.

8.1.4 Glass-encased components

Glass-encased components (such as diodes) may be enclosed in transparent resilient sleeving. Space-approved materials shall be used for support, conformal coating or potting. When heat-shrinkable tubing is used, extreme care shall be taken to prevent damage due to excessive heat or shrinkage of tubing.

8.1.5 Stress relief

Stress relief shall be incorporated into all leads and conductors in solder connections and between interfacial connections to provide freedom of movement of component leads or conductors between points of constraint. Freedom of movement shall be sufficient to prevent detrimental stresses to either the component or solder connection due to mechanical fixations or thermal variations. Excessive lead lengths or large loops between constraint points shall be avoided to prevent assembly and vibration damage. Leads shall not be temporarily constrained against spring-back force during soldering so that the lead material or solder joint are subject to residual stresses. The solder fillet shall not negate the stress relief bend. Some examples of stress relief are shown in Figures 3, 6, 11, 12 and 13.



SR = Stress relief bend
C = Constraint point

Figure 3: Stress relieved component terminations on PCB

8.1.6 Reinforced plated-through holes

See subclauses 6.7.2 and 8.4.2.

8.1.7 Lead and conductor cutting

Leads and conductors shall be cut to the required length before soldering.

Under no circumstances shall any solder termination be cut or damaged following the soldering operation.

8.1.8 Heat-generating components

Heat-generating components (generally 1 W or more) shall be thermally shunted by a method such as clamps or approved heat-conductive adhesive to minimize the heat dissipation into the solder terminations.

8.1.9 Moulded components

Components shall be so mounted that the moulding material applied by the manufacturer on the leads does not enter the mounting hole or soldered connection.

8.1.10 Hook-up wire

Solid hook-up wire shall be supported by a means other than the solder connections if wire length exceeds 25 mm. Distance between supports shall not exceed 25 mm. Attachment to a surface by approved conformal coating or cementing with resin is adequate support. A single wire shall not be used to connect more than two points.

8.1.11 Location

Component bodies shall not be located in contact with soldered or welded terminations.

8.1.12 Conformal coating, cementing and encapsulation

When conformal-coating, cementing or encapsulating components with plastic materials, the operator shall take care to avoid negating the stress relief designed into the assembly or introducing additional stresses. Coatings and cementing compounds should not be allowed to bridge stress relief loops or bends at terminations in component leads or connecting wires (see also subclause 6.8).

8.2 Lead bending requirements

8.2.1 General

During bending, component leads shall be supported to minimize axial stress and avoid damage to seals or internal bonds. The inside radius of a bend shall not be less than the lead diameter or ribbon thickness. The distance from the bend to the end seal shall be approximately equal at each end of the component. The minimum distance shall be two lead diameters for round leads and 0,50 mm for ribbon leads. The direction of the bend should not cause the marking on the mounted component to be obscured. Where the lead is welded (as on a tantalum capacitor), the minimum distance shall be measured from the weld (see Figure 4). Tools shall not be placed over the weld (see also subclause 5.5.4).

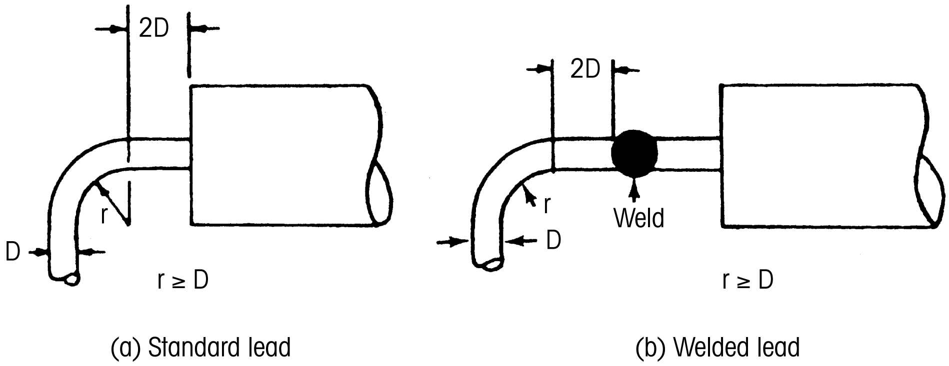


Figure 4: Minimum lead bend

8.2.2 Components with leads terminating on the opposite side of a PCB

Stress relief shall be provided in the component lead between the component body and solder terminations (see Figures 3(a)-(c) and (e)). The lead may be terminated by clinch, stud, or lap configuration, as per subclauses 8.4.3 to 8.4.7.

8.2.3 Components with leads terminating on the same side of a PCB

Stress relief shall be provided by forming the component leads at a bend angle to the PCB of not more than 90° nor less than 45°. The lap termination described in subclauses 8.4.5 and 8.4.6 shall be used. See Figure 5.

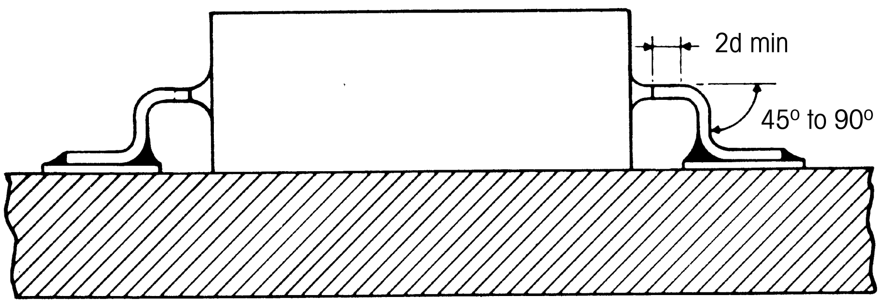
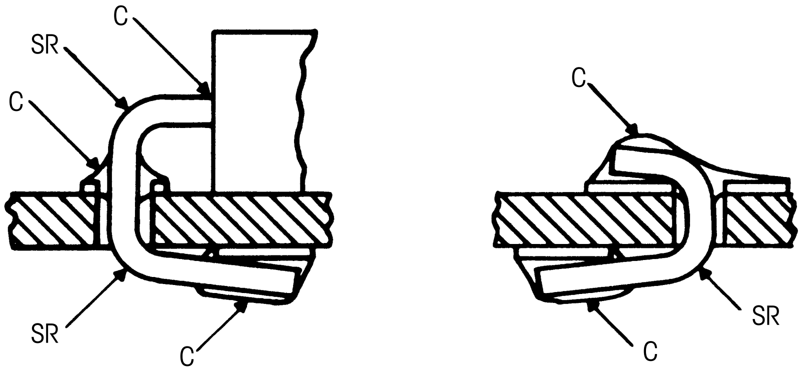


Figure 5: Component and solder termination on the same side

8.2.4 Conductors terminating on both sides of a non-plated-through hole

Stress relief shall be provided in the component lead between the component body and solder terminations. When a solid hook-up wire is used to interconnect solder terminations on opposite sides of a PCB, stress relief shall be provided in the wire between the two terminations. See Figure 6.



SR = Stress relief
C = Constraint point

Figure 6: Leads with solder termination on both sides

8.2.5 Non-bendable leads

Leads which cannot be bent (e.g. when bending damages the component or the PCB because of the lead-material composition, presence of delicate seals or an excessive lead diameter) shall be cut according to subclauses 5.5.3 and 8.4.4.

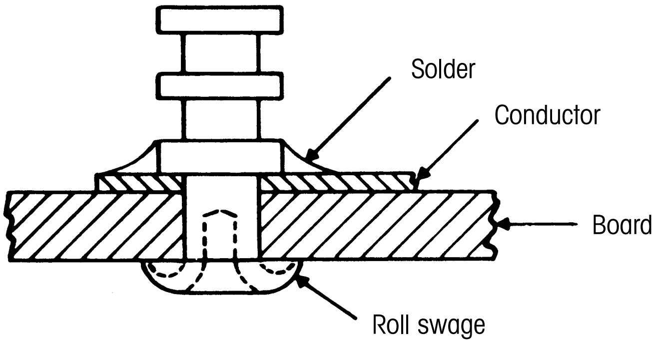
8.3 Mounting of terminals to PCB

8.3.1 General

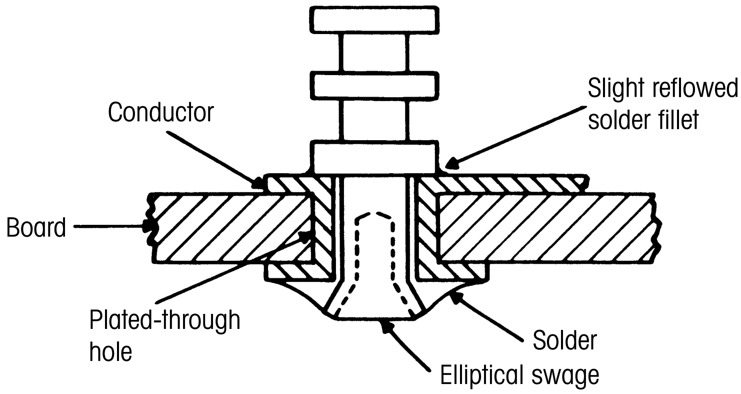
Use of terminals shall be restricted generally to situations where components are expected to be removed or replaced, or where there are other compelling design requirements. Furthermore, terminals shall not be used as interfacial connections on PCBs.

8.3.2 Methods of attachment

- Swage-type terminals designed to have the terminal shoulder soldered to printed conductors shall be secured to the PCB by a roll swage (see Figure 7(a)).
- Swage-type terminals that are mounted in a plated-through hole shall be secured to the PCB by an elliptical funnel swage to permit complete filling of the plated-through hole with solder (see Figure 7(b)). This technique requires special care when used on multi-layer boards in order to avoid damage to the internal connections.
- Swaging shall be accomplished so as not to damage the PCB.
- After swaging, the terminal shall be free from circumferential splits or cracks, but may have a maximum of three radial splits or cracks, provided the splits or cracks do not extend beyond the swaged area of the terminal. Radial splits or cracks shall be a minimum of 90° apart.



(a) Single sided



(b) Double sided

Figure 7: Types of terminal swaging

8.4 Lead attachment to PCBs

8.4.1 General

All termination surfaces shall be solder-tinned before solder assembly (see subclauses 6.7.3 and 7.1.6 b.). Solder terminations shall be visible for inspection after soldering. Component leads should be terminated to PCBs by lap, clinch or stud terminations. A separate hole, preferably plated-through, shall be used for each component lead extending through the PCB. The number of different hole sizes should be kept to a minimum.

8.4.2 Lead access holes

a. **Unsupported holes**. The diameter of an unsupported hole used for a clinch or stud termination shall not exceed, by more than 0,20 mm, the nominal diameter of the component lead (see Figures 8 and 10(a)). The diameter of a hole used for a lap joint shall not exceed 1,5 times the nominal lead diameter or width.

b. **Plated-through holes**. Plated-through holes may be used unaided as an interfacial electrical connection between conductor patterns on standard double-sided PCBs and multi-layer boards procured from final-customer-qualified manufacturers. The plated-through copper diameter of plated-through holes shall provide from 0,30 mm to 0,65 mm clearance between the lead or terminal and the hole wall to allow solder flow-through (see Figure 9).

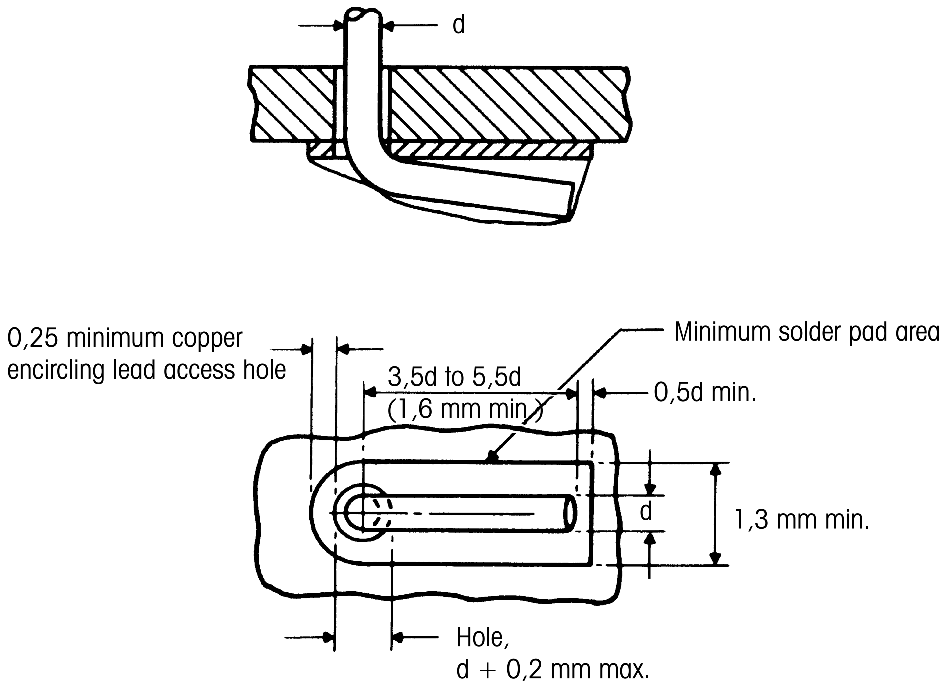


Figure 8: Clinched-lead terminations - unsupported holes

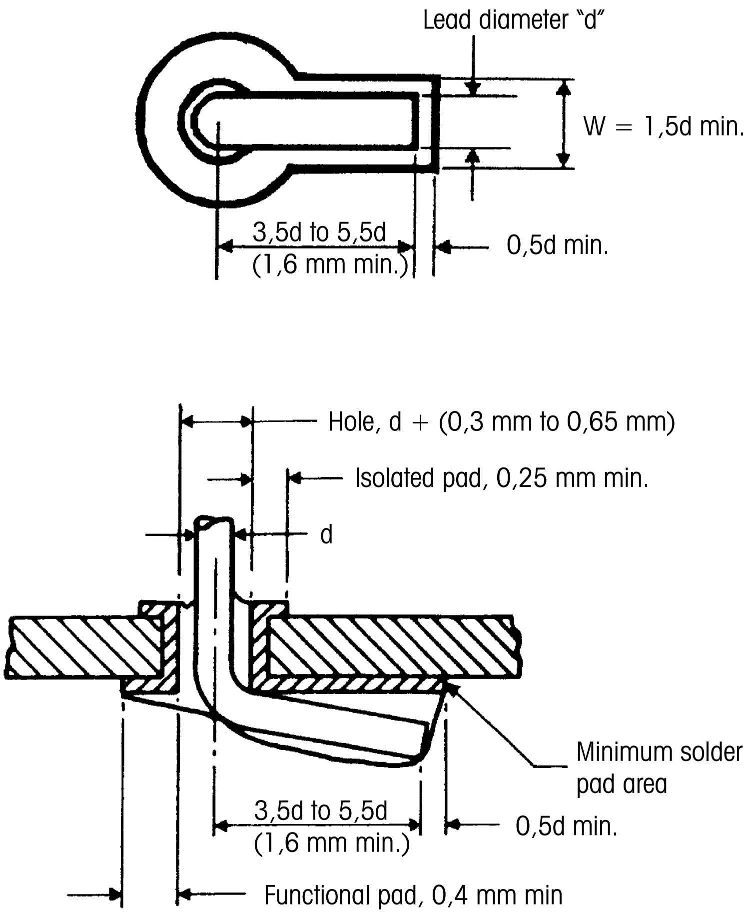


Figure 9: Clinched lead terminations - plated through-holes

8.4.3 Clinched leads

Clinched leads terminating at a PCB pad shall be bent to make contact with the printed circuit tracks unless the leads have been specifically documented as being non-bendable (see subclause 8.2.5). The clinch shall not be forced to make the lead lie flat at the bend radius and some innate spring-back of the component lead is desirable (see Figure 9). The clinched lead shall not extend beyond the conductor pattern edge and its length shall depend upon the plated-hole size and the solder-pad area, as indicated in Figure 9.

a. **Rounded termination areas**. (refer to Figures 8 and 9) The lead shall extend through and overlap the solder pad. The lead shall be bent in the direction of the longest dimensions of the solder pad provided by design, allowing nominal spring back. However, if the pad dimensions are not sufficient, the lead shall be bent in the direction of the printed circuit path. A length of conductor pattern equal to 0,5 times the lead diameter shall be provided at the cut-off end of the lead to accommodate solder filleting. In instances where the component lead is less than 0,50 mm in diameter, lead overlap shall be no less than 1,6 mm. There shall be sufficient solder-pad area extending beyond the sides of the lead to accommodate solder filleting.

b. **Irregularly shaped termination areas**. For irregularly shaped termination areas, such as for shield and ground-plane connections, the minimum clinch-lead length shall be twice the diameter of the lead hole, and the maximum shall be four times the hole diameter.

8.4.4 Stud leads

Stud leads shall be so cut that when mounted the leads protrude through the board circuitry (1,5 ± 0,8) mm (see Figure 10).

NOTE When stud leads are used, they should be inserted into plated-through holes whenever possible.

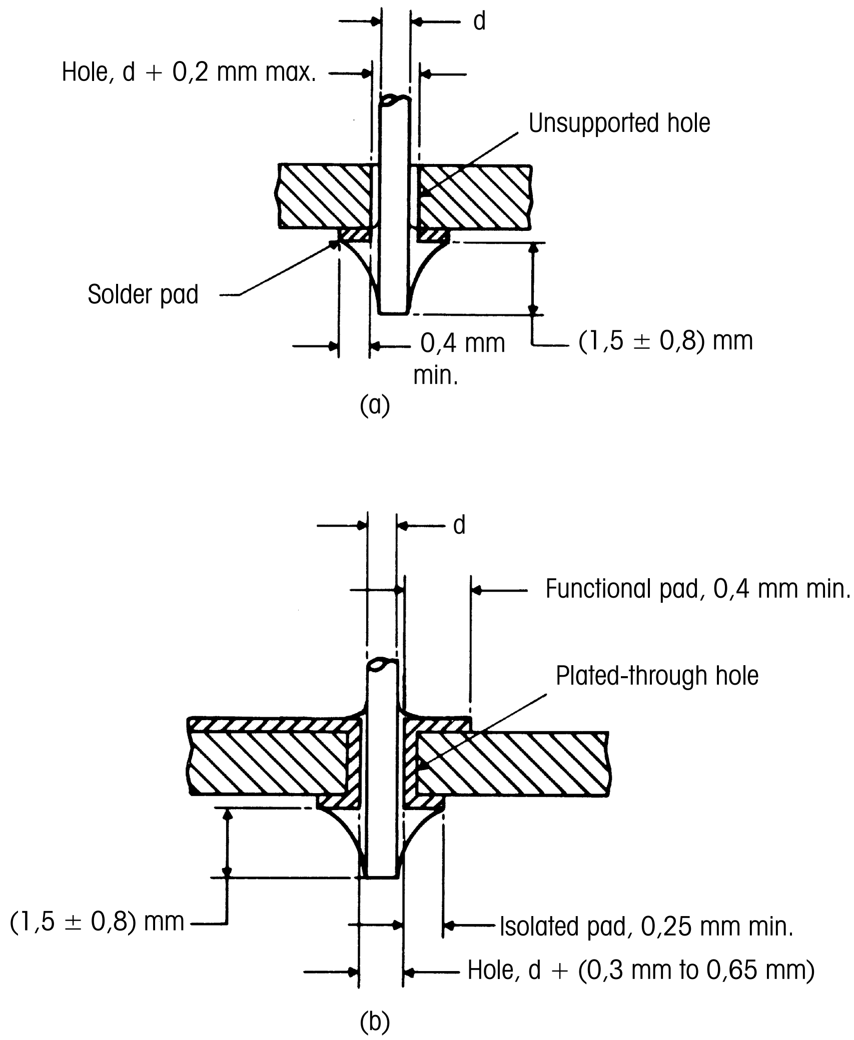


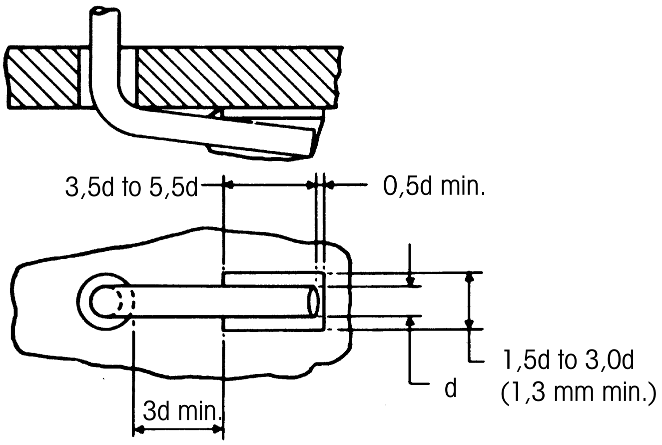
Figure 10: Stud terminations

8.4.5 Lapped round leads

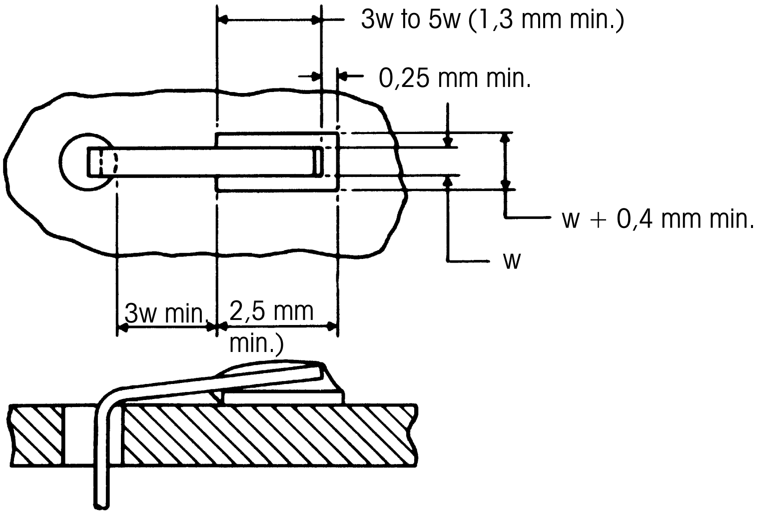
The round lead shall overlap the solder pad a minimum of 3,5 times the lead diameter to a maximum of 5,5 times the lead diameter, but shall in no case be less than 1,3 mm. The cut-off end of the lead shall be no closer than 1/2 the lead diameter to the edge of the solder pad. Only that portion of the lead extending to the component body or to another soldered connection shall be beyond the solder pad (see Figure 11(a)).

8.4.6 Lapped ribbon leads

The ribbon lead shall overlap the solder pad a minimum of 3 lead widths to maximum of 5 lead widths. Only that portion of the lead extending to component body or to another soldered connection shall be beyond the pad. The cut-off end of the lead shall be 0,25 mm minimum to 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 (see Figure 11(b)). In instances where ribbon leads are less than 0,50 mm in width, ribbon overlap shall be no less than 1,3 mm.



(a) Round lead



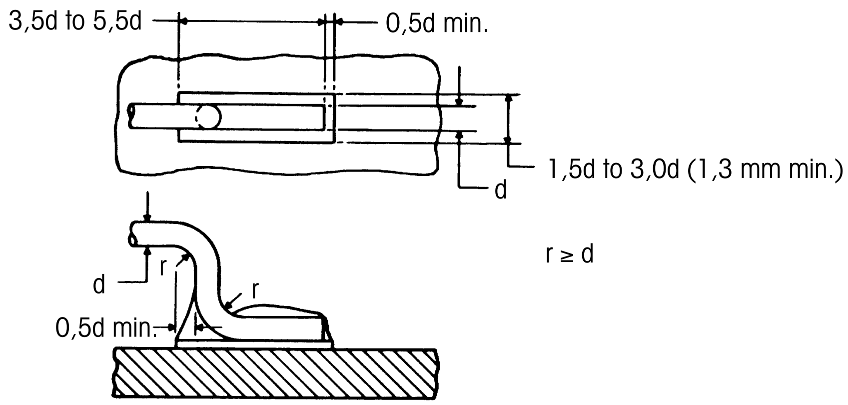
(b) Ribbon lead

Figure 11: Through-hole lapped terminations

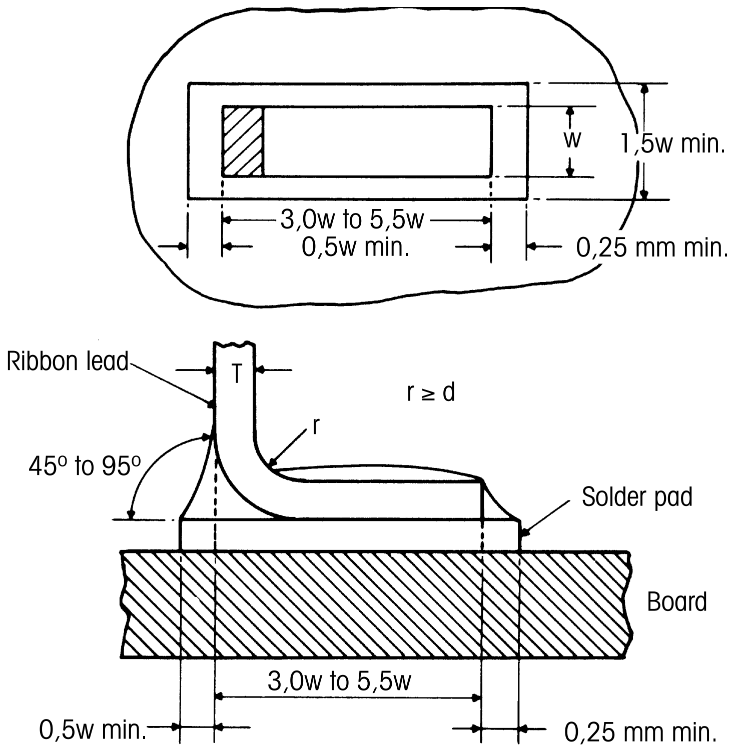
8.4.7 Lapped round- and ribbon-lead parts with solder connection on same side

Round or ribbon-leaded parts (such as flat packages having a maximum dimension (diagonal) no greater than 14 mm) mounted on the same side as their solder connections shall have a minimum lead-to-solder-pad contact of 3,0 times the lead diameter/ribbon width to a maximum of 5,5 times the lead diameter/ribbon width (see Figure 12). There shall be a minimum dimension of 0,5 of the lead diameter or ribbon width at the heel of the part lead to accommodate solder filleting. Care shall be exercised to minimize the skewing of leads in relation to terminal areas. Leads may not extend beyond pad edges. When the heel is soldered, fillets shall conform to the applicable workmanship standards.

NOTE Flat packages are constructed in a variety of styles and dimensions. For those having gull wing formed leads (ribbon or round cross-section) and a body dimension (diagonal) greater than 14 mm ECSS-Q-70-38 applies.



(a) Round lead



(b) Ribbon lead

Figure 12: Design dimensions for single-surface lapped terminations (not all can be measured after soldering).

8.5 Mounting of components to terminals

8.5.1 General

Components shall be mounted in the manner prescribed in subclause 8.1.

8.5.2 Special constraints

- The length of leads between components and terminals shall be approximately equal at both ends, except when special part shapes, such as flanges on top hat diodes, require staggering.
- Each lead shall have provision for stress relief as depicted in Figure 13.
- Degree of wrap, routing and connection to terminals are specified in clause 9 and clause 10.
- All swaged solder connections should be heat-sinked during the component-lead soldering operation. Also, care shall be exercised to ensure that swaged solder connections are not mechanically stressed during component-mounting operations.

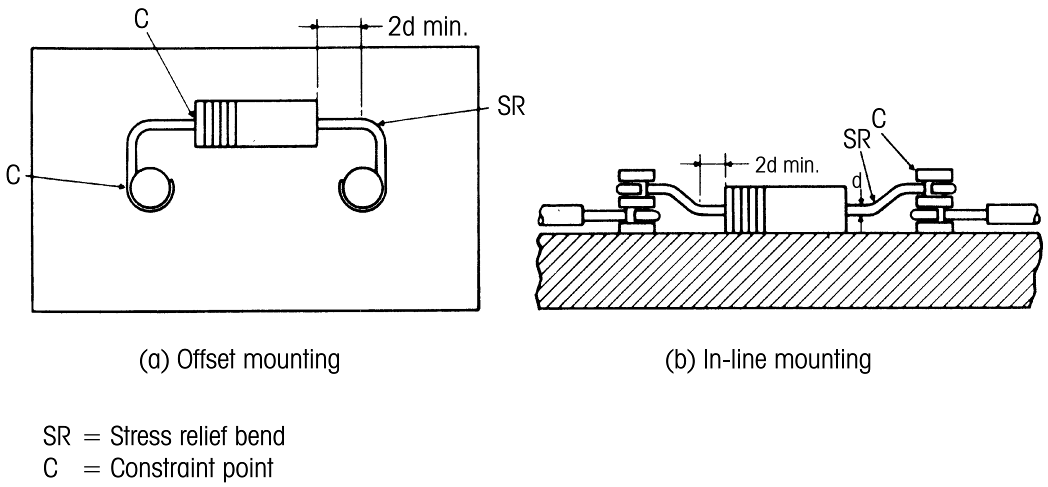


Figure 13: Method of stress relieving parts attached to terminals

8.6 Cordwood modules

- Components in cordwood modules shall be mounted with the component axis perpendicular to the two parallel PCBs.
- Tubular components shall be uniformly spaced between the PCBs.
- Coated components shall be so mounted that the coating on leads does not enter the mounting hole.
- Termination of components shall be as specified herein. Particular attention shall be given to provisions for stress relief.

8.7 Mounting of connectors to PCBs

8.7.1 General

Connectors shall be mounted in the manner prescribed in subclause 8.1.

8.7.2 Special constraints

PCB connectors shall be supplied with either pre-formed leads supporting stress relief bends or straight, epoxy bonded leads exiting straight from the connector body.

De-golding/pre-tinning of leads (see subclause 7.1.6) shall be performed prior to mechanical fixing of connectors to the PCB. Connector leads, following mechanical fixation, shall protude through the board in accordance with subclause 8.4.4.

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9

Attachment of conductors to terminals, solder cups and cables

9.1 General

9.1.1 Conductors

Conductors shall be attached to terminals as illustrated in this clause, which shows the requirements for routing to terminals, terminal fill, insulation clearance and the extent of conductor wrap or bend.

9.1.2 Terminals

Gold-plated terminals and solder cups shall have the gold removed in the area for conductor attachment and replaced with a hot tin-lead solder coating by a method described in subclause 7.1.6 c.

Terminals with uneven or excessive coating on the mounting surfaces shall not be used, as such coating can loosen in subsequent soldering operations. Terminals shall be of proper size to accommodate the conductors. Terminals and conductors shall not be modified to accommodate improper sizes.

9.1.3 Component leads

A component lead shall not be used as a terminal (see also ECSS-Q-70-28 for repair or modification).

9.2 Wire termination

9.2.1 Breakouts from cables

For multiple wires routed from a common cable trunk to equally spaced terminals, the length of the wire ends, including vibration bend allowance, shall be uniform to prevent stress concentration on any one wire.

9.2.2 Minimum and maximum insulation clearance

These are described in subclause 7.1.4.

9.2.3 Multiple parallel entry

For multiple parallel entry of wires to a terminal, insulation clearances need not be equal.

9.2.4 Variations

When characteristic impedance or circuit parameters are affected, as in high-voltage circuits or RF coaxial line terminations, the insulation clearance requirements may be modified. All variations shall be documented in the process procedures.

9.2.5 Solid hook-up wire

Solid hook-up wire shall not exceed a length of 25 mm between supports.

Cementing with resin or conformal coating should be used. A single wire shall not be used to connect more than two points.

9.2.6 Stress relief

Each conductor terminating at a solder connection shall have provision for stress relief to minimize stresses to the connection during thermal or mechanical variations. Wicking shall be controlled as indicated in subclause 7.1.6 a.

9.2.7 Mechanical support

Wire bundles shall be so supported that the solder connections are not subjected to mechanical loads.

9.3 Turret and straight pin terminals

9.3.1 Side route

The side route shall be connected as follows (see Figure 14(a)):

- Conductors shall be wrapped a minimum of 1/2 turn to a maximum of 3/4 turn around the post (see Figure 14(c)).
- For turret terminals, all conductors shall be confined to the guide slots.
- Conductors shall not extend beyond the base of the terminal.
- More than one wire may be installed in a single slot of sufficient width provided each wire is wrapped on the terminal post and not on another wire.
- Wires terminating at terminals that do not have a mechanical shoulder or turret shall not be attached closer than one conductor diameter to the top of the terminal.

9.3.2 Bottom route

The conductor shall enter the terminal from the bottom, be brought through the side slot at the top, and wrapped as required for side route (see Figure 14(b)).

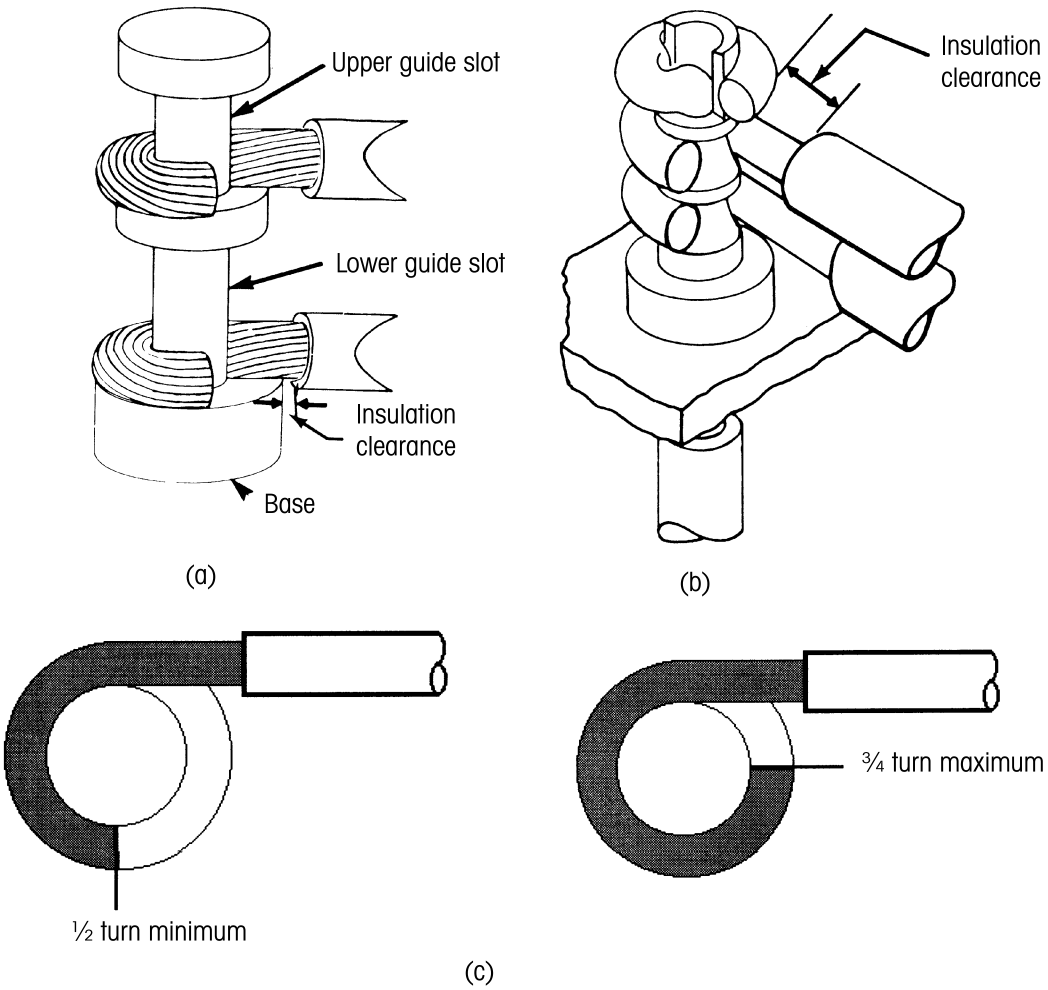

Figure 14: Side- and bottom-route connections to turret terminals

9.4 Bifurcated terminals

9.4.1 General

Top, side, or bottom routes, or combinations as illustrated in this subclause, may be used. Terminal side-route connections shall not extend beyond the top of the terminal.

9.4.2 Bottom route

Bottom route shall be connected as shown in Figure 15. Conductors shall not extend beyond the diameter of the base except as shown in Figure 15(c), which is acceptable only when physical clearance is adequate for the intended environment and electrical characteristics.

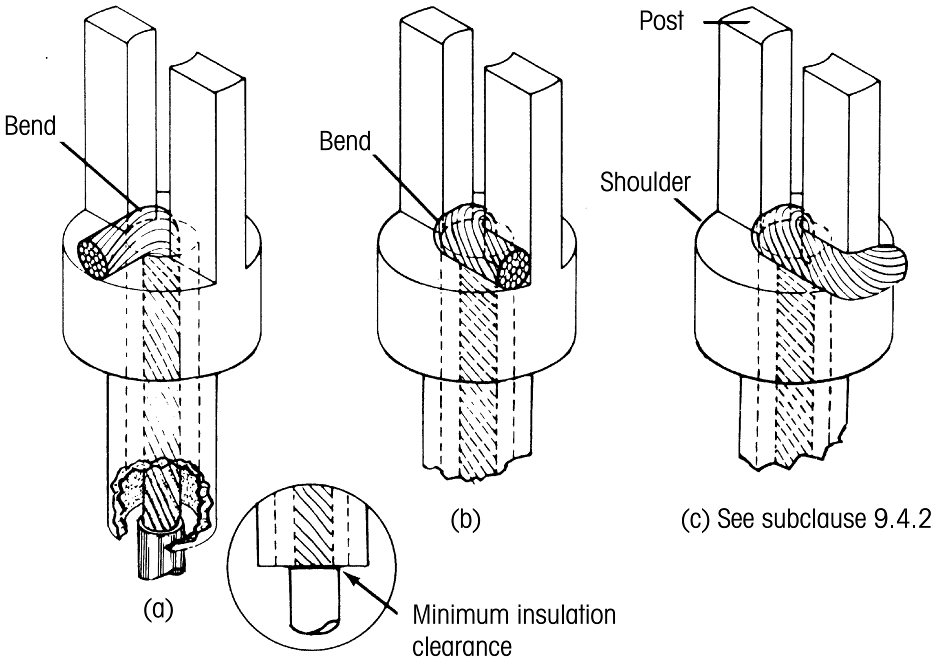

Figure 15: Bottom-route connections to bifurcated terminal

9.4.3 Side route

Side route shall be connected as shown in Figure 16. The conductor shall enter the mounting slot perpendicular to the posts. When more than one conductor is connected to a terminal, the direction of bend of each additional conductor shall alternate (Figure 16(b) and (d)). Conductors shall not extend beyond the diameter of the base except as shown in Figure 16(c), which is acceptable only where physical clearance is adequate for environment and electrical characteristics.

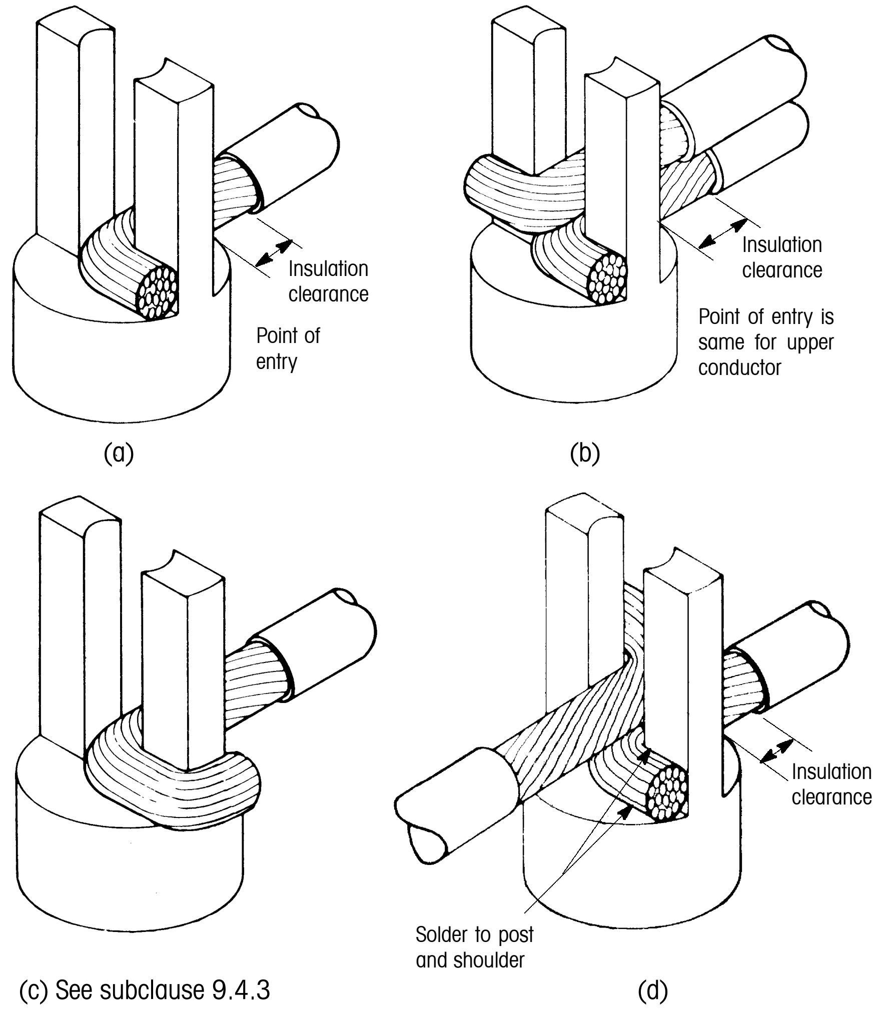

Figure 16: Side-route connection to bifurcated terminal

9.4.4 Top route

The top route shall not be used if there is sufficient room for side entry. Top route shall be connected as shown in Figure 17. Conductors which fill the gap between vertical posts shall be inserted to the depth of the shoulder. Conductors which do not fill the gap shall be accompanied by a tinned filler wire (solid or stranded) to help hold the conductor in position, or shall be bent double as shown, provided the combined diameters are sufficient to fill the gap. The top route and side route shall not be used on the same terminal.

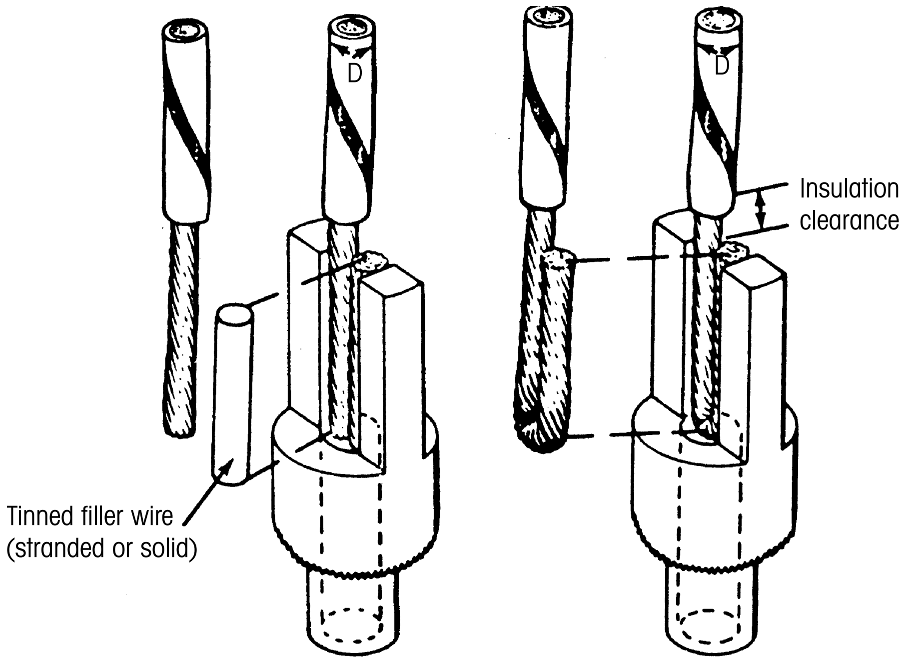

Figure 17: Top-route connection to bifurcated terminal

9.4.5 Combination of top and bottom routes

The bottom route shall be installed first as shown in Figure 15, then the top route as shown in Figure 17, with the top-route conductor bottoming on the bottom-route conductor.

9.4.6 Combination of side and bottom routes

The bottom route shall be installed first as shown in Figure 15, then the side route as shown in Figure 16.

9.5 Hook terminals

Connections to hook terminals shall be as shown in Figure 18. The bend to attach conductors to hook terminals shall be a minimum of 1/2 turn to a maximum of 3/4 turn. Protrusion of conductor ends shall be limited to avoid damage to insulation sleeving where used.

9.6 Pierced terminals

Connections to pierced terminals shall be as shown in Figure 19. The bend to attach conductors to pierced terminals shall be a minimum of 1/4 to a maximum of 3/4 turn. Protrusion of conductor ends shall be limited to avoid damage to insulation sleeving where used.

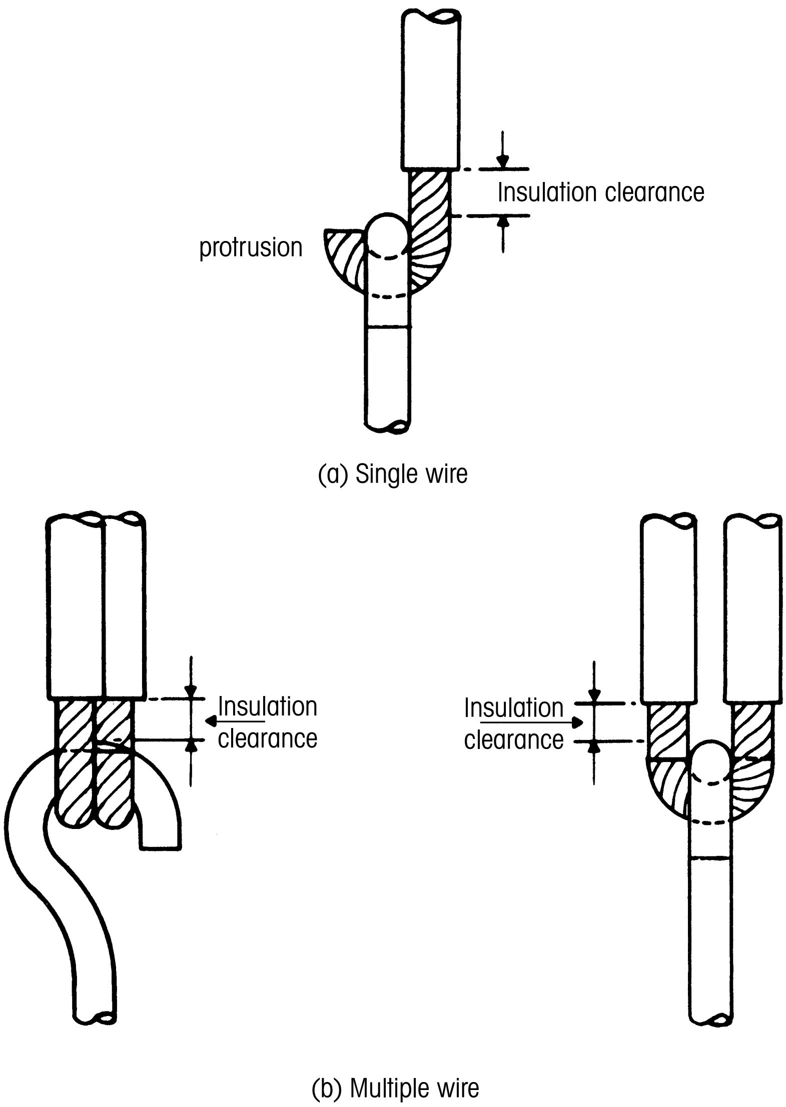

Figure 18: Connections to hook terminals

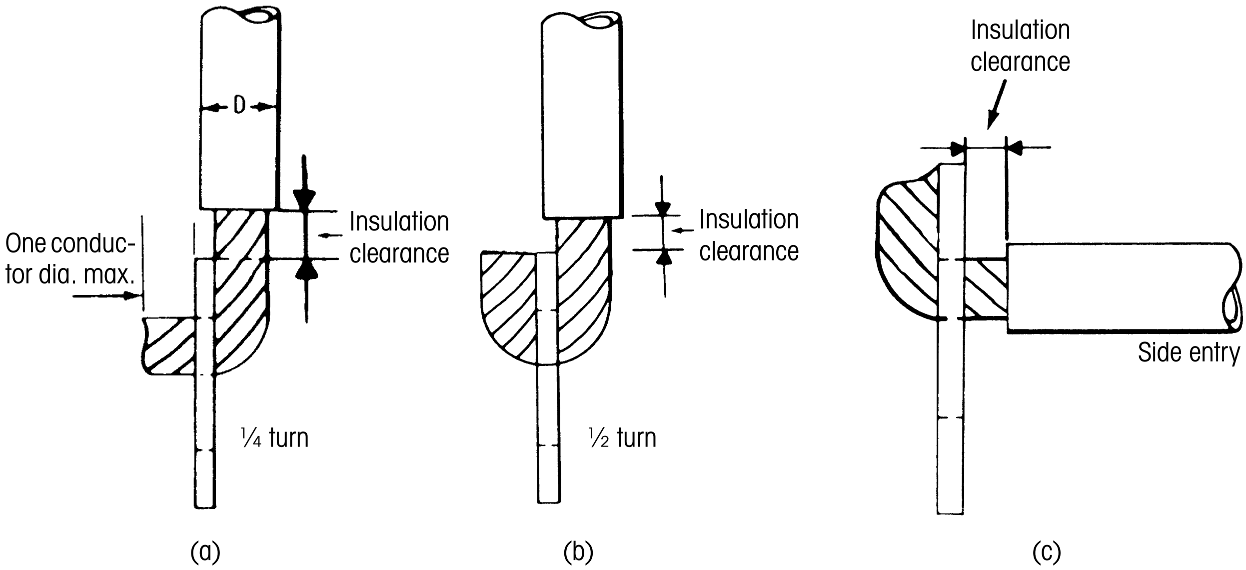

Figure 19: Connections to pierced terminals

9.7 Solder cups (connector type)

Conductors shall enter the pre-tinned, degolded solder cup in the manner shown in Figure 20. Pre-tinned 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 which can be in contact with the full height of the inner wall of the cup. The soldering time shall be sufficiently long to avoid the entrapment of any flux within the cup of the connector.
Solid, rigid conductor wire shall not be joined to floating contacts unless perfect alignment is possible.

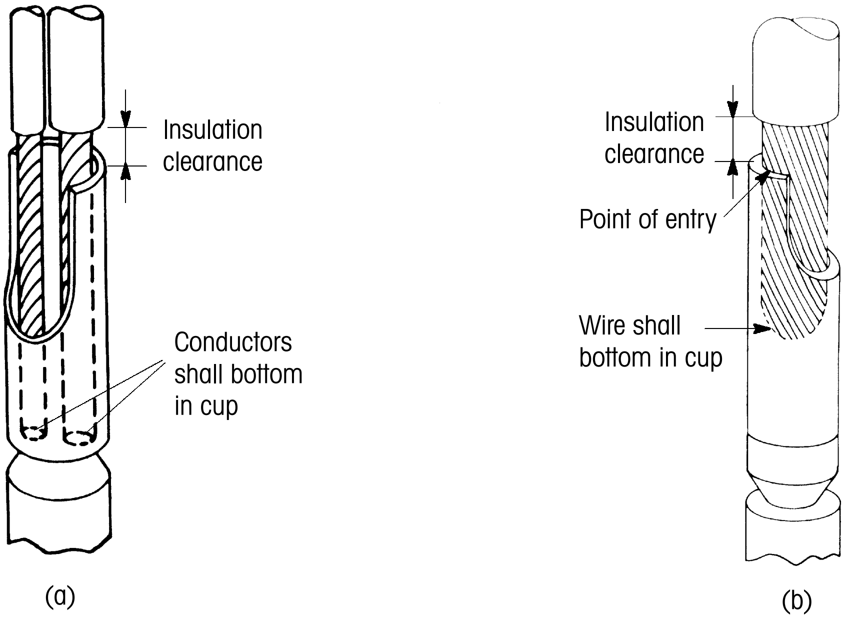

Figure 20: Connections to solder cups (connector type)

9.8 Insulation tubing application

Space-qualified, heat-shrinkable transparent insulation tubing shall be used for electrical insulation, as appropriate (see ECSS-Q-70-71 for material selection). For example, hook terminals, solder cups and bus wires which are not protected by insulation grommets, potting, or conformal coating shall be protected by insulating tubing. Where a component covered by insulating tubing requires mechanical support, measures shall be taken to ensure that the component is not free to move within the tubing. Extreme care shall be taken to prevent damage to the assembly due to excessive heat while shrinking the tubing.

9.9 Wire and cable interconnections

9.9.1 General

Methods which utilize fluxed solder preforms within heat shrinkable sleeves shall not be permitted.
Soldered wire interconnections shall be made by a process which will allow for the removal of flux and flux residue, and in such a way as to permit full visual inspection of the interconnection and surrounding materials. Conductors shall be finally covered with heat-shrinkable tubing; some undyed polyolefin sleeves shrink when heated between 100 °C and 140 °C. Fluorocarbon sleeves should not be used, as they need to be shrunk at high temperatures that can damage/reflow the soldered connections.

9.9.2 Preparation of wires

The wire insulation shall be removed according to subclause 5.5.6, and to a distance which will provide for an insulation clearance prescribed in subclause 7.1.4. Approved soldering aids (see subclause 5.5.9) shall be used to restrict wicking of flux or solder under the insulation.

9.9.3 Preparation of shielded wires and cables

A sharp scalpel or other suitable tool shall be used to score and remove between 5 mm and 12 mm of the insulation jacket. The area of exposed shield may be at the end (end termination) or at any position along the length of a wire or cable (centre splice). Extreme care shall be taken to avoid any damage to the exposed shield material (see also subclauses 7.1.2 and 7.1.3). The shield material shall be of good solderability and need not be pre-tinned; it shall, however, be cleaned with a solvent specified in subclause 6.3.

9.9.4 Pre-assembly

a. A length of heat-shrinkable insulating tube shall be threaded over one part of the wire(s) intended to be joined. The length of tubing shall be designed to cover the finished soldered joint completely and to extend over the insulation of each conductor to a distance of (5 ± 2) mm. This tube material shall provide adequate electrical insulation and some mechanical support to the finished interconnection.

b. The conductors shall be secured to prevent any disturbances during the soldering operation and while the solder is solidifying. Either one or a combination of the following holding methods shall be used:

   - a holding fixture which clamps the wires and ensures their proper alignment;
   - a fine strand of binding wire (e.g. bare, tinned copper) thinner than AWG 34 as shown in Figure 21(a);
   - small heat-shrinkable rings positioned over the ends of the wire insulations (see Figure 21(b)) or twist splice wire around the braid (Figure 21(c)).

c. The conductors to be joined shall lie parallel and in contact with each other. This can require slight preforming of the pre-tinned lengths when thick insulation is employed. Bending tools are specified in subclause 5.5.4.

   - Wires for splicing shall be lap joined (not butt).
   - For shield terminations the conductor of the grounding wire of cable shall be positioned on the exposed shield.
   - No conductor should overlap the insulation of another wire. Any overlap shall not be greater than the diameter of the largest wire or cable of the interconnection.

9.9.5 Soldering procedures

a. Selection of the soldering iron shall be as specified in subclause 5.5.7 and the soldering-bit temperature shall in no instance exceed 330 °C. The solder alloy and flux composition shall comply with those permitted respectively in subclauses 6.1 and 6.2.

b. Approved soldering aids (see subclause 5.5.9) should be used to restrict wicking of flux or solder under the insulation.

c. After solder solidification, the contour of each wire conductor shall be visible and adjacent conductors shall be connected by means of concave fillet.

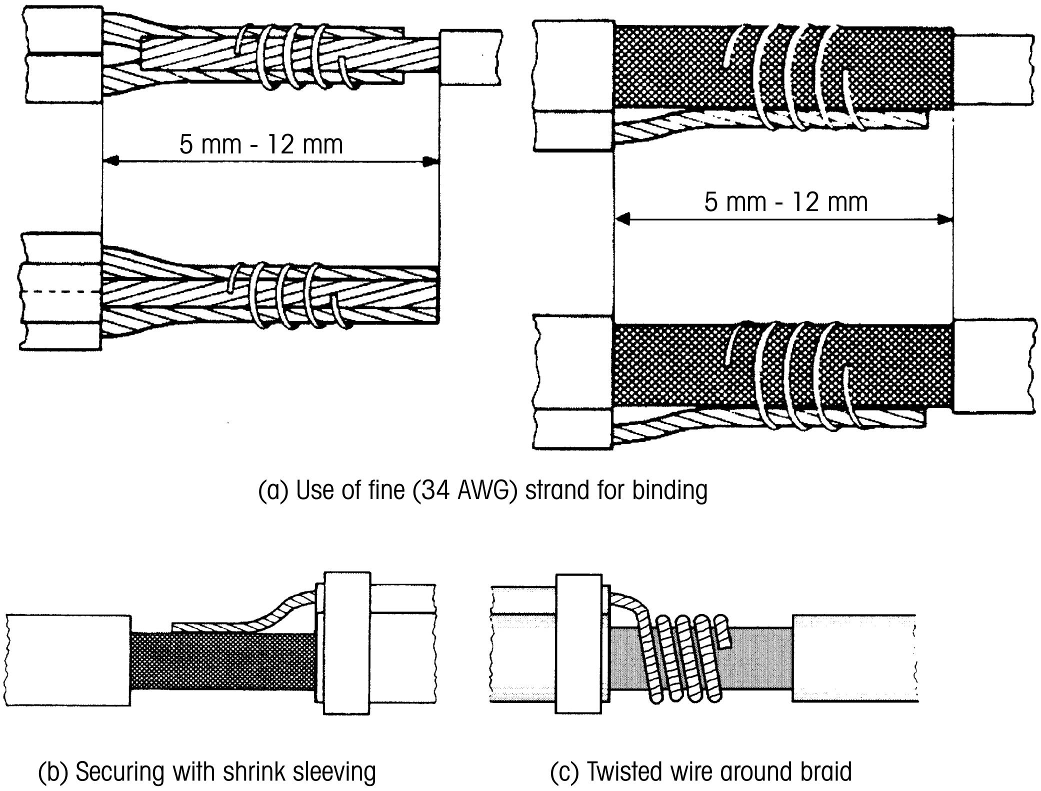

Figure 21: Methods for securing wires

9.9.6 Cleaning

Removal of flux and residue shall be as specified in clause 11.

9.9.7 Inspection

Each interconnection shall be inspected according to clause 12. The accept and reject criteria of subclauses 12.2 and 12.3 shall be applied.

9.9.8 Workmanship

Soldering shall be accomplished in a careful manner and the workmanship shall be such that all joints have a smooth, bright appearance. The acceptance criteria for the solder joint shall be in accordance with those shown in annex A. These workmanship standards may be applied to similar configurations of wire interconnection.

9.9.9 Sleeving of interconnection

The heat-shrinkable insulation tubing (subclause 9.9.4) shall be centred over the cleaned and inspected interconnection and will then be shrunk to a tight fit by means of heated gas or radiant energy. Heat shall not be applied for a time greater than 8 seconds and at no stage shall the melting point of the solder alloy be exceeded; a maximum temperature of 140 °C should be used (for undyed polyolefin sleeves).

9.10 Connection of stranded wires to PCBs

Stranded wires shall be attached to PCB terminations by means of lap joints or plated-through holes as shown in Figures 22(a), (b) and (c). Provision shall be made for stress relief. The interpretation of dimensions are listed in Table 4.

Table 4: Dimensions for Figure 22

r ≥ 2 dc	dc = conductor diameter
r1 ≥ 2 dg	dg = outer wire diameter
1 mm ≤ H ≤ 2 mm	H = insulation clearance
(1,5 ± 0,8) mm	L_P = lead protrusion through board

(a) Lap joint termination

(b) Through-hole joint termination

(c) Through-hole screened cable termination

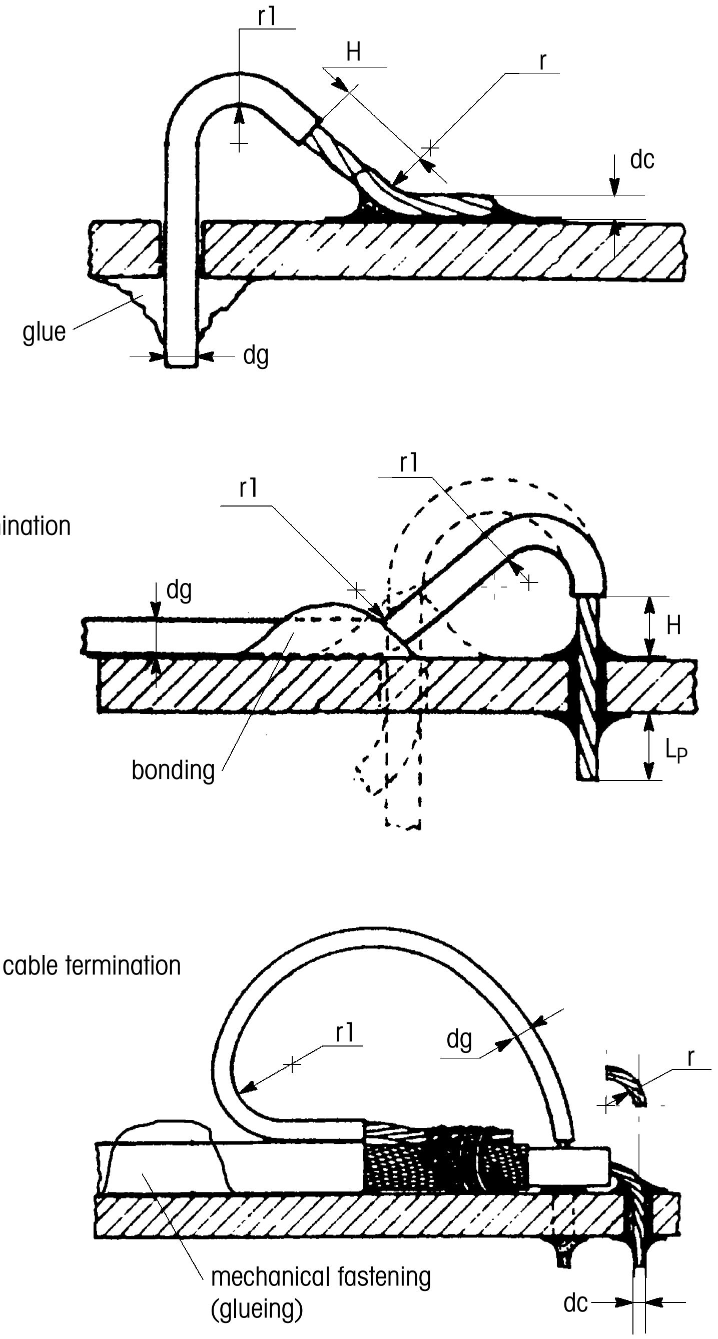

Figure 22: Stranded wires to PCBs

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10

Soldering to terminals and PCBs

10.1 General

10.1.1 Securing conductors

There shall be no relative motion between conductors and the terminal during soldering and while the solder is solidifying. Conductors shall not be temporarily constrained against spring-back force during solder solidification so as to produce residual stress in the joint. Under no conditions shall soldering directly onto gold plating be permitted.

10.1.2 Insulation sleeving, potting or coating

Protective coverings or coatings on the soldered parts shall comply with requirements of the assembly.

10.1.3 Thermal shunts

Thermal shunts shall be used where heat during the soldering operations can degrade conductors, insulation, components, or previously soldered connections.

10.1.4 High-voltage connections

High-voltage connections, where corona suppression is required, shall follow a special design. All aspects of soldered joints shall be covered by smooth fillets, free of discontinuities or severe change in contour, i.e. sharp edges and points shall be avoided.

10.2 Solder application to terminals

10.2.1 Soldering of swaged terminals onto PCBs

Terminals swaged to a solid flat conductor shall be soldered to one surface of the conductor.

10.2.2 Soldering of conductors onto terminals (except cup)

a. A concave fillet of solder shall be formed between the terminal and each side of the conductor.

b. The contour of the conductor shall be visible after soldering.

c. Terminals with more than one wire shall have each wire in contact with and soldered to the terminal.

10.2.3 Soldering of conductors onto cup terminals

a. The solder shall form a fillet between the wire and cup entry slot. The fillet shall follow the contour of the cup opening within the limits illustrated in the satisfactory solder connections (annex A).

b. Solder spillage along the outside surface of the solder cup is permissible to the extent that it approximates tinning and does not interfere with the assembly or functions of the connector.

10.3 Solder application to PCB

10.3.1 Solder coverage

The molten solder shall flow around the conductor and over the termination area. Solder quantity shall be as shown in annex A, except for high‑voltage connections, which shall be as prescribed in subclause 10.1.4.

10.3.2 Solder fillets

Solder filleting shall be complete and as illustrated in annex A. On lap terminations where one side of a ribbon lead is flush with the edge of the termination pad, a fillet of solder shall be present along at least 3 of the 4 sides of the lead. Where a component is mounted on the same side as the lap termination, a heel fillet is required where the ribbon or round lead bends away from the pad. The fillet of solder along the lead shall extend up the side of the lead a minimum distance of 1/2 the lead thickness or diameter.

10.3.3 Soldering of component leads to plated‑through holes

The solder fillet on the heat/solder application side of the plated‑through hole shall meet the requirements established by this standard. For the connection on the opposite side of the PCB (i.e. the component side), all terminal pads shall show evidence of solder flow‑through and bonding of the lead to the pad. A complete solder fillet should be used around the entire periphery of the hole; the minimum solder fillet shall occupy 25 % of this periphery.

10.3.4 Solder application

Solder should only be applied to the solder side of a plated‑through hole. A well tinned tip should be applied to the joint and the solder introduced at the junction of the tip and the connection for maximum heat transfer. After applying heat and achieving heat transfer, the solder should be applied to the joint and not to the soldering iron tip. Under conditions of high heat‑sinking, additional heat may be simultaneously applied to both sides of the plated‑through hole. This activity shall have been demonstrated to cause no damage to components or materials, and the process shall be fully documented.

10.4 Wicking

Approved soldering aids (see subclause 5.5.9) may be used to restrict wicking of flux or solder under the insulation. Solder shall not obscure the contour of the conductor at the termination of the insulation.

10.5 Solder rework

Rework of soldered PCB assemblies shall be performed in accordance with the soldering requirements of this standard. A maximum number of three (3) reworks is permitted on any one joint. During rework it is preferred that the solder be completely removed from the termination, that it be cleaned and the joint remade. Tools and aids as defined in ECSS-Q-70-28 are permitted. Although rework is detailed, ECSS-Q-70-28 shall be adhered to for any repairs and modifications that are performed.

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11

Cleaning of PCB assemblies

11.1 General

After the solder has solidified and cooled, flux and residue shall be carefully removed from each soldered connection with the aid of a solvent specified in subclause 6.3.1. Solvent shall be applied in a manner that minimizes entry of solvent under wire insulation and prevent entry into the interior of parts. It is stressed that any flux and residue shall be removed, preferably as soon as possible, but within 24 hours after the soldering operations, as even rosin fluxes are difficult to remove after longer periods of ageing.

Immersion of the PCB assembly into solvents or other cleaning liquids shall not exceed 10 minutes. This is to avoid galvanic corrosion between adjacent metallic surfaces.

11.2 Ultrasonic cleaning

Ultrasonic cleaning of parts should not be used and shall not be employed for assemblies containing delicate components such as integrated circuits, diodes and transistors.

11.3 Monitoring for cleanliness

The effectiveness of the cleaning procedure can be determined by the following methods.

11.3.1 Cleanliness testing

Cleanliness testing is used to monitor the effectiveness of the cleaning process employed for PCB assemblies (post-soldering). Two basic methods should be used:

a. Resistivity of solvent extract test as per subclause 11.3.4 a.

b. Sodium chloride (NaCl) equivalent ionic contamination test as per subclause 11.3.4 b.

11.3.2 Testing frequency

a. Testing shall be performed periodically and at least every six months, or after changing flux materials, process parameters, actions which affect, for instance, cleanability.

b. Statistical control methods should be used to control continuous solvent cleaning processes. Records of relevant readings shall be maintained for early detection of any trend towards an out-of-specification condition.

c. In the event that the result of a test is unacceptable, all the PCB assemblies that were cleaned since the last test that passed shall be subjected to final customer review (ECSS-Q-20).

11.3.3 Test limits

a. **Resistivity of solvent extract.** The resistivity of the solvent extract shall have a final value greater than 2×10^6 Ω cm.

b. **Sodium Chloride (NaCl) ionic contamination equivalence test.** The final value for this test shall be less than 1,56 μg cm^{-2} of PCB surface area.

11.3.4 Test methods

a. **Resistivity of solvent extract**

Solvent extract resistivity shall be measured as follows (see Table 5):

- Prepare a test solution of 75 % by volume isopropyl alcohol and 25 % by volume deionized water. Pass this solution through a mixed bed deionizer cartridge. After passage through the cartridge, the resistivity of the solution shall be greater than 6×10^6 Ω cm. Clean a funnel, a wash bottle and a container with a portion of this test solution. Measure out 1,55 ml of fresh test solution for each cm^2 of assembly area. Assembly area includes the areas on both sides of the PCB.
- Slowly direct the test solution in a fine stream onto both sides of the PCB assembly until all of the measured solution is used.
- Determine the resistivity of the used solution (solvent extract).

b. **Sodium Chloride (NaCl) equivalent ionic contamination**

Sodium chloride (NaCl) equivalent ionic contamination shall be measured as follows:

- The sodium chloride (NaCl) equivalent ionic contamination test shall use a solution of 75 % isopropyl alcohol and 25 % deionized water. This solution shall be verified for correct composition upon initial use.
- The equipment shall be periodically calibrated using a known amount of sodium chloride standard on the same schedule as the percentage composition verification

The test shall be performed and calculated as described in the relevant equipment's test methods manual.

Table 5: Cleanliness test values

Test method	Starting resistivity (Ω cm)	Ending value
a. Solvent extract resistivity	6×10^6	Shall be greater than 2×10^6 Ω cm.
b. Sodium chloride equivalent	20×10^6	Shall be less than 1,56 μg cm^{-2}

12

Final inspection

12.1 General

Each soldered connection shall be visually inspected in accordance with the criteria of this clause. Inspection shall be aided by magnification appropriate to the size of connections, between 4× and 10× magnification. Additional magnification shall be used as necessary to resolve suspected anomalies or defects. Parts and conductors shall not be physically disturbed to aid inspection. Inspection standards for typical soldered connections are shown in annex A.

12.2 Acceptance criteria

Acceptable solder connections shall be characterized by:

a. Clean, smooth, bright undisturbed surface;

b. Solder fillets between conductor and termination areas as described and illustrated herein (for plated-through hole connections, see the criteria in subclause 10.3.3);

c. Contour of wire sufficiently visible to determine presence of the wire, the direction of the bend and the termination end of the wire (except high-voltage connections; see subclause 10.1.4);

d. Complete wetting as evidenced by a low contact angle between the solder and the joined surfaces;

e. Proper amount and distribution of solder;

f. Absence of the defects mentioned in subclause 12.3.

12.3 Rejection criteria

The following are characteristics of unsatisfactory conditions, any of which shall be cause for rejection:

a. Charred, burned, or melted insulation of parts;

b. Conductor pattern separation from circuit board;

c. Burns on base materials;

d. Discoloration which is continuous between two conductors (e.g. measling, delamination, halo effect);

e. Excessive solder (including peaks, icicles and bridging).

f. Flux residue, solder splatter, or other foreign matter on circuitry or adjacent areas;

g. Dewetting;

h. Insufficient solder;

i. Pits, holes or voids, or exposed base metal in the soldered connection;

j. Granular or disturbed solder joints;

k. Fractured or cracked solder connection;

l. Cut, nicked, gouged, or scraped conductors or conductor pattern;

m. Improper conductor length or direction of clinch and lap termination on a PCB;

n. Repaired or damaged conductor pattern (Rework shall meet the requirements of this standard. Rework is not repair – see subclause 3.1);

o. Bare copper or base metal (excluding the copper ends of cut wire or leads);

p. Soldered joints made directly to gold-plated terminals and conductors (without de-golding);

q. Cold solder joints;

r. Component body (moulding) within solder fillet.

13

Verification

13.1 General

Verification tests shall be conducted to establish confidence in the reliability of solder-joint configurations not shown in this document. The configuration is considered verified if there are no cracked solder joints or part damage found after 200 thermal cycles in accordance with temperature cycling and vibration testing (listed below) when examined under 15× minimum magnification. The order in which the vibration and thermal testing are performed does not matter. Boards shall be tested in flight configurations (i.e. utilizing the same encapsulants, adhesives and conformal coatings declared for flight).

13.2 Temperature cycling

The test specimen shall be temperature cycled in an air circulating oven from room temperature to -55 °C to +100 °C and back to room temperature at a rate not to exceed 10 °C per minute. Soak time at each temperature extreme should be 15 minutes. The duration of each cycle should average one hour. These conditions may be modified to conform with the particular spacecraft project environmental qualification conditions for the assembly being verified.

13.3 Vibration

The test specimen shall be subjected to vibration. The test levels, frequencies and durations shall be derived from the system requirements. The severity of the vibration tests shall not be inferior to that shown in Table 6.

Vibration testing shall be performed in two axes, one parallel to the board and the other perpendicular to the board.

Table 6: Minimum severity for vibration testing

Sine vibration	Vibration amplitude:	(Peak-to-peak) 10 - 70 Hz at 1,5 mm
	Frequency range:	70 - 2000 Hz at 15 g
	Sweep speed:	1 octave per minute
	Duration:	1 cycle from 10 - 2000 - 10 Hz
Random vibration	Frequency range:	20 - 2000 Hz at 15 g – r.m.s.
	Power spectral density:	0,1 g^2 Hz^{-1}
	Duration:	10 minutes per axis

14 Quality assurance

14.1 General

The quality assurance requirements are defined in ECSS-Q-20. Particular attention shall be paid to the following points.

14.2 Data

The quality records (e.g. logbooks) shall be retained for at least ten years or in accordance with project contract requirements, and contain as a minimum the following:

- copy of final inspection documentation;
- nonconformance reports and corrective actions;
- copy of the inspection and test results with reference to the relevant procedure, personnel, tools, solders, fluxes and solvents utilized.

14.3 Nonconformance

Any nonconformance which is observed in respect of the soldering process shall be dispositioned in accordance with the quality assurance requirements, see ECSS Q-20-09.

14.4 Calibration

Each insulation stripper, soldering iron, piece of measuring equipment and reference standard shall be periodically calibrated. Any suspected or actual equipment failure shall be recorded as a project nonconformance report so that previous results may be examined to ascertain whether or not re-inspection or retesting is required. The final customer shall be notified of the nonconformance details.

14.5 Traceability

Traceability shall be maintained throughout the process from incoming inspection to final test, including details of test equipment and personnel employed in performing the task.

14.6 Workmanship standards

Visual standards consisting of satisfactory work samples or visual aids which clearly illustrate the quality characteristics of all soldered connections involved shall be prepared and shall be available to each operator and inspector. The illustrations presented in annex A of this standard, supplemented as necessary, shall be included as examples.

14.7 Inspection

During all stages of the process the inspection points shall be observed. Particular attention shall be paid to the requirements stated in the following subclauses:

- subclause 9.9.7,
- subclause 12.1,
- subclause 12.2,
- subclause 12.3.

14.8 Operator and inspector training and certification

Trained and competent personnel shall be employed for all soldering operations and inspections. A training programme shall be developed, maintained and implemented to provide for excellence of workmanship and personnel skill and a thorough knowledge of the requirements detailed in this Standard.

Trained personnel performing soldering operations and inspections shall be certified. This certification shall be based upon objective evidence of soldering quality, resulting from test and inspection of soldered joints. Retraining or re-assessment of personnel shall apply in cases of repetitive unacceptable quality levels and changes in soldering techniques, parameters or required skills.

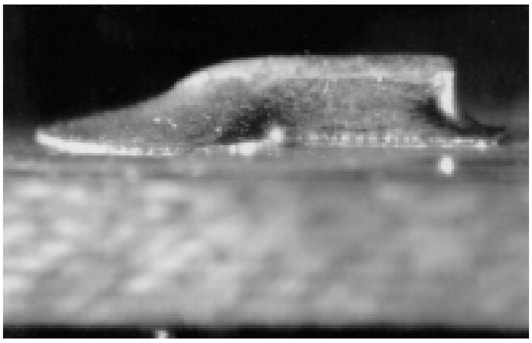
Records shall be maintained of the training and certification status of soldering operators and inspection personnel.

All training and certification shall only be performed at a school authorized by the final customer.

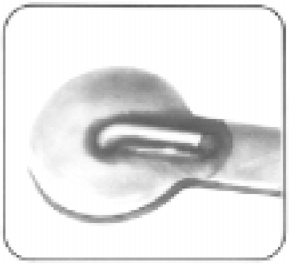
Annex A (informative)

Typical satisfactory and unsatisfactory solder connections

The illustrations in this annex depict typical satisfactory and unsatisfactory solder connections and shall be used as visual workmanship standards.

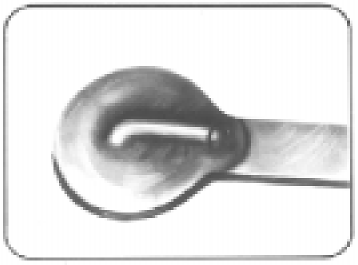


Preferred solder

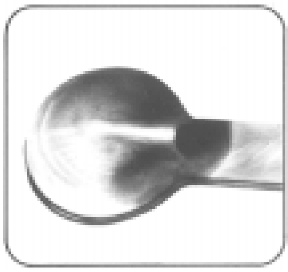


Unacceptable
Insufficient solder

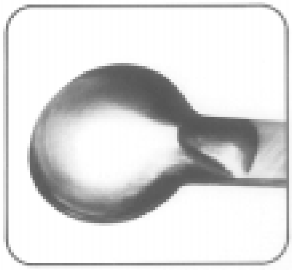
Acceptable
Minimum solder



Preferred solder

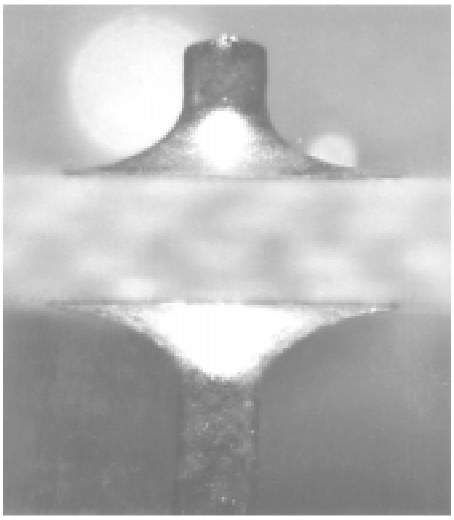


Acceptable
Maximum solder

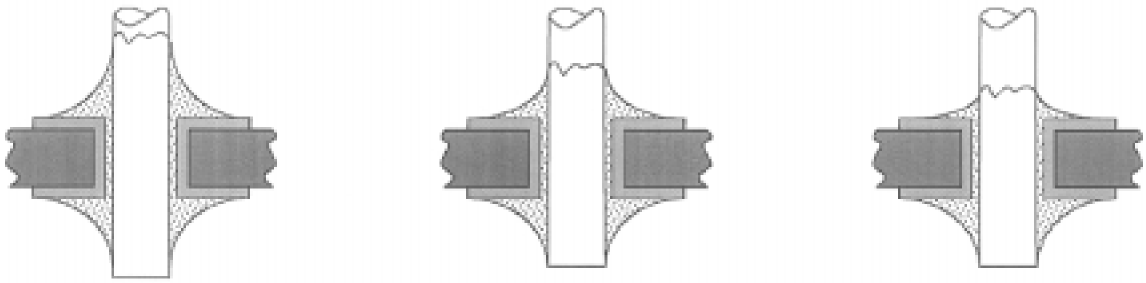


Unacceptable
Excessive solder

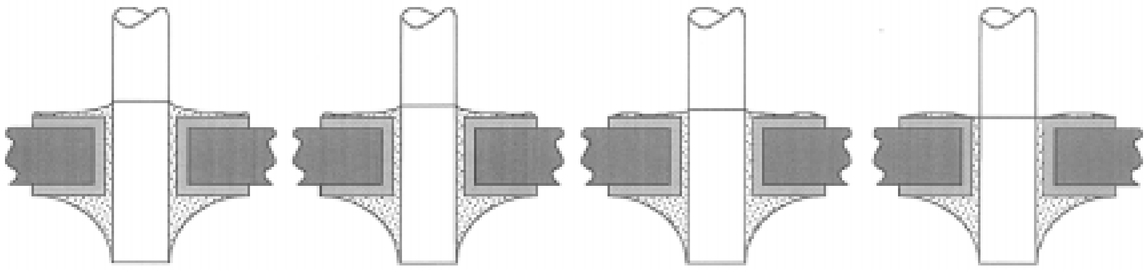
Figure A-1: Soldered clinched terminals



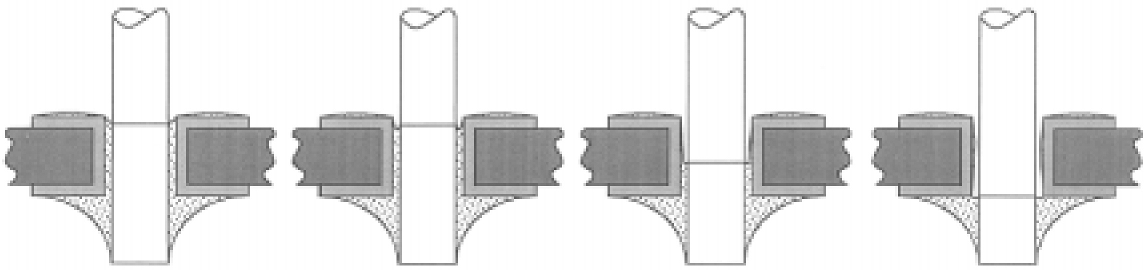
Preferred solder



Preferred solder



Acceptable
Minimum solder



Unacceptable
Insufficient solder

Figure A-2: Soldered stud terminals

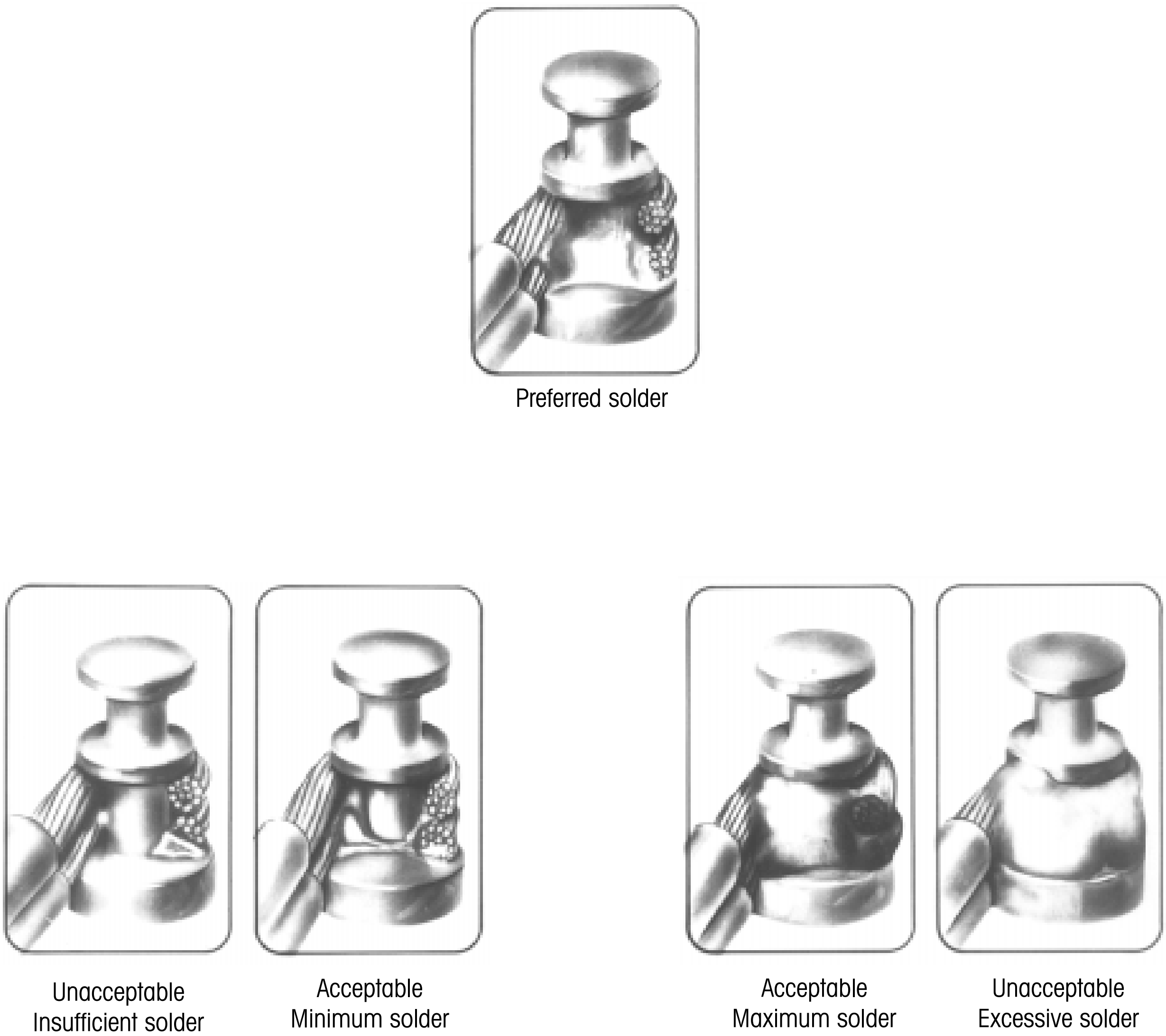
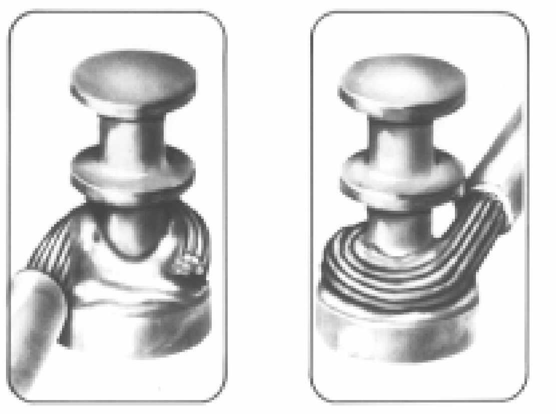
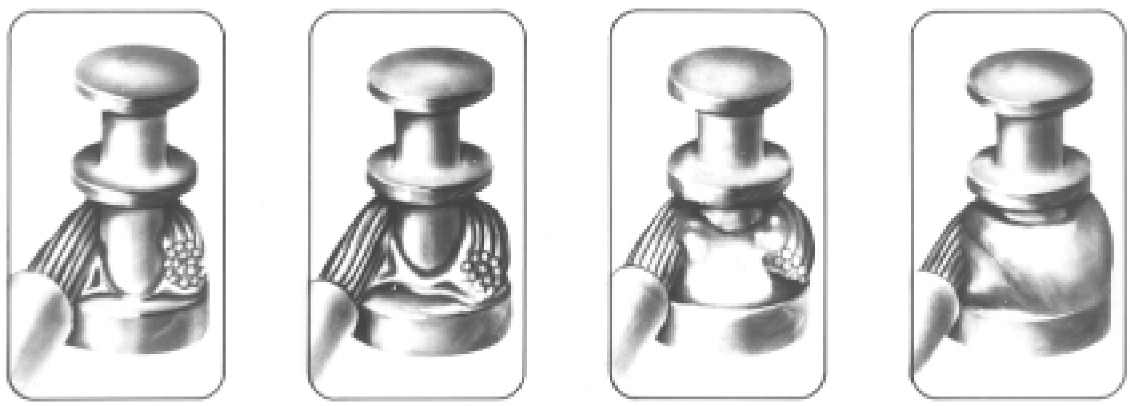


Figure A-3: Soldered turret terminals



Preferred solder



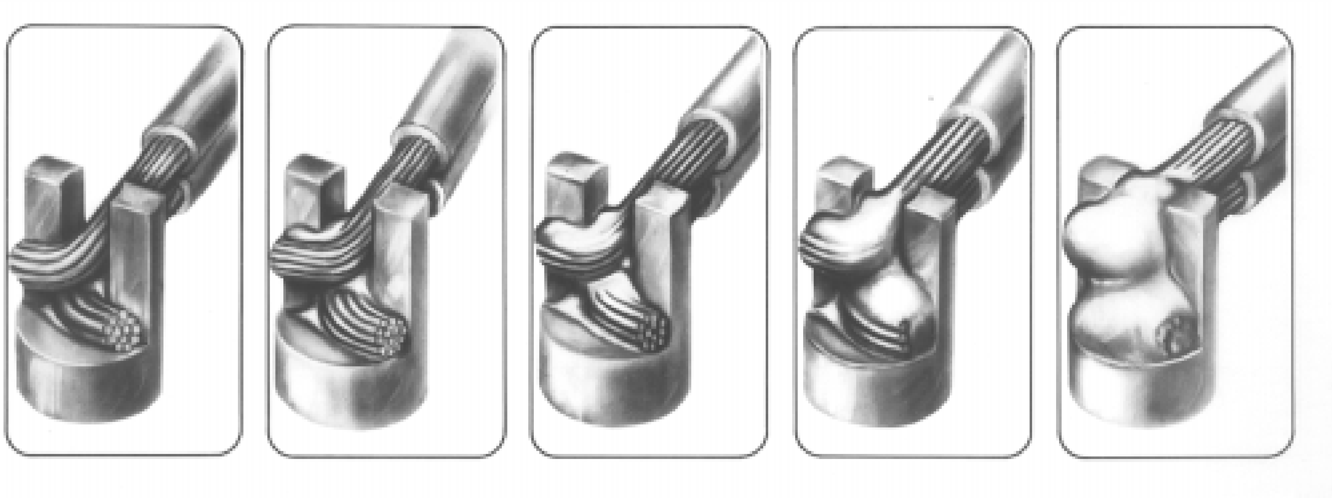
Unacceptable
Insufficient solder

Acceptable
Minimum solder

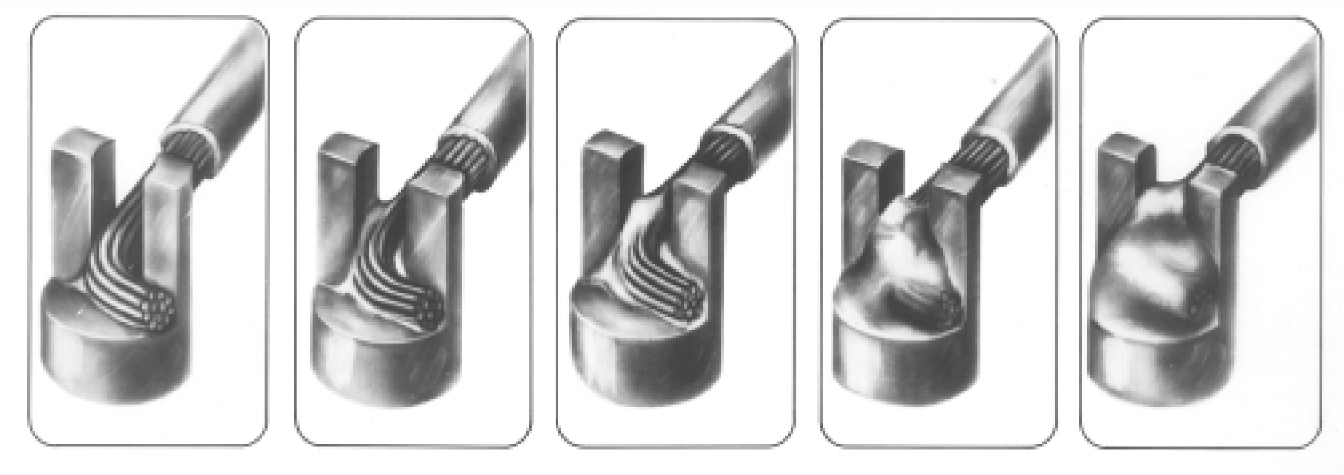
Acceptable
Maximum solder

Unacceptable
Excessive solder

Figure A-4: Soldered turret terminals



Unacceptable Insufficient solder | Acceptable Minimum solder | Preferred solder | Acceptable Maximum solder | Unacceptable Excessive solder



Unacceptable Insufficient solder | Acceptable Minimum solder | Preferred solder | Acceptable Maximum solder | Unacceptable Excessive solder

Figure A-5: Soldered bifurcated terminals

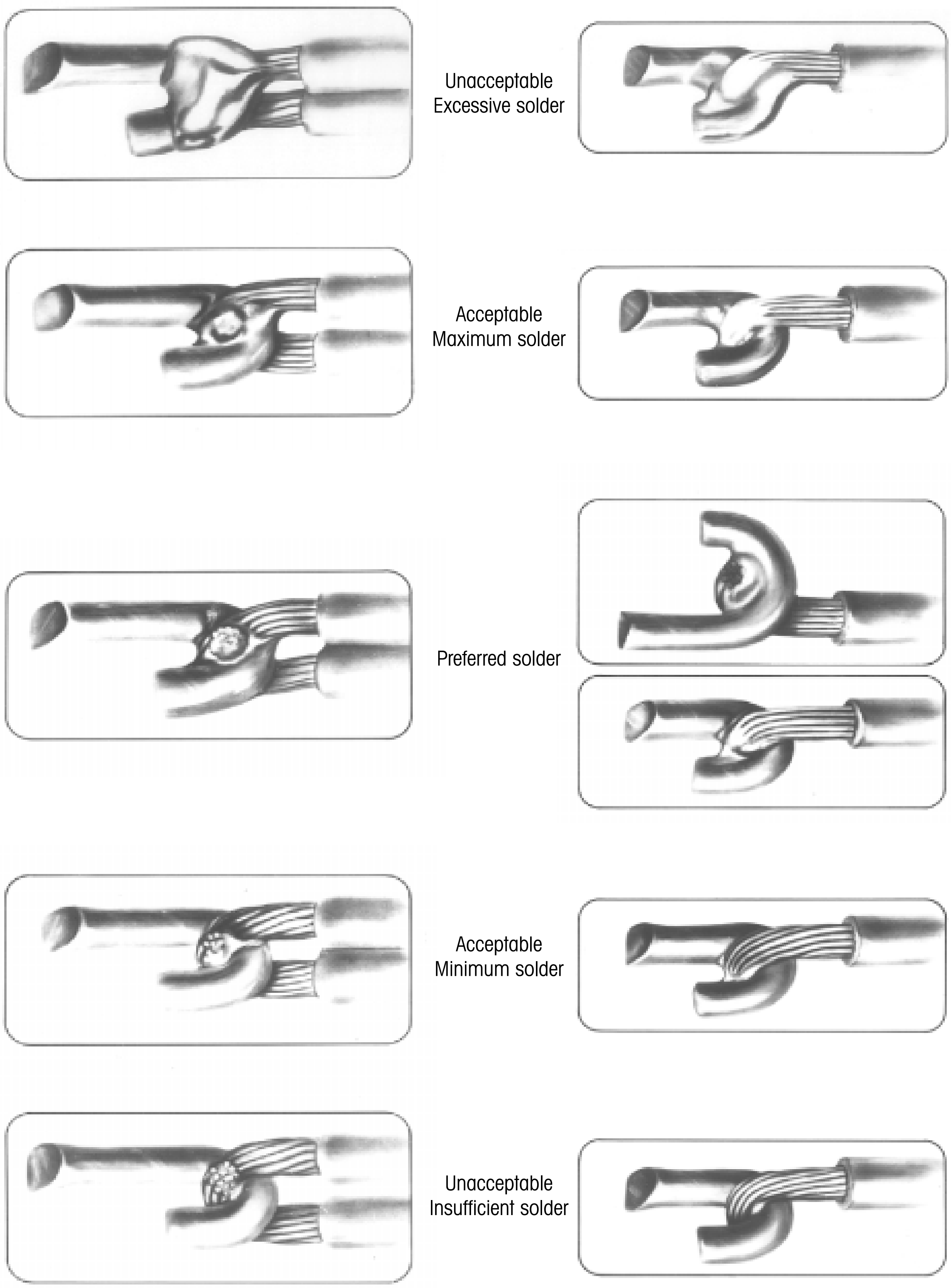


Figure A-6: Soldered hook terminals

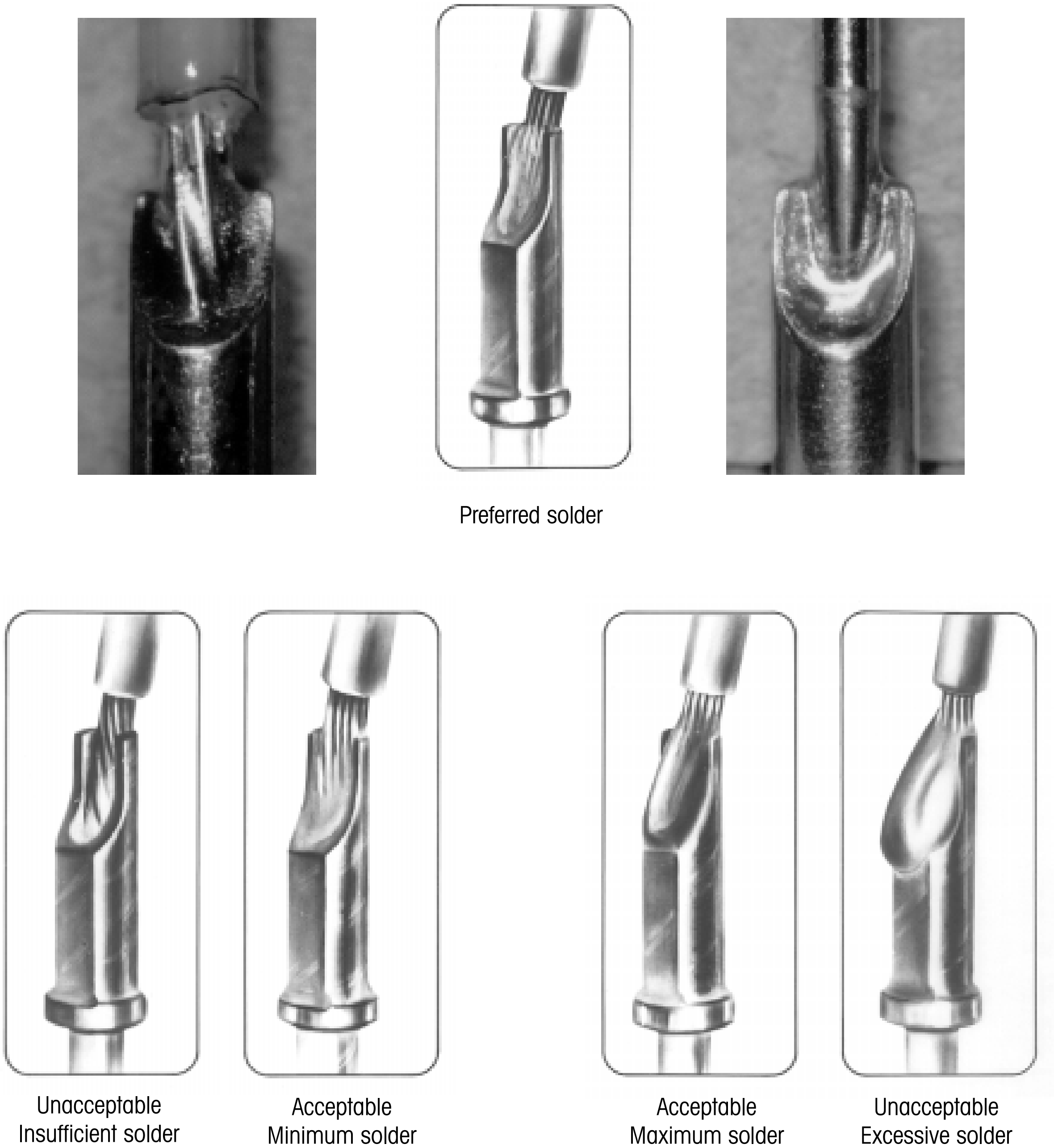
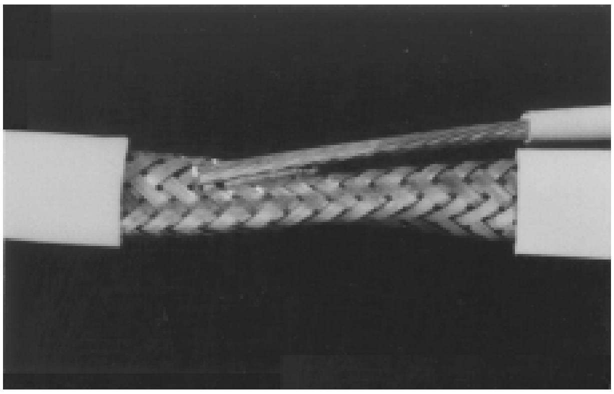
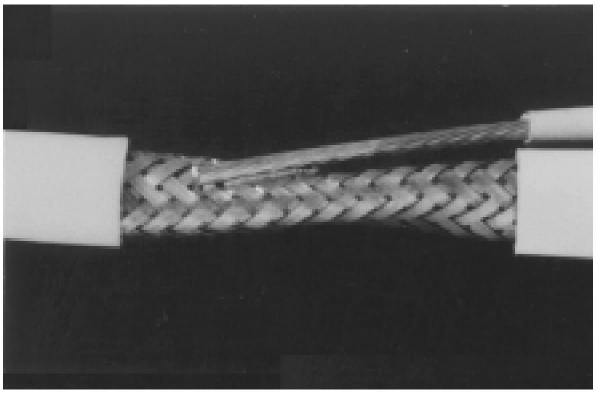


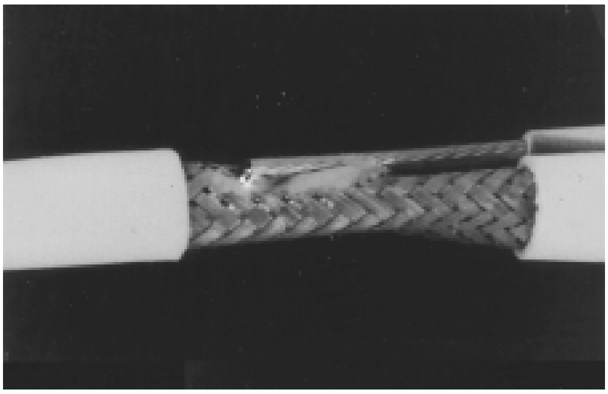
Figure A-7: Soldered cup terminals



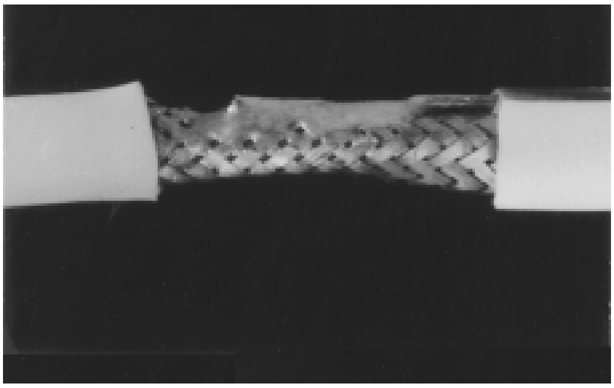
Unacceptable
Insufficient solder



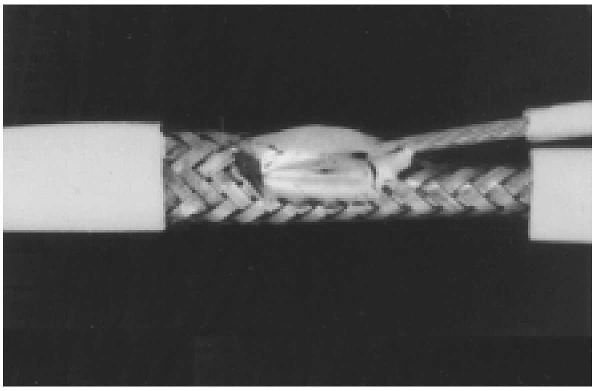
Acceptable
Minimum solder



Preferred solder

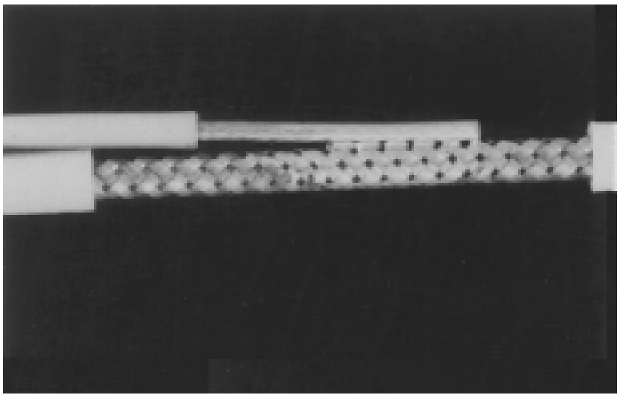


Acceptable
Maximum solder

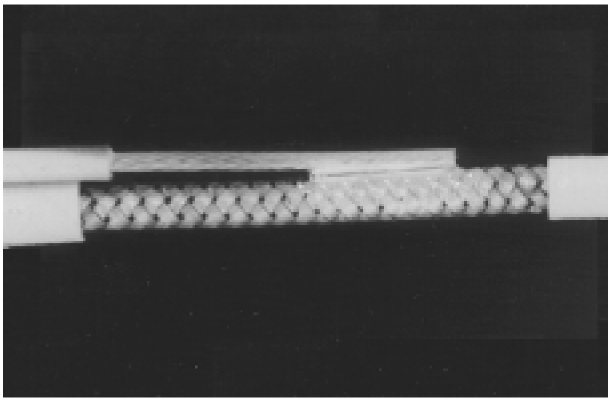


Unacceptable
Excessive solder

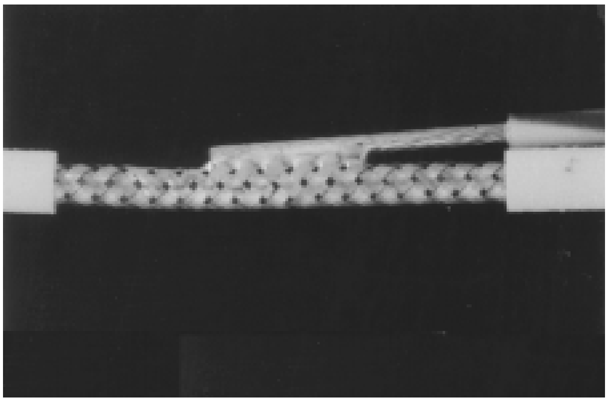
Figure A-8: Hand-soldered wire to shielded cable interconnections



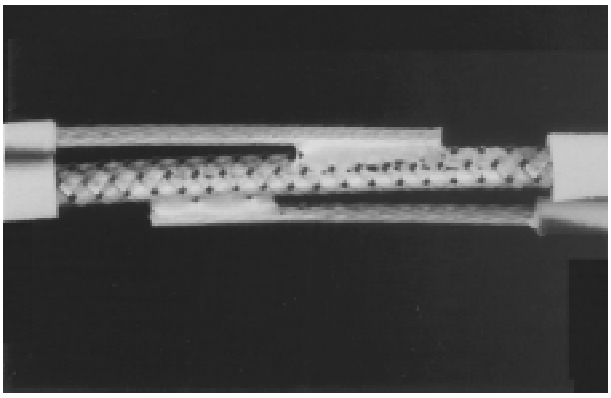
Unacceptable
Insufficient solder
Insulation overlap too great



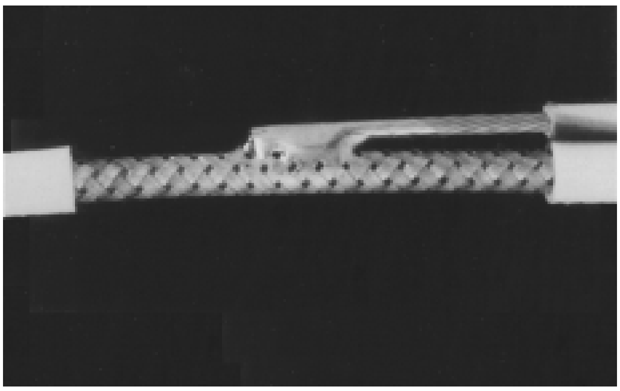
Acceptable
Minimum solder
Maximum overlap



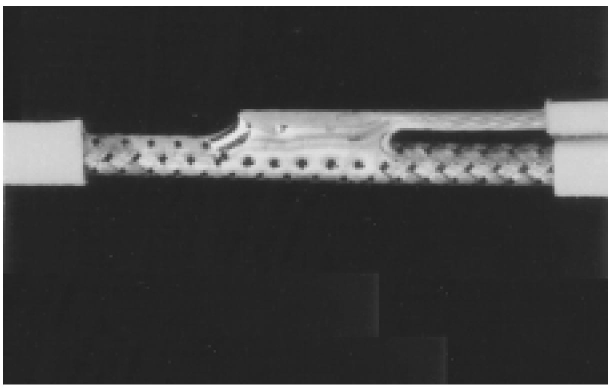
Preferred solder



Preferred solder

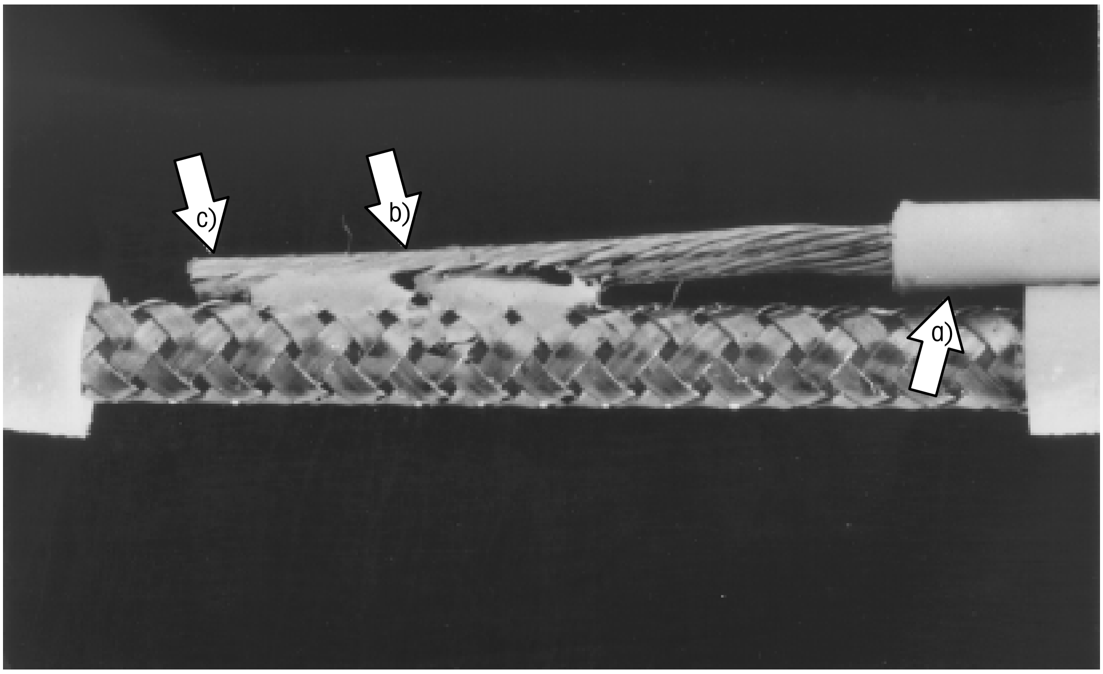


Acceptable
Maximum solder

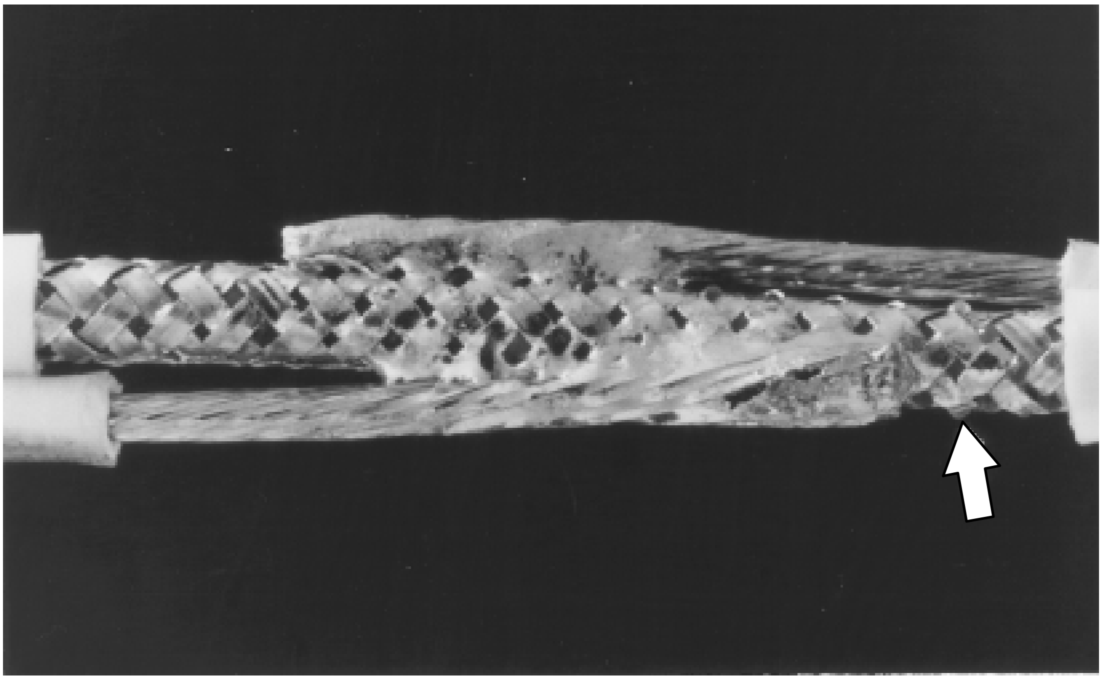


Unacceptable
Excessive solder

Figure A-9: Hand-soldered wire to shielded wire interconnections



a) Acceptable maximum insulation overlap
b) Acceptable pit in solder fillet caused by weave of shield material
c) Unacceptable lack of solder between conductors



Unacceptable
Unclean connection (flux and flux residue)
Unacceptable molten dielectric insulation

Figure A-10: Hand-soldered wire interconnections – details of defects

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ECSS Document Improvement Proposal

1. Document I.D.	**2. Document date**	**3. Document title**
ECSS-Q-70-08A	6 August 1999	The manual soldering of high-reliability electrical connections
4. Recommended improvement (identify clauses, subclauses and include modified text or graphic, attach pages as necessary)		
5. Reason for recommendation		
6. Originator of recommendation		
Name:	Organization:	
Address:	Phone: Fax: E-mail:	**7. Date of submission:**
8. Send to ECSS Secretariat		
Name: W. Kriedte ESA-TOS/QR	Address: ESTEC, P.O. Box 299 2200 AG Noordwijk The Netherlands	Phone: +31-71-565-3952 Fax: +31-71-565-6839 E-mail: wkriedte@estec.esa.nl

Note: The originator of the submission should complete items 4, 5, 6 and 7.

This form is available as a Word and Wordperfect-Template on internet under
http://www.estec.esa.nl/ecss/improve/

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