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EUROPEAN COOPERATION
ECSS
FOR SPACE STANDARDIZATION

Space product assurance

The manual soldering of high-reliability electrical connections

This ECSS document is a draft standard. It is therefore subject to change and may not be referred to as an ECSS standard until published as such.

For ECSSxxxxxx

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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 organize or perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

The formulation of this standard takes into account the existing ISO 9000 family of documents.

This Standard has been prepared by the ECSS-Q-70-08B Working Group. It has been reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

The significant changes between the Issue A and B are the following:

- The environmental conditions of the assembly area have been modified,
- The flux designation has been completed,
- The use of new solvents is allowed after the successful testing,
- The use of non-bendable devices have been implemented,
- The wetting acceptance limits have been modified,
- The vibration levels have been modified.

NOTE from Bob Hussey:

BLUE highlight indicates queries for WG/ECSS in the query list.

GREEN highlight in the text are outstanding items awaiting action from WG members.

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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 the results of verification 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 manufacture and verification of manually-soldered, high–reliability electrical connections.

The Standard defines acceptance and rejection criteria for high reliability manufacture of manually–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 document. Workmanship standards are included to permit discrimination between proper and improper work.

The assembly of surface-mount devices is covered in ECSS-Q-70-38.

Requirements related to printed circuit boards are contained in ECSS-Q-70-10 and ECSS-Q-70-11.

Verification of manual soldering assemblies which are not described in this standard are performed by vibration and thermal cycling testing. The requirements for verification are given in this Standard.

This standard does not cover the qualification and acceptance of EQM and FM equipment with hand soldered connections.

The qualification and acceptance tests of equipment manufactured in accordance with this Standard are covered by ECSS-E-10-03.

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Normative references

The following dated normative documents are called by the requirements of this ECSS Standard and therefore constitute requirements to it. Subsequent amendments to, or revisions of any of these publications do not apply.

NOTE 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.

ECSS-P-001B	Glossary of terms
ECSS-Q-20B	Space product assurance - Quality assurance
ECSS-Q-20-09B	Space product assurance - Nonconformance control system
ECSS-Q-70-02A	Space product assurance - Thermal vacuum outgassing test for the screening of space materials
ECSS-Q-70-10A	Space product assurance - Qualification of printed circuit boards
ECSS-Q-70-11A	Space product assurance - Procurement of printed circuit boards
ECSS-Q-70-28A	Space product assurance - The repair and modification of printed circuit board assemblies for space use
ECSS-Q-70-71A	Space product assurance - Data for selection of space materials and processes
ESCC-23500	Requirements for lead materials and finishes for components for space application
IEC61190-1-3 (2002)	Attachment materials for electronic assembly - Part 1-3: Requirements for electronic grade solder alloys and fluxed and non-fluxed solid solders for electronic soldering applications
ISO 8402 (1994)	Quality management and quality assurance : vocabulary

EN 61340-5-1	Protection of electronic devices from electrostatic phenomena - 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
terminal containing a slot or split in which wires or leads are placed before soldering

3.1.3

bit
removable heat store of a soldering iron

3.1.4

blister
delamination in a distinct local area or areas

3.1.5

bridging
build–up of solder or conformal coating between parts, component leads and/or base substrate forming an elevated path (see “fillet”)

3.1.9

cold flow
movement of insulation, for example Teflon (PTFE), caused by pressure.

3.1.10

cold solder joint
joint in which the solder has a blocky, wrinkled or piled–up appearance and shows signs of improper flow or wetting action

NOTE 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

3.1.12
component

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

NOTE The terms component and part may be interchanged.

Example Transistors, integrated circuits, hybrids, capacitors

3.1.13
component lead

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

3.1.15
conductor

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

3.1.16
conformal coating

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

3.1.17
connection

electrical termination

3.1.18
contact angle

angle enclosed between half–planes, tangent to a liquid surface and a solid–liquid interface at their intersection

NOTE 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. The contact angle is always the angle inside the liquid

3.1.19

contamination

particles, liquids, gases, materials and micro–organisms which by their presence can disturb the performance of an item

3.1.21

corrosion

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

3.1.22

cracked solder joint

soldered connection which has fractured or broken within the solder

3.1.25

dewetting

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

NOTE This is often seen as a dull surface with islands of thicker shiny solder)

3.1.27

disturbed solder joint

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

3.1.29

electrical connection

conductive connection in electrical or electronic circuits

3.1.34

fillet

smooth concave build–up of material between two surfaces

Example 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

3.1.36

flux

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

3.1.37

flux activity

property of a flux which allows the smallest contact angle between molten solder and a solid surface

NOTE See also “rosin”.

3.1.40

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

3.1.43

hook terminal
terminal formed in a hook shape

3.1.45

icicles
see "solder icicle"

3.1.47

interfacial connection
conductor which connects conductive patterns between opposite sides of a printed circuit board

NOTE Normally a plated–through hole.

3.1.48

lap joint
joining or fusing of two overlapping metal surfaces with solder without use of any other mechanical attachment or support

3.1.49

measling/measles
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

NOTE During soldering this can be caused by excessive heat.

3.1.50

multi–layer circuit board
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

NOTE See also "printed circuit board".

3.1.52

pad
termination of a conducting surface on a printed circuit board to which leads are soldered to form electrical connections

NOTE These can be described as either functional, where an active track is terminated, or non–functional, where the pad is isolated.

3.1.54

pits
small holes or sharp depressions in the surface of solder

NOTE This can be caused by flux blow–out due to entrapment or overheating

3.1.55

plated–through hole

one formed by a deposition of metal on the inside surface of a hole

NOTE 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

3.1.57

potting compound

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

3.1.58

printed circuit board (PCB)

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

NOTE The term printed circuit board covers the following families:

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

3.1.59

Repair

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 non-conforming 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.

Note 3 A repair consists of changing a component, with all its associated connections, including the fixing down of a pad or track or any similar procedure.

3.1.60

resin

natural substance that is usually transparent or translucent and yellowish to brown

NOTE 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 (see "Rosin")

3.1.61

resistance soldering
method of soldering by passing a current between two electrodes through the area to be soldered

3.1.62

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

Note 1 Rework is one type of disposition of a non-conforming product.

Note 2 A typical rework is the removal of solder and resoldering, without replacement of the component.

3.1.63

rosin
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

NOTE It is non–corrosive and electrically non–conducting. Rosin is the basic constituent of the rosin flux family (see ISO EN 29454)

3.1.64

rosin–soldered joint
unsatisfactory connection which has entrapped rosin flux

3.1.65

selective plating
area of a plated circuit board that is designed to have a different plated finish than the rest of the board

Example A gold-finished RF board that supports tin-lead terminations (land areas).

3.1.66

shield
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

NOTE The shield also includes an insulating jacket that can cover the metallic sheath

3.1.67

solder
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

3.1.68

solderability
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.

3.1.69
solder coating
surface coated with a thin, uniform layer of solder

3.1.70
solder–cup terminal
hollow, cylindrical terminal closed at one end to accommodate one or more conductors

3.1.71
solder icicle
conical peak or sharp point of solder usually formed by the premature cooling and solidification of solder upon removal of the heat sources

3.1.72
solder pad
termination area on a printed circuit conductor

3.1.73
soldering
process of joining metallic surfaces through the use of solder without direct fusion of the base metals

3.1.74
Soldering time
time required for a surface to be wetted by solder under specified conditions

3.1.76
stress lines
three 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

c. lines running circumferentially around the mid section of the solder fillet caused by shrinkage during the last stage of solidification

3.1.77
stress relief
method or means to minimize stresses to the soldered termination or component

NOTE 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

3.1.78
stud termination
upright conductor termination through a printed circuit board

3.1.81
termination/terminal area
conductive surface on a printed circuit board used for making electrical connections

NOTE Also referred to as printed circuit pad, solder pad.

3.1.82
thermal shunt
device with good heat–dissipation characteristics used to conduct heat away from an article being soldered

3.1.83
tinning
coating of a surface with a uniform layer of solder before it is used in a soldered connection

3.1.84
tip
application surface at the end of the soldering–iron bit

3.1.85
turret terminal
round post–type grooved stud around which conductors are fastened before soldering

3.1.86
unaided eye
normal Snellen 6/6 (metric) vision including eye glasses required to correct defective vision to 6/6 (metric) equivalent

NOTE This does not include microscopes, eye loupes or any other magnifying device

3.1.88
wetting
flow and adhesion of a liquid to a solid surface, characterized by smooth, even edges and low contact angle

3.1.89
wicking
flow of molten solder or cleaning solution by capillary action

NOTE 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

3.1.90
wire
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

NOTE 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
ESD	electrostatic discharge
INH1	IEC 61190-1-3 (2002) flux designation: inorganic, high activation (> 2% halide)
PCB	printed circuit board
PTFE	polytetrafluoroethylene
RF	radio frequency
R_g	resistance to ground
R_s	surface resistance
ROH1	IEC 61190-1-3 (2002) flux designation: rosin, high activation (≥ 2% halide)
ROL0	IEC 61190-1-3 (2002) flux designation: rosin, very low activation (< 0.01% halide)
ROL1	IEC 61190-1-3 (2002) flux designation: rosin, low activation (< 0.15% halide)
r.m.s.	root–mean–square
SMT	surface mount technology

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4 Principles of reliable soldered connections

The following are the general principles to ensure reliable manually-soldered connections:

- Reliable soldered connections are achieved by using proper design, having control of tools, selecting the right materials, applying processes with precaution in a controlled work environment and taking into account inspection requirements.
- The basic design concepts to ensure reliable connections and to avoid solder joint failure are as follows:
  - — Stress relief is an inherent part of the design, which reduces detrimental thermal and mechanical stresses on the solder connections.
  - — Where adequate stress relief is not possible, a method of solder–joint reinforcement is incorporated.
  - — Materials are selected such that the mismatch of thermal expansion coefficients is a minimum at the constraint points in the component–mounting configuration.
  - — Materials and processes which result in the formation of brittle intermetallics are avoided.
  - — The assembled substrates are designed to allow inspection.
  - — Soldering to gold using tin-lead alloy can cause failure.
- The mounting and supporting of components, terminals and conductors prescribed herein applies to assemblies designed to operate within the temperature limits of –55 ^{0}C to +85 ^{0}C:
  - — For temperatures outside this normal range, special design, verification and qualification testing is performed to ensure the necessary environmental survival capability.
  - — Special thermal heat sinks are applied to devices having high thermal dissipation (e.g. junction temperatures of 110ºC, power transistors) in order to ensure that solder joints do not exceed 85 ºC.

5
Preparatory conditions

5.1 Calibration

Records of the calibration and verification of the tools and inspection equipments shall be maintained.

5.2 Facility cleanliness

a. Personnel facilities shall be separated from the soldering areas.

Example Washrooms, eating areas, smoking facilities.

b. Furniture shall be kept to a minimum in the work area.

c. Furniture shall be arranged to allow easy and thorough cleaning of the floor.

d. Areas used for soldering shall be kept free from contaminants.

NOTE Loose material such as dirt, dust, solder particles, oil or clipped wires can contaminate soldered connections.

e. Working areas shall be kept free from any tools or equipment not used for the current task.

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

g. Tools used during soldering operations shall be free of visible contaminant.

h. Excess lubricants shall be removed from tools before soldering starts.

5.3 Environmental conditions

a. The soldering area shall have a controlled environment to limit the entry of contaminants.

NOTE It is good practice to solder in a clean room (see ISO 14644-1).

b. The room temperature of the facility shall be continuously maintained at 22 ^{0}C ± 3 ^{0}C.

c. The relative humidity at room temperature of the facility shall be continuously maintained at 55 % ± 15 %.

d. The soldering area shall not be exposed to draughts.

e. Air shall be supplied to the room through a filtering system that provides a positive pressure difference with respect to adjacent rooms.

5.4 Lighting requirements

a. Lighting intensity shall be a minimum of 1080 lux on the work surface.

b. At least 90 % of the work area shall be without shadows or severe reflections.

5.5 Precautions against static discharges

5.5.1 General

a. An ESD Control Program in accordance with EN 61340-5-1 shall be developed and implemented by the supplier.

b. Electrostatic sensitive components shall be prepared, mounted, soldered and cleaned in an ESD protected area.

c. Electrostatic sensitive components shall be kept as shipped (e.g. in anti-static tubes or foam) until assembly preparation.

d. Containers for ESD sensitive components shall be so labelled.

5.5.2 Precautions against ESD during manufacturing

a. The working bench shall have a static dissipative top with surface resistance (R_s) in the range 1×10^4 to 1×10^{10} Ω .

b. The working bench shall have a static dissipative top resistance to ESD protected area ground (R_g) in the range $7,5 \times 10^5$ to 1×10^9 Ω.

c. A wrist strap having a resistance to ESD protected area ground (R_g) in the range $7,5 \times 10^5$ to $3,5 \times 10^7$ Ω shall be worn by the operator when handling sensitive items.

d. Seating shall have static dissipative surfaces with resistance to ESD protected area ground (R_g) greater than 1×10^{10} Ω.

NOTE These measures prevent the build–up of static charges and avoid potential differences by keeping personnel, equipment and device leads at the same electrical potential, i.e. ground.

e. Powered equipment at the work station shall be grounded.

NOTE It is expected that the resistance between the tip of the soldering systems and the ground of the ESD protected area does not exceed 5 Ω. The measurement is generally performed at soldering temperature.

f. A ground–fault circuit interrupter shall be installed.

g. Protective clothing shall be made from static dissipative material.

h. Gloves and finger cots shall be made from static dissipative material.

NOTE Tools, such as mounting aids, and consumables, masking tape, are expected to be conductive or static dissipative.

i. Paperwork (e.g. traveller logs, drawings and instructions) accompanying ESD sensitive components shall be contained in static dissipative bags or envelopes.

j. Paperwork shall not come into contact with ESD sensitive components.

k. Ionised air in presence of high voltage or RF shall not be used.

NOTE Static charges on isolated parts or tooling can be dissipated using ionised air.

5.6 Equipment and tools

5.6.1 General

New equipment shall be checked for conformity prior to use.

5.6.2 Brushes

a. Medium–stiff natural- or synthetic-bristle brushes shall be used for cleaning provided that they do not damage any surface to be cleaned or adjacent materials.

b. Brushes shall be cleaned in a solvent in accordance with subclause 7.4.

c. Brushes shall not be affected by the solvents used for PCB cleaning.

d. Wire brushes shall not be used.

5.6.3 Cutters and pliers

a. Cutting edge profiles and cutter usage shall be in accordance with Figure 1.

b. The cutter used for trimming conductor wire and component leads shall shear sharply, producing a clean, flat, smooth–cut surface along the entire cutting edge.

Note 1 These measures minimize the transmission of mechanical and shock loads to delicate parts.

Note 2 Smooth, long–nose pliers or tweezers can be used for attaching or removing conductor wires and component leads

c. No twisting action shall occur during the cutting operation.

d. The cutting edges of pliers shall be checked for damage and maintained in a sharp condition.

e. .

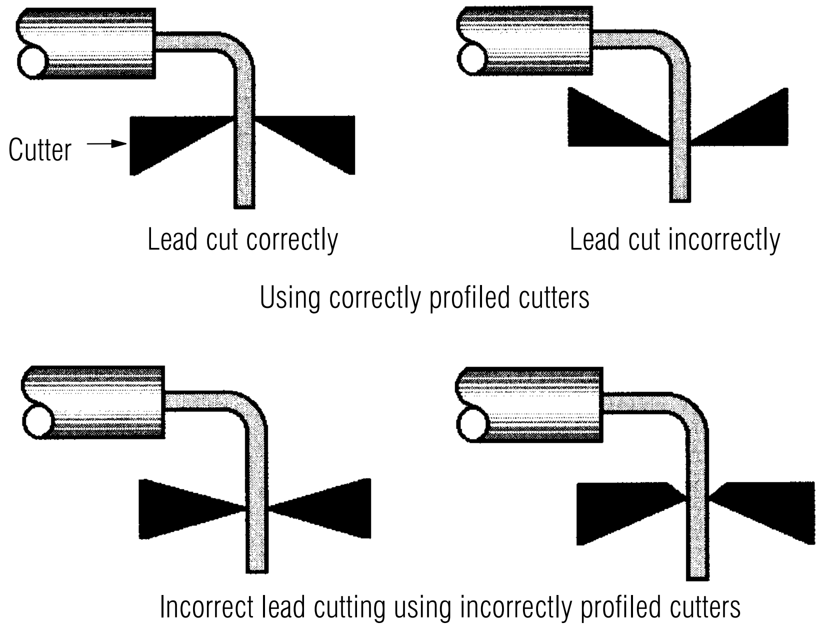

Figure 1: Profiles of correct and incorrect cutters for trimming leads

5.6.4 Bending tools

a. Bare component leads shall be bent or shaped using tools, including automatic bending tools, which do not cut, nick or damage the leads or insulation.

b. Components shall not be damaged by the bending process (see also subclause 9.2).

NOTE It is good practice to use bending tools with polished finish. The preferred surface finish for shaping tools is hard chromium plating.

c. Bending tools shall have no sharp edges in contact with the component leads.

5.6.5 Clinching tools

Clinching tools shall not damage the surfaces of printed–circuit conductors, components or component leads.

5.6.6 Insulation strippers

5.6.6.1 Thermal strippers

The temperature of the stripper shall be controlled to prevent damage to the insulation

Note 1 Thermal–type insulation strippers can be used for wire insulation types susceptible to damage by mechanical strippers.

Note 2 It is good practice to apply Thermal strippers for use with AWG 22 and smaller wire sizes where there is a possibility of the wire stretching if a mechanical stripper is used.

b. .

Note 3 Overheating can produce blistering and excessive melting of the insulation.

Note 4 It is expected to use local extraction units during thermal stripping.

5.6.6.2 Precision mechanical cutting–type strippers

a. Automatic power–driven strippers with precision, factory–set, cutting and stripping dies and wire guards shall be used.

b. Precision–type hand strippers with accurately machined and factory–preset cutting heads may be used.

c. Mechanical strippers, of the types shown in Figure 2 shall not be used.

d. Stripping tools or machines shall be of the adapted size for the wire conductor.

NOTE It is good practice to mask off the dye openings for wire sizes not in use.

f. The conductor shall not be twisted, ringed, nicked, cut or scored by the process.

Figure 2: Examples of non–approved types of mechanical strippers

5.6.7 Verification of stripping tools

Thermal and mechanical stripping tools shall be verified by sampling at the start of each production run.

5.6.8 Soldering irons and resistance soldering equipment

a. Selection of soldering irons

1. The size and shape of the soldering iron and bit shall not prevent soldering without causing damage to adjacent areas or connections.
2. Temperature–controlled soldering irons shall be used.

   NOTE It is good practice to verify periodically the solder tip temperature.

3. The tip shape, such as spade, chisel or pyramid, shall be selected according to the workpiece.
4. Files shall not be used for dressing plated copper soldering–iron tips.
5. Spare bits, of the various shapes, shall be available.
6. The soldering iron or resistance–heating electrode shall heat the joint area to the solder liquidus temperature in a time between 1 second and 2 seconds.

7. The soldering iron or resistance–heating electrode shall maintain the soldering temperature at the joint throughout the soldering operation.
8. Thermal shunts shall be used to protect thermally-sensitive components.
9. For soldering of electronic components, the soldering–bit temperature shall not exceed 350 ºC.
10. A soldering–bit temperature up to 380 ºC may be used for polyimide PCBs with heat sinks or large ground planes.

    NOTE It is good practice to have a soldering–bit temperature of 280 ºC.

11. 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 shall be used.

NOTE It is good practice to use a cage–type holder that leaves the soldering–iron tip unsupported when a temperature-controlled soldering iron is used.

5.6.9 Soldering tools

a. **General**:

Tools shall not cut, nick or damage leads.

b. **Forked tools**:

The forked tool used as soldering aids shall not be wetted by the solder during the assembly.

c. **Thermal shunts**:

1. Thermal shunts shall be used for the de–golding, pre–tinning and soldering of temperature–sensitive components.

   NOTE An effective clamp–type thermal shunt can be constructed by sweating small copper bars into the jaws of an alligator clip.

2. The heat sink shall be used when the non-thermal sensitivity of the device cannot be demonstrated
3. The thermal shunt shall not disturb the solder joint by mechanical interference.
4. Shunts shall be applied and removed without mechanically damaging the component or the assembly.

   NOTE Shunts can be held in place by friction, spring tension, or any other means that does not damage the finish or insulation.

d. **Anti–wicking tools:**

The conductor gauge sizes of the anti–wicking tools shall be marked on the tool.

NOTE Anti-wicking tools can be used for pre–tinning the stranded wires.

e. **Lead–holding tool:**

Lead–holding tools shall be designed to avoid damage to the leads.

6
Materials selection

6.1 General

Material selection shall be performed in accordance with ECSS-Q-70-71.

6.2 Solder

6.2.1 Form

a. Solder ribbon, wire and preforms shall be used provided that the alloy and flux meet the requirements of this standard.

b. Alloy for use in solder baths shall be supplied as ingots (without flux).

6.2.2 Composition

a. The solder alloy shall have a composition specified in Table 1, unless approved by the Approval authority.

Note 1 See ISO 9453 for further details.

Note 2 The solder alloy used depends on the application. See Annex A.1 for guidelines for the choice of solder type.

Table 1: Chemical composition of spacecraft solders

ESA designation	Sn min-max	Pb max	In min-max	Sb max	Ag min-max	Bi max	Cu max	Fe max	Zn max	Al max	As max	Cd max	Other max
63 tin solder	62,5-63,5	Rem.	-	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
62 tin silver loaded	61,5-62,5	Rem.	-	0,05	1,8-2,2	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
60 tin solder	59,5-61,5	Rem.	-	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
96 tin solder	Rem.	0,10	-	0,05	3,5-4,0	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
75 indium lead	max. 0,25	Rem.	74,0-76,0	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
70 indium lead	0,00-0,10	Rem.	69,3-70,7	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
10 tin lead	9,0-10,5	Rem.	-	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08

6.3 Flux

6.3.1 Rosin–based fluxes

a. Fluxes shall be selected in accordance with Table 2.

NOTE The preferred flux standard is IEC61190-1-3 (2002).

b. For the pretinning of component leads, metallized terminations and terminal posts the following fluxes shall be selected:

1. In cases of normal pretinning, mildly-activated, rosin–based fluxes (e.g. ROL1) shall be used.
2. In cases of difficult pretinning, fully activated rosin–based fluxes (e.g. ROH1) may be used.

   NOTE ROH1 flux is extremely aggressive and can cause corrosion and damage to electronic materials.

3. In cases of very difficult pretinning, where rosin–based fluxes are inadequate, then INH1 corrosive, water–soluble, acid flux may be used in accordance with subclause 6.3.2.

   NOTE Difficulties in pretinning can arise from poor solderability.

c. For assembly the following fluxes shall be selected:

1. For normal assembly, pure rosin flux shall be used.

   Example Pure rosin flux ROL0.

2. When mildly-activated rosin flux is used, the effectiveness of subsequent cleaning operations shall be monitored in accordance with subclause 11.3.

   Example Mildly-activated rosin flux ROL1.

d. Fully activated rosin–based fluxes shall be stored separately from pure rosin fluxes and mildly-activated rosin fluxes.

Example Fully-activated rosin flux ROH1.

6.3.2 INH1 corrosive acid flux

a. INH1 flux residues shall be removed immediately after use in accordance with Clause 11, before any further soldering operations.

b. This flux shall not be used where vapours or residues of spattered flux can come into contact with electrical insulation material.

c. INH1 flux shall be stored separately from pure rosin fluxes and mildly-activated rosin fluxes.

NOTE INH1 flux leaves residues that promote stress–corrosion cracking and general surface corrosion.

6.3.3 Application of flux

1. The quantity of flux used shall be such that the solder joint is in accordance with Clause 12.
2. When flux-cored solder is used, it shall be positioned such that the flux flows and covers the components to be joined as the solder melts.
3. When an external liquid flux is used in conjunction with flux-cored solders, the fluxes shall be compatible.

4. When external flux is used, liquid flux shall be applied to the surfaces to be joined prior to the application of heat.

Table 2: Fluxes

	IEC61190-1-3 (2002) designation	Equivalent designation from ISO 29454 (1994)	Nature	Nominal composition (Weight %)
Pretinning:				
normal	ROL1	1.1.2.W or X	Rosin	< 0,15% halide
difficult	ROH1	1.1.2.Z	Rosin	≥ 2,0% halide
very difficult	INH1		Inorganic Water soluble	> 2,0% halide
Assembly:				
preferred	ROL0	1.1.1	Rosin	< 0,01% halide
requiring cleanliness testing	ROL1	1.1.2.W or X	Rosin	< 0,15% halide

6.4 Solvents

6.4.1 Acceptable solvents

a. Solvents for the removal of grease, oil, dirt, flux and flux residues shall be electrically non–conductive and non–corrosive.

b. Solvents shall not dissolve or degrade the quality of parts or materials.

c. Solvents shall not remove component identification markings.

d. Solvents shall be labelled.

e. Solvents shall be maintained in an uncontaminated condition.

f. Solvents showing evidence of contamination or decomposition shall not be used.

g. Solvents shall not be used such that dissolved flux residue contaminates electrical contact surfaces.

NOTE Examples of electrical contact surfaces are those in switches, potentiometers or connectors.

h. The following solvents shall be used for cleaning in soldering operations (see clause 12):

1.• ethyl alcohol, 99,5 % pure or 95 % pure by volume,

2.• isopropyl alcohol, 99 % pure,

3.• deionized water at a maximum temperature of 40 ^{0}C is used for removing certain fluxes provided that the assembly is thoroughly dried directly after cleaning,

4.• any mixture of the above.

i. Other solvents shall pass a compatibility test programme agreed by the Approval authority.

j. Water-based solvents containing saponifiers shall not be used.

6.4.2 Drying

Solvents shall be selected such that they dry completely.

6.5 Flexible insulation materials

a. Materials shall have low outgassing properties in accordance with ECSS-Q-70-02.

b. The following flexible insulation materials may be used in a space environment:

- FEP and PTFE.
- Polyolefin and Kynar® sleeving for heat-shrinkable wire terminations.
- Irradiated polyethylene, fluorinated resin and polyimide.

c. PTFE materials shall not be heated above 250 °C.

NOTE Small amounts of poisonous gases can be liberated above this temperature.

6.6 Terminals

6.6.1 Materials

a. Terminals shall be made from one of the following materials:

1. Bronze (copper/tin) alloys.

   NOTE It is good practice to use bronze terminals.

2. Brass (copper/zinc) alloys.

b. When a brass terminal is used it shall be plated with a barrier layer of copper or nickel of 3 µm to 10 µm.

Note 1 A barrier layer is necessary on brass items to prevent the diffusion, and subsequent surface oxidation, of zinc

Note 2 It is good practice to use a copper barrier layer on brass terminals because nickel is magnetic and can have a poor solderability.

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c. Terminals shall be tin/lead coated.

Example Hot–dipped or reflowed electro–deposited coatings.

d. Terminals with coatings on the mounting surface shall be rejected if the coatings loosen in subsequent soldering operations.

6.6.2 Tin–, silver– and gold–plated terminals

a. Terminals on PCBs shall not be tin, silver or gold plated.

b. These finishes shall be replaced using one of the methods prescribed in subclause 8.1.3.

6.6.3 Shape of terminals

Bifurcated and turret terminals shall have ledges or grooves to allow both the accurate location of connecting wires and the flow of solder.

6.7 Wires

a. Wire shall be made from high–purity copper or copper alloy.

b. The wire shall have one of the following finishes:

- Silver-coating.
- Wire-drawn, fused pure tin.
- Enamelled.

c. Wires shall be stripped of their insulation in accordance with subclause 7.2.1.

d. When stripping the ends of enamel wires using chemical processes or thermal compression, the complete removal of the enamel shall be verified by visual inspection.

e. Contamination of the enamel shall not occur during the stripping process.

6.8 PCBs

6.8.1 Boards

a. Boards shall be made of materials, and manufactured, according to the requirements of ECSS-Q-70-10 and procured according to ECSS-Q-70-11.

NOTE It is good practice to use plated through-holes for connections.

b. For non–plated–through holes, interfacial connections shall be made according to subclause 8.2.2.

6.8.2 Gold finish on conductors

a. Gold-plated conductors shall not be soldered.

b. Degolding of conductors shall be in accordance with subclause 7.2.3.

NOTE RF circuits with gold finishes can have their conductors selectively plated such that the terminal pads have a tin–lead finish.

6.9 Component lead finishes

Component lead finishes shall conform to the requirements of ESCC-23500.

6.10 Adhesives (staking compounds and heat sinking), encapsulants and conformal coatings

a. Adhesives shall be dispensable, non-stringing, and have a reproducible dot profile after application.

b. The uncured (tack) strength shall be capable of holding devices during handling prior to cure.

c. Adhesives, encapsulants and conformal coatings shall be non-corrosive to devices and substrates.

d. No materials that emit acetic acid, ammonia, amines, hydrochloric acid and other acids shall be used.

NOTE Such compounds can cause stress–corrosion cracking of part leads

e. The adhesives, encapsulants and conformal coatings used shall not damage substrate materials or attached devices.

Note 1 The effects of some conformal coatings on the reliability of solder joints are described in ESA SP 1173 [2].

Note 2 Adhesion to fused tin-lead finishes is poor, see also ECSS-Q-70-28.

f. Adhesives, encapsulants and conformal coatings shall conform with the outgassing requirements of ECSS-Q-70-02A, Clause 7.

g. Shrinkage of resin during cure and repair shall not degrade the coated articles.

h. All materials covered by this subclause shall be individually assessed when flammability requirements are applicable.

i. Adhesives, encapsulants and conformal coatings shall be selected on the basis of their thermal conductivity and dielectric properties (see ESA STM 265).

NOTE Some thermally conductive adhesives used to dissipate Joule heating are listed in ESA STM 265.

j. Stress relief of device leads shall not be negated by the encapsulant or conformal coating.

Note 1 This is particularly important at low service temperatures.

Note 2 The coefficient of thermal expansion, glass transition temperature and modulus of adhesives used under devices for thermal reasons, for achieving stand-off heights or for mechanical support during vibration, can be considered to ensure that the additional stress put on the solder joints does not degrade the solder joint reliability.

7 Preparation for soldering

7.1 General

Operators shall use tools that are fit for the purpose and undamaged prior to use.

7.2 Preparation of conductors, terminals and solder cups

7.2.1 Insulation removal

7.2.1.1 Stripping tools

Stripping tools or machines shall be in accordance with subclause 5.6.6.

7.2.1.2 Damage to insulation

a. The remaining conductor insulation shall not be damaged by the insulation removal process.

b. Conductors with damaged insulation shall not be used.

Example Insulation damage includes nicks, cuts, crushing and charring.

NOTE The normal operation of mechanical stripping tools can leave slight pressure markings in the remaining conductor insulation.

c. The insulation material shall not be charred by thermal stripping.

NOTE Some discoloration of the insulation material after thermal stripping is normal.

7.2.1.3 Damage to conductors

a. The conductor shall not be damaged by the insulation removal process.

Example Conductor damage includes twisting, ringing, nicks, cuts or scores.

b. Part leads and other conductors that are reduced in cross–sectional area by the insulation removal process shall not be used.

c. Coated wires where the base material is exposed shall not be used.

7.2.1.4 Insulation clearance

a. The maximum insulation clearance, measured from the solder joint:
   1. for non-PTFE insulation, except in the case of coil winding wires, shall be as stated in Table 3.
   2. for PTFE insulation shall be 2 mm.
   3. exceptions may be made for the assembly of coil winding wires.

b. The minimum insulation clearance shall:
   1. not result in insulation imbedded in the solder joint.
   2. not obscure the contour of the conductor at the termination end of the insulation.
   3. be a minimum of 1 mm for PTFE insulation.

      NOTE The clearance values for PTFE insulation are to accommodate cold flow.

Table 3: Clearances for non-PTFE insulation

Wire diameter (American Wire Gauge)	Conductor diameter, D (mm)	Insulation clearance (maximum)
32 to 24	0,200 to 0,510	$4 \times D$
22 to 12	0,636 to 2,030	$3 \times D$
≥ 10	≥ 2,565	$2 \times D$

7.2.2 Surfaces to be soldered

a. **Cleaning**.
   1. Before assembly, devices, wire, terminal and connector contacts shall be visually examined for cleanliness, absence of oil films and freedom from tarnish or corrosion
   2. Conducting surfaces to be soldered shall be cleaned using solvents specified in subclause 6.4.
   3. Conducting surfaces to be soldered shall have good solderability.
   4. Abrasives shall not be used for surface preparation except for gold-plating on substrates and devices in accordance with 7.2.3.b.

   Example Abrasives can include pumice, pumice-impregnated erasers and emery paper.

b. **Wire lay**
   1. Disturbed lay in stranded-wire conductors shall be restored before soldering.
   2. Restoration of the lay shall be done without contaminating the conductor.

      NOTE The use of bare fingers can cause contamination.

c. **Terminals and solder cups**.

   The size of terminals or solder cups shall not be modified.

      NOTE A terminal or solder cup size is selected to match the size of conductors.

7.2.3 De-golding of gold-plated leads and terminals

a. **General**
   1. Tin-lead alloy solders shall not be used to solder to gold.

2. Indium-lead solder alloys may be used for soldering to gold.

Example Soldering of RF SMT devices.

Note 1 Gold-plated metallization on substrates or devices can be removed by mechanical abrasion using a pumice-impregnated eraser in accordance with 7.2.3.b.

Note 2 Mechanical abrasion can also improve solderability or liquid solder degolding processes.

4. Solder baths used for degolding and pretinning shall be in accordance with Table 4.
5. Surface impurities shall be skimmed from the bath surface before use.
6. A controlled method shall be established and implemented for the replacement of solder baths as follows:
   a. **Composition**: Do not exceed the contamination limits in Table 4.
   b. **Pretinning quality**: Replace the bath when the solder produces a dull, frosty or granular appearance on the work, or
   c. **Time**: establish a schedule of solder-bath replacement with justification of the replacement frequency.

Table 4: Solder baths for degolding and pretinning

	Solder bath 1	**Solder bath 2**
Use	Gold dissolution	Pretinning
Composition	60 tin solder	60 tin solder
Temperature range (°C)	250 to 280	210 to 260
Contamination limits (weight %)	Au < 1	Cu < 0.25; Au < 0.2; (Cu + Au) < 0.3; Zn, Al and Fe: Trace.

b. **Removal of gold from PCB conductors by mechanical abrasion:**
   1. This process shall not be used for removing gold plating greater than 1 μm thick.
   2. The gold plating shall be removed using a pumice-impregnated eraser.
   3. The process shall not damage the substrate materials.
   4. The process shall not impair the solderability of the conductor.
   5. The process shall not reduce the thickness of the copper conductor.

   NOTE It is good practice to design PCBs with selective plating to avoid the necessity to remove gold plating, see subclause 6.8.2.

c. **Solder bath method:**
   1. Gold-plated component leads and terminals shall be dipped into solder bath 1 for between 2 seconds and 3 seconds.
   2. The leads shall be pre–tinned in bath 2 in accordance with subclause 8.1.5.

d. **Solder cup method:** to dissolve the gold plating;.
   1. Solder shall be melted within the gold-plated solder cup.

NOTE The liquid solder dissolves the gold plating.

2. The liquid solder shall be wicked–out using stranded wire.

e. **Constraints on degolding methods:**

1. The maximum soldering rating of the component, stated by the manufacturer, shall not be exceeded.
2. Thermal shunts, in accordance with subclause 5.6.9.c., may be used.

7.2.4 Pretinning of stranded wires

a. **Solder baths:**

1 Solder baths for pretinning shall be in accordance with subclauses 7.2.3.a.4, 5 and 6.

2 Stranded wires may also be pre–tinned by applying solder to the wire using a heated soldering–iron tip.

b. **Solder bath method:**

1. The insulation shall be removed in accordance with subclause 7.2.1.
2. Pure rosin flux shall be applied to the end of the strands.
3. The fluxed end of the wire shall be dipped into solder bath 2 for a time between 2 seconds and 3 seconds.

NOTE Pretinning promotes solderability and prevents untwisting or separation stranded wires.

c. **Constraints on pretinning methods**:

1. Solder shall penetrate to the inner strands of stranded wire.
2. Solder shall not obscure the wire contour at the termination end of the insulation.
3. Anti–wicking tools in accordance with subclause 5.6.9.d. may be used.
4. Pretinning shall not degrade the characteristics of the wire.

Example Flow of solder (wicking) beyond the insulation can reduce the flexibility of the wire.

5. The insulation shall not be damaged by the pretinning.
6. Flux shall be removed by means of a cleaning solvent, see subclause 7.4.
7. Cleaning solvent shall not flow under the conductor insulation.

NOTE Application using a lint–free cloth can limit the flow of solvent.

7.2.5 Pre–tinning of component leads and solid–wire conductors

a. **Solder baths:**

Solder baths for pretinning shall be in accordance with subclauses 7.2.3.a.4, 5 and 6.

b. **Pretinning**

1. Component leads and solid wires shall be pre–tinned by dipping into solder bath 2 (see Table 4) for a duration of between 2 seconds and 8 seconds.

   Note 1 It is good practice to observe an immersion period of between 3 seconds and 4 seconds.

   Note 2 Pretinning, with a tin-lead finish containing more than 10 % lead, may be done by the component manufacturer.

   Note 3 Such component leads, having good solderability, may be used without further pretinning.

2. The cross–sectional area of conductors shall not reduce by dissolution into the solder bath.
3. Pretinning shall result in a solder coating more than 2 µm thick.

   NOTE A slow, vertical and smooth withdrawal of the component lead from the bath promotes an even coating.

4. The component shall cool before cleaning.

   NOTE Rapid cooling by contact with cleaning solvents can crack packages or glass-to-metal seals.

c. **Constraints**

1 Components having glass–to–metal lead seals shall be preformed according to subclause 5.6.4 before pre–tinning.

2. Liquid solder shall not come into contact with the component body or its glass meniscus.

3 The limit of the pretinned coating shall be at least 0,75 mm from any lead–to–glass seal of the component package.

4 Fluxes used for pretinning of components having poor solderability shall be in accordance with subclause 6.3.1

7.3 Preparation of the soldering bit

7.3.1 Fit

The bit shall be fitted in accordance with the equipment manufacturer's specification.

7.3.2 Maintenance

a. Oxidation products shall be removed from the bit.

   NOTE Build up of oxidation products can reduce the ability of the tip to transfer heat.

b. Plated tips

1. Plated tips shall be examined for cracking.

   NOTE Cracked platings allow the liquid solder to alloy with and erode the underlying copper, forming intermetallics which reduce heat transfer and lead to unacceptable joints.

2. Prior to examination, solder obscuring the surface shall be removed when the iron is hot by wiping the bit with moist, lint–free, sponge material.

3. Bits with cracked platings shall be removed from the soldering area.

7.3.3 Plated bits

a. Superficial deposits shall be removed using a moist sponge.

b. Adherent deposits may be removed using fine abrasive paper (grain size 600).

7.3.4 Tip in operation

a. The working surface of the tip shall be pretinned in accordance with subclause 7.2.5

NOTE Pretinning prevents oxidation of the bit.

7.4 Maintenance of resistance–type soldering electrodes

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

7.5 Handling (work station)

a. Component leads, terminals, wire ends and PCB termination areas shall not be touched with bare hands.

b. Personnel working with cleaned PCB assemblies shall wear clean lint–free gloves or finger cots.

c. Contaminated metal surfaces shall be cleaned with a solvent specified in subclause 6.4.

d. ESD-sensitive components shall be handled in accordance with subclause 5.5

7.6 Storage (work station)

7.6.1 Components

a. Storage facilities shall protect components from contamination and damage.

b. Storage boxes and bags shall be made of materials which do not degrade the solderability of the components.

c. Storage materials shall not contain amines, amides, silicones, sulphur or polysulphides.

d. Packaging and containers for ESD-sensitive devices shall be in accordance with subclause 5.5.

7.6.2 PCBs

PCBs shall be stored in moisture–free containers.

7.6.3 Materials requiring segregation

a. Solders not in accordance with subclause 6.2 shall be removed from the work area.

b. Activated fluxes shall be stored in accordance with subclause 6.3.1.d.

Example ROH1 flux.

c. Corrosive acid fluxes shall be stored in accordance with subclause 6.3.2.a.

Example INH1 flux.

d. Solvents that do not conform to subclause 7.4 shall be removed from the work area.

Example Solvents contaminated with impurities such as inorganic acids.

7.7 Preparation of PCBs for soldering

7.7.1 Process

a. PCBs shall be:

1. Cleaned using solvent conforming to subclause 6.4.
2. Demoisturized in accordance with subclause 7.7.2.

b. Prepared PCBs shall be stored in accordance with subclause 7.6.2.

7.7.2 Demoisturization methods

a. The demoisturization process conditions shall be selected according to the maximum temperature rating of the PCB.

b. Oven bake method:

1. The oven temperature shall be between 90 ºC and 120 ºC.
2. The process time shall be a minimum of 4 hours.

Note 1 Long baking periods at higher temperatures can reduce the solderability of PCB terminations.

Note 2 Vacuum bake method can be selected for temperatures less than 90 ºC.

7.7.3 Storage of prepared PCBs

Storage of prepared PCBs for periods greater than 8 hours prior to initial exposure to soldering temperatures shall be in a controlled moisture–free atmosphere.

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8
Mounting of components

8.1 General requirements

8.1.1 Introduction

a. Components shall be mounted:
   1. Parallel to the mounting surface.
   2. Preferably in contact with the mounting surface.
   3. Not more than 3,5 mm above the mounting surface.

b. A component that meets one or more of the criteria stated in subclause8.1.2, subclause 8.1.3 or subclause 8.1.4 shall be classed as an exception to subclause8.1.1.a.

c. Materials used to support components shall be meet the requirements of ECSS-Q-70-71A, Clause 5..

8.1.2 Heavy components

a. Components weighing more than 5 grams shall be supported by either of the following methods:
   1. Adhesive compounds in accordance with subclause6.10.
   2. Mechanical methods.

b. The support method shall not impose stresses that result in functional degradation or damage to the part or assembly.

c. The support method shall not impair stress relief designs, see subclause 8.1.5 and subclause 8.1.6.

8.1.3 Metal–case components

a. Metal–case components shall be electrically insulated using space-approved materials where they meet one of the following conditions:
   1. mounted over printed conductors.
   2. in contact with another metal–case component.
   3. in contact with a conductive material.

b. Metal-cased components shall not be mounted over soldered connections.

c. Component identification marks shall not be obscured by the insulation.

Example Serial numbers

8.1.4 Glass–encased components

Example a.

NOTE b.

a. Glass-encased parts shall be enclosed with sleeving when epoxy material is used for staking, conformal coating or encapsulating.

NOTE Epoxy material cannot be applied directly to the glass.

b. Glass–encased components may be enclosed in resilient transparent sleeving.

Example Diodes, thermistors or resistors.

c. Glass–encased components may be enclosed in heat–shrinkable sleeving.

Example Heating and shrinkage of sleeving can damage glass-encased components.

8.1.5 Stress relief of components with bendable leads

a. Stress relief shall be incorporated into:

1. Leads and conductors in solder connections.
2. Interfacial connections.

Note 1 Stress relief provides freedom of movement for component leads or conductors between points of constraint.

Note 2 Stresses can arise between points of constraint due to mechanical loading or temperature variations.

b. Stress relief methods, shown in Figures 3, 6, 11 and 12, shall apply.

c. Stress relief designs shall not damage the assembly.

Note 3 Long lead lengths or large loops between constraint points can vibrate and damage the assembly.

d. Leads shall not be temporarily constrained against spring–back force during soldering.

NOTE Residual stresses are produced in the lead material or solder joint.

e. Solder fillets shall not negate the effect of stress relief bends.

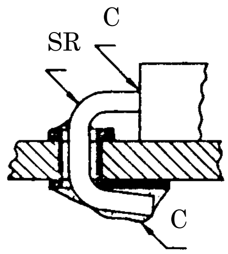
8.1.6 Stress relief of components with non–bendable leads

a. Component leads which cannot be bent shall be cut in accordance with subclause 5.6.3 and subclause 8.4.4.

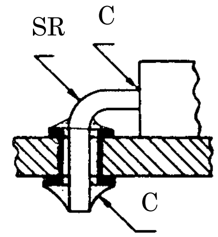
NOTE Bending can damage the component or the PCB when lead diameters are large or components have delicate seals or where lead–material composition makes bending impracticable.

b. Stress relief for components with non-bendable leads mounted in contact with the PCB or adhesively bonded to the PCB shall use bendable wire extensions, see Figure 4.

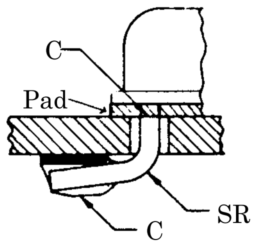
c. Bendable wire extensions may be soldered to non-bendable leads to provide stress relief.



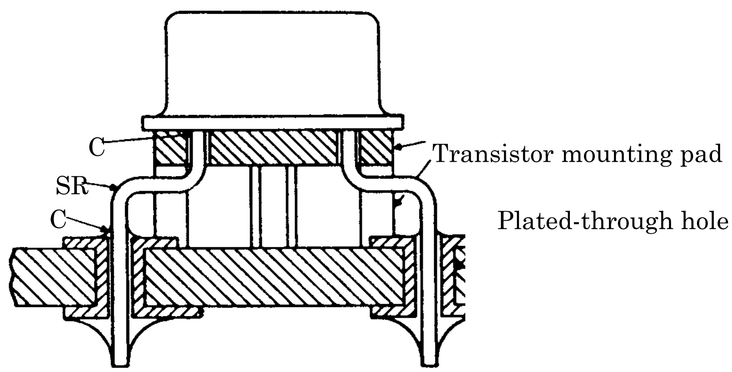
(a) Clinched lead



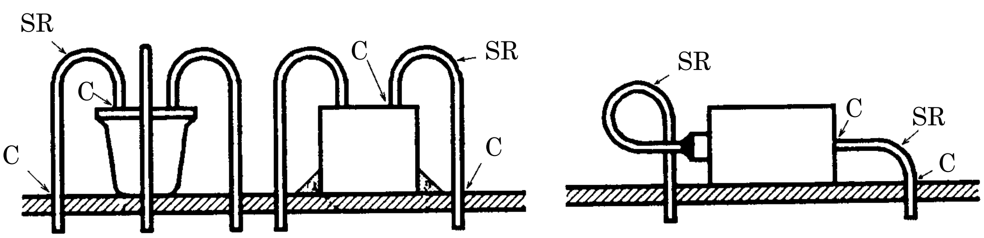
(b) Stud-mounted lead



(c) Offset lap joint



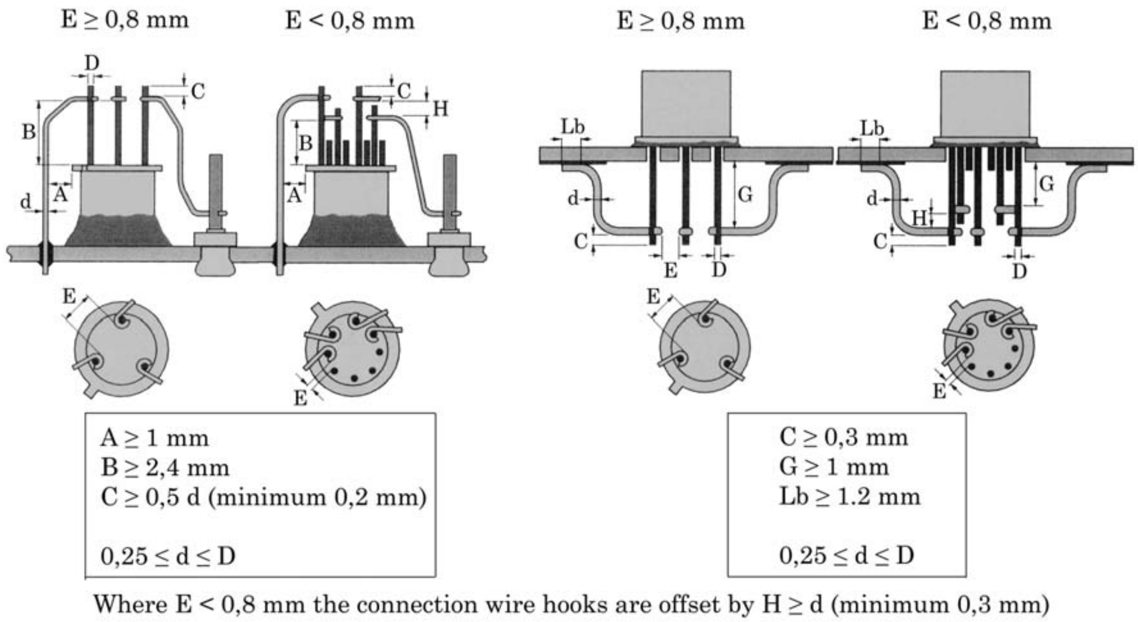
(d) Stud-mounted leads



(e) Alternative methods

SR = Stress relief bend
C = Constraint point

Figure 3: Methods for incorporating stress relief with components



having bendable leads

Figure 4: Methods for attaching wire extensions to non-bendable leads

8.1.7 Reinforced plated–through holes

Subclause 7.8.1 shall apply.

8.1.8 Lead and conductor cutting

Solder terminations shall not be cut after the soldering operation.

NOTE Component leads and wires are cut and shaped before soldering.

8.1.9 Solid hook–up wire

a. Solid hook–up wire shall be supported at intervals not exceeding 30 mm.

b. The support shall be provided using staking or conformal coating.

8.1.10 Location

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

8.1.11 Conformal coating, cementing and encapsulation

a. Coatings and cementing compounds shall not bridge stress relief loops or bends at terminations in component leads or connecting wires.

b. Stress relief of device leads shall not be negated by encapsulants or conformal coatings.

8.2 Lead bending requirements

8.2.1 General

a. During bending, component leads shall be supported to avoid axial stress and damage to seals or internal bonds.

b. The inside radius of a bend shall not be less than the lead diameter or ribbon thickness.

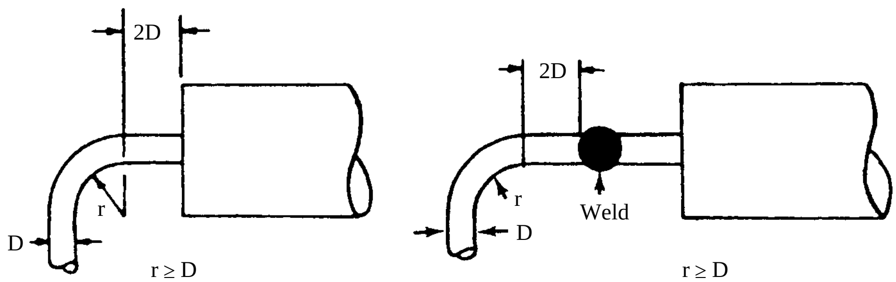
c. The distances between the bends and the end seals at either end of an axial component shall be similar.

d. The minimum distance from the bend to the end seal shall be two lead diameters for round leads and 0,50 mm for ribbon leads.

e. Where the component lead is welded the minimum distance to the bend shall be measured from the weld in accordance with Figure 5.

Example Tantalum capacitors.

f. Bending tools shall not impinge on the weld, see also subclause 5.6.4.



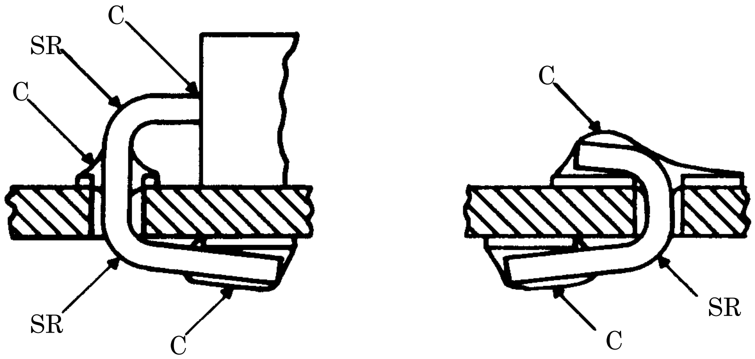
(a) Standard lead (b) Welded lead

Figure 5: Minimum lead bend

8.2.2 Conductors terminating on both sides of a non–plated–through hole

a. Stress relief shall be provided in the component lead on both sides of the PCB, see Figure 6 (a).

b. 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 (b).



SR = Stress relief
C = Constraint point

Figure 6: Leads with solder termination on both sides

8.3 Mounting of terminals to PCBs

a. 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).

b. Swage–type terminals that are mounted in a plated–through hole shall be secured to the PCB by an elliptical funnel swage, see Figure 7 (b).

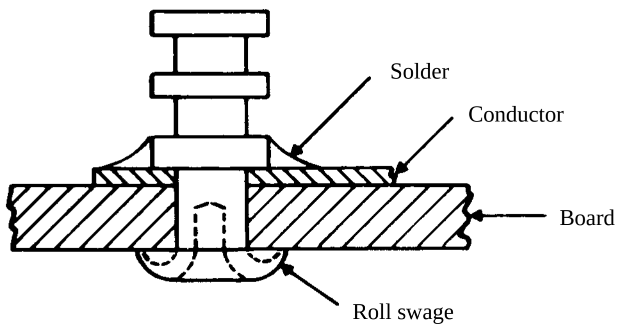
NOTE An elliptical funnel swage enables complete filling of the plated–through hole with solder.

c. The PCB shall not be damaged by the swaging process.

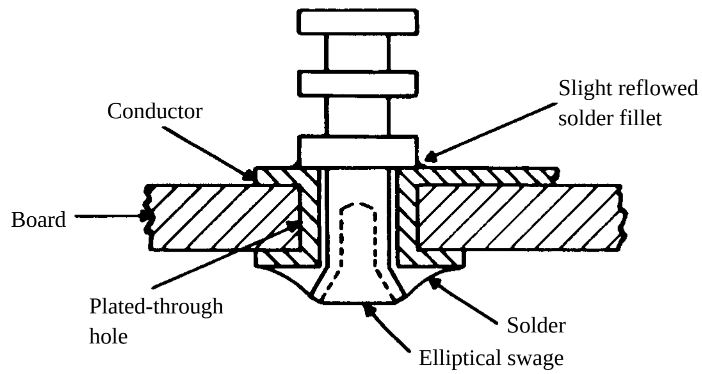
d. After swaging, the terminal shall be free from circumferential splits or cracks.

e. The terminal may have a maximum of three radial splits or cracks, provided that the splits or cracks do not extend beyond the swaged area of the terminal and are a minimum of 90° apart.

f. After swaging, the terminal shall be inspected for circumferential splits or cracks.



(a) Single sided



(b) Double sidec

Figure 7: Types of terminal swaging

8.4 Lead attachment to PCBs

8.4.1 General

a. Solder terminations shall be visible for inspection after soldering.

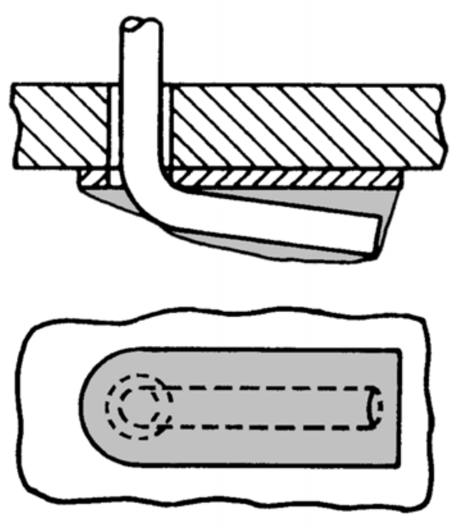
b. Component leads shall be terminated to PCBs by clinch, stud or lapped terminations.

8.4.2 Clinched leads

a. Non-bendable leads shall not be clinched, see also subclause 8.1.6.

b. Clinched leads terminating at a PCB pad shall be bent to make contact with the printed circuit conductors.

c. The clinched lead shall not extend beyond the edge of the conductor pattern, see Figure 8.



d. The lead shall not be forced to lie flat at the bend radius, see Figure 9.

NOTE Component leads can spring–back when clinched.

e. Rounded termination areas:

1. The lead shall extend through and overlap the solder pad.
2. The lead shall be bent in the direction of the longest dimension of the solder pad.
3. The area of the solder–pad shall permit a solder fillet to be formed.

Figure 8: Clinched–lead terminations - unsupported holes

Figure 9: Clinched lead terminations - plated through–holes

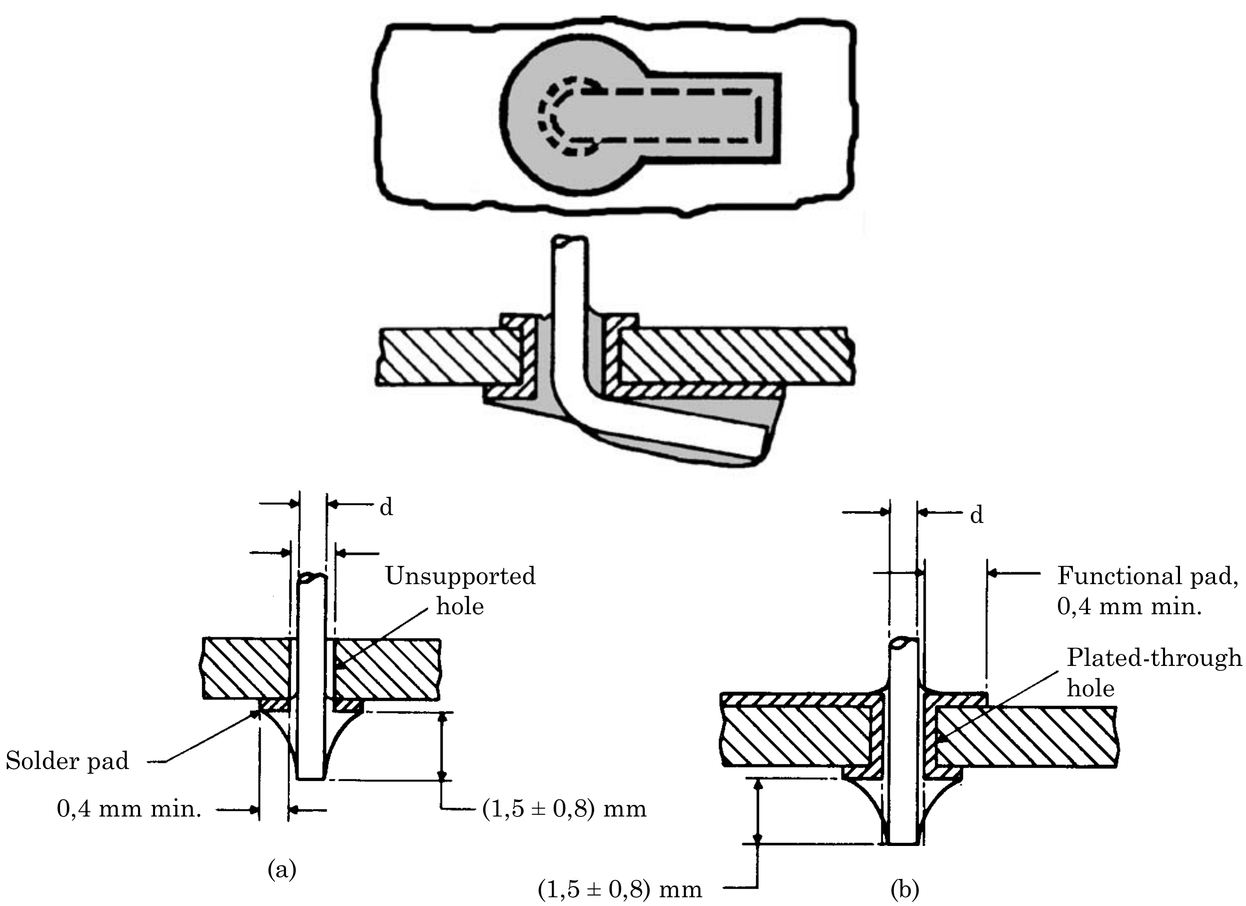
8.4.3 Stud leads

a. **Unsupported hole:** Cut stud leads shall protrude beyond the PCB surface by 1,5 mm ± 0,8 mm, see Figure 10 (a).

b. **Plated-through hole less than 2,2 mm in length:** Cut stud leads shall protrude beyond the PCB surface by 1,5 mm ± 0,8 mm, see Figure 10 (b).

c. **Components with short leads and plated-through holes greater than or equal to 2,2 mm in length:** protrusion may be zero, provided the outline of the lead is visible and there is wetting between the lead and pad around the entire circumference, see Figure 10 (c).

Figure 10: Stud terminations



8.4.4 Lapped round leads

a. Round leads shall overlap the solder pad:

1. Minimum overlap: Either 3,5 times the lead diameter or 1.3 mm, whichever is the greater.
2. Maximum overlap: 5,5 times the lead diameter.

b. The distance from the cut end of the lead to the edge of the solder pad shall be more than 0,5 times the lead diameter.

c. No portion of the soldered lead termination shall project beyond the edges of the pad.

8.4.5 Lapped ribbon leads

a. Ribbon leads shall overlap the solder pad, see Figure 11 (b):

1 Minimum overlap: Either 3 times the lead width or 1.3 mm, whichever is the greater.

2 Maximum overlap: 5 times the lead width.

b. No portion of the soldered lead termination shall project beyond the edges of the pad.

c. The distance from the cut end of the lead to the edge of the solder pad shall be more than 0,25 mm.

d. One side of the lead may be flush with the edge of the solder pad.

e. At least two of the three lead edges shall permit a solder fillet to be formed.

8.5 Mounting of components to terminals

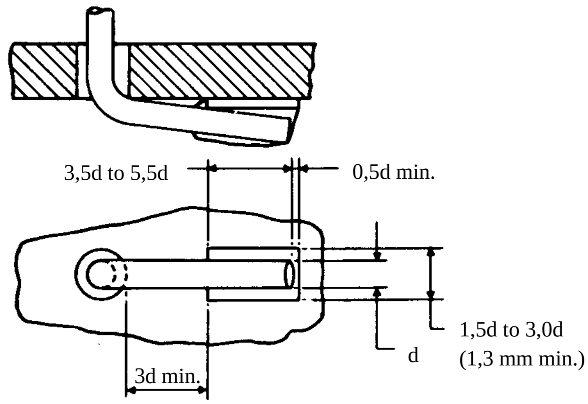
a. Components shall be mounted in accordance with subclause 9.1.

b. Degree of wrap, routing and connection to terminals shall be in accordance with Clause 9 and Clause 10.

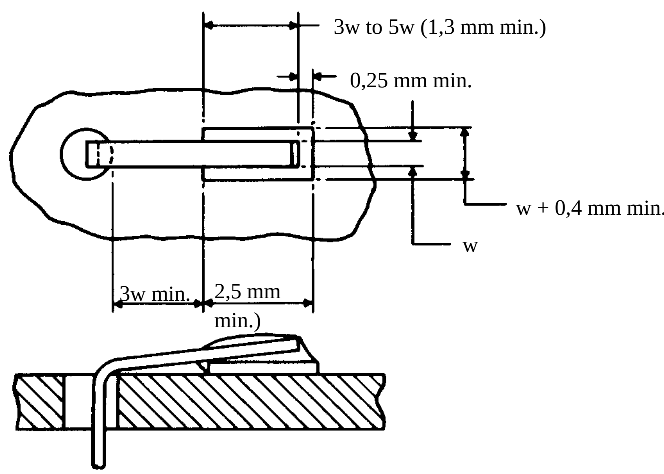
c. The lead length between the component and the terminals shall be similar at both ends, except where component package shapes dictate staggering.

Example Top hat diodes with flanges.

d. Stress relief shall be provided in accordance with Figure 12.

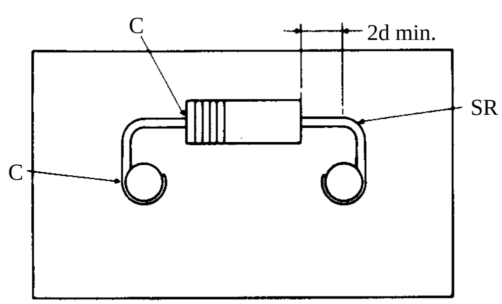


(a) Round lead

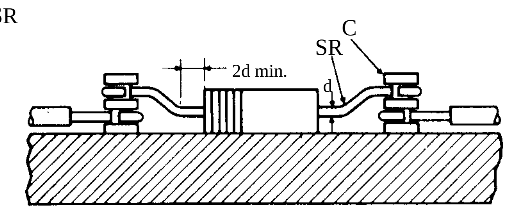


(b) Ribbon lead

Figure 11: Methods of through–hole lapped termination



(a) Offset mounting



(b) In-line mounting

SR = Stress relief bend
C = Constraint point

Figure 12: Method of stress relieving parts attached to terminals

8.6 Mounting of connectors to PCBs

a. Connectors shall be mounted in accordance with subclause 8.1.

b. PCB connectors shall be supplied with either:

   1. pre–formed leads supporting stress relief bends, or
   2. straight, epoxy-bonded leads.

c. De–golding and pre–tinning of leads in accordance with subclause 7.2.3and subclause7.2.5 shall be performed before mechanical fixing of connectors to the PCB.

d. Connector leads shall protrude through the board in accordance with subclause 8.4.3.

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9 Attachment of conductors to terminals, solder cups and cables

9.1 General

9.1.1 Conductors

A conductor shall be wrapped onto a terminal in the same sense as the final curvature of the wire.

9.1.2 Terminals

a. Gold–plated terminals and solder cups shall have the gold removed in the conductor attachment area and be pretinned in accordance with subclause 7.2.3.

b. Terminals shall be the adapted size for the conductors.

9.2 Wire termination

9.2.1 Breakouts from cables

The length of individual wires routed from a common cable to equally-spaced terminals shall be uniform (including wire ends and stress-relief bends).

NOTE Uniform lengths prevent stress concentration in any one wire.

9.2.2 Insulation clearance

a. Where characteristic impedance or circuit parameters are not affected, the insulation clearance values stated in subclause 7.2.1.4 shall apply.

b. Where characteristic impedance or circuit parameters are affected:

1. Insulation clearance requirements may be modified.
2. Variations shall be documented in the process procedures.

Example High–voltage circuits or RF coaxial line terminations.

9.2.3 Solid hook–up wire

a. Solid hook–up wire shall be supported at intervals not exceeding 30 mm.

b. Support shall be provided by staking or conformal coating.

9.2.4 Stress relief

a. Conductors terminating at solder connections shall incorporate stress relief.

b. Wicking shall be controlled, see subclause 7.2.4.c.3 and subclause 7.2.4.c.4.

9.3 Turret and straight-pin terminals

9.3.1 Side route

a. Side route connections shall be made as shown in Figure 13 (a).

b. Conductors shall be wrapped around the post (see Figure 13 (c)):

1. a minimum of 1/2 turn.
2. a maximum of 3/4 turn.

c. For turret terminals, all conductors shall be confined to the guide slots.

d. Conductors shall not project beyond the base of the terminal.

e. Wires shall not be wrapped over other wires.

f. More than one wire may be installed in a single slot of a terminal post provided that the combined diameters of the wires are less than the width of the slot.

g. 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, pass through the side slot at the top, and be wrapped as for the side route, see Figure 13 (b).

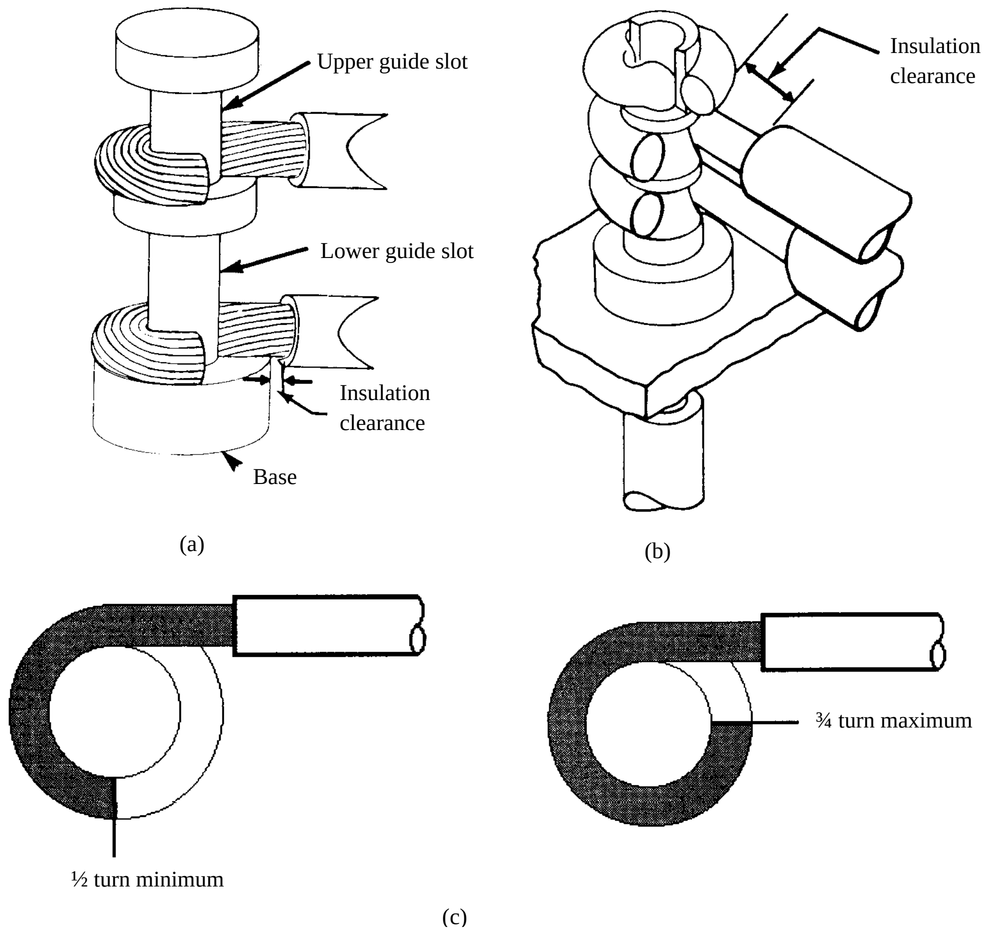


Figure 13: Side– and bottom–route connections to turret terminals

9.4 Bifurcated terminals

9.4.1 General

a. Top, side or bottom routes, or combinations thereof, shall be used.

b. Top route and side route shall not be used together on the same terminal.

9.4.2 Bottom route

a. Bottom route connections shall be as shown in Figure 14.

b. Conductors may project beyond the diameter of the base, see Figure 14 (c), provided that clearances, environmental and electrical characteristics are not compromised.

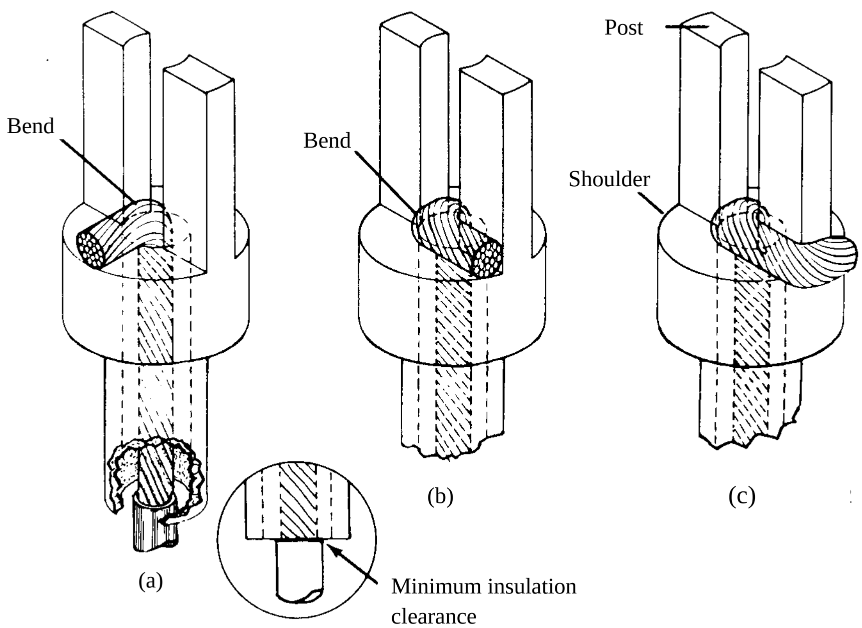


Figure 14: Bottom–route connections to bifurcated terminal

9.4.3 Side route

a. Side route connections shall be as shown in Figure 15.

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

c. When more than one conductor is connected to a terminal, the direction of bend of each additional conductor shall alternate, see Figures 15 (b) and (d).

d. Side–route connections shall not project above the top of the terminal.

e. Conductors may project beyond the diameter of the base, see Figure 15 (c), provided that clearances, environmental and electrical characteristics are not compromised.

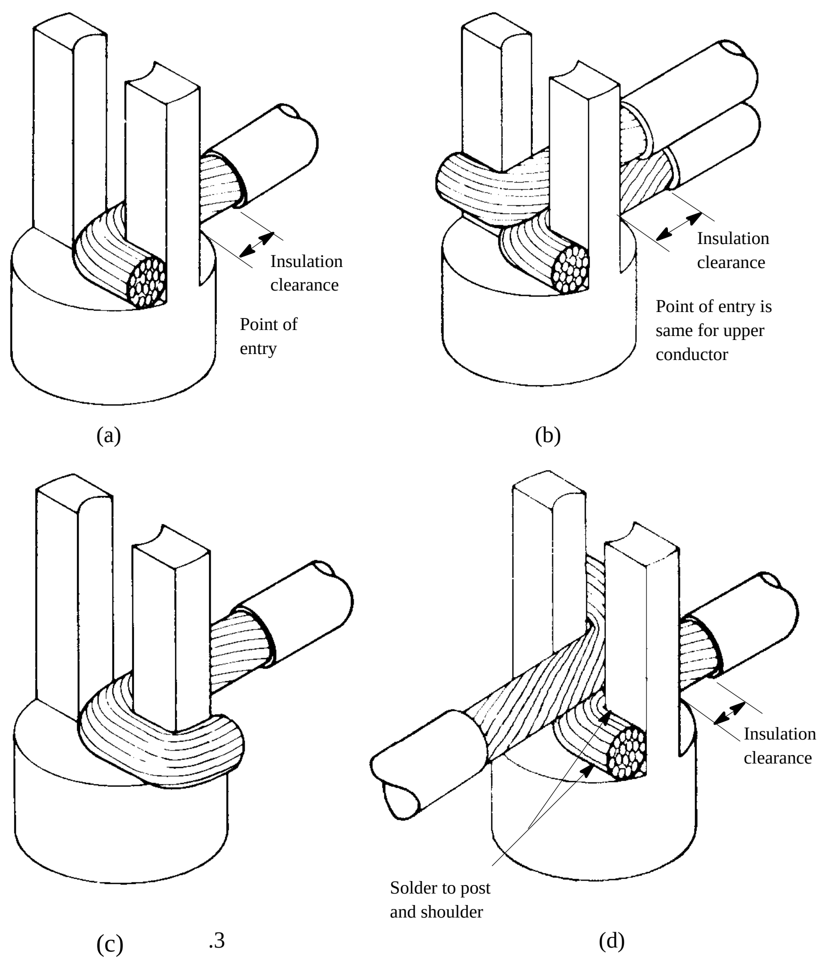


Figure 15: Side–route connection to bifurcated terminal

9.4.4 Top route

a. The top route shall not be used where side entry is possible.

b. Top route connections shall be as shown in Figure 16.

c. Conductors shall be inserted between the vertical posts to the depth of the shoulder, except for combined top and bottom routes (see subclause 9.4.5).

d. Conductors which do not fill the gap, see Figure 16, shall be either:

   1. accompanied by a tinned filler wire (solid or stranded), such that the combined diameters fill the gap.
   2. bent double, provided that the combined diameters fill the gap.

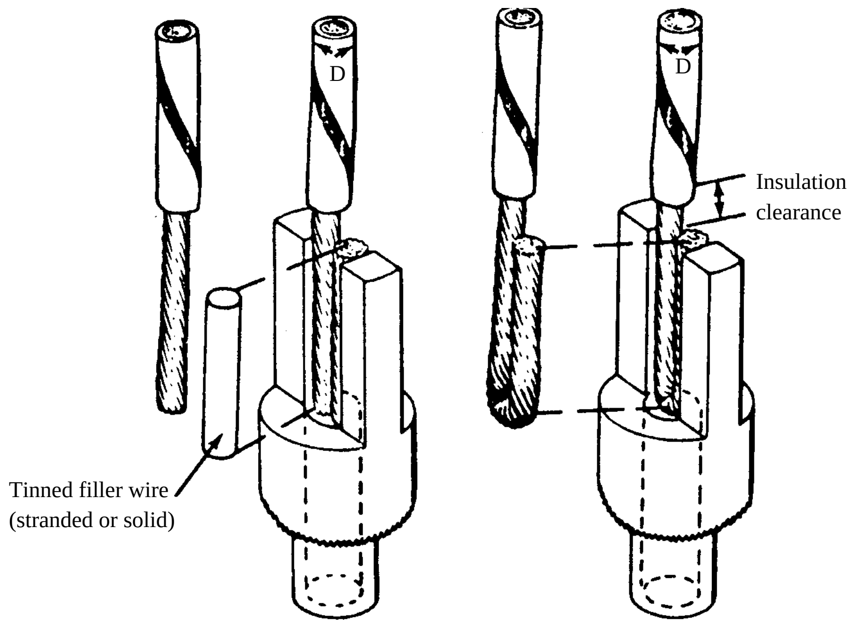


Figure 16: Top–route connection to bifurcated terminal

9.4.5 Combination of top and bottom routes

a. The bottom route conductor shall be installed before the top route conductor.

b. The top–route conductor shall be inserted to contact the bottom–route conductor.

9.4.6 Combination of side and bottom routes

The bottom route conductor shall be installed before the side route conductor.

9.5 Hook terminals

a. Connections to hook terminals shall be as shown in Figure 17.

b. The bend to attach conductors to hook terminals shall be:

   1. a minimum of 1/2 turn.
   2. a maximum of 3/4 turn.

c. Protrusion of conductor ends shall not damage insulation sleeving.

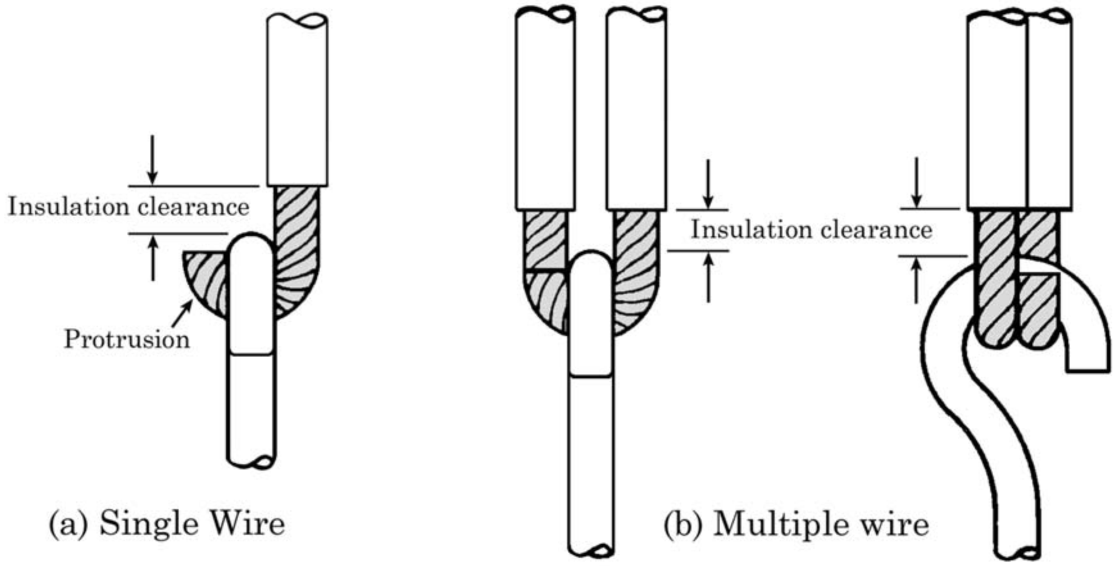


Figure 17: Connections to hook terminals

9.6 Pierced terminals

a. Connections to pierced terminals shall be as shown in Figure 18.

b. The bend to attach conductors to pierced terminals shall be:

   1. a minimum of 1/4 turn.

   2. a maximum of 3/4 turn.

c. Protrusion of conductor ends shall not damage insulation sleeving.

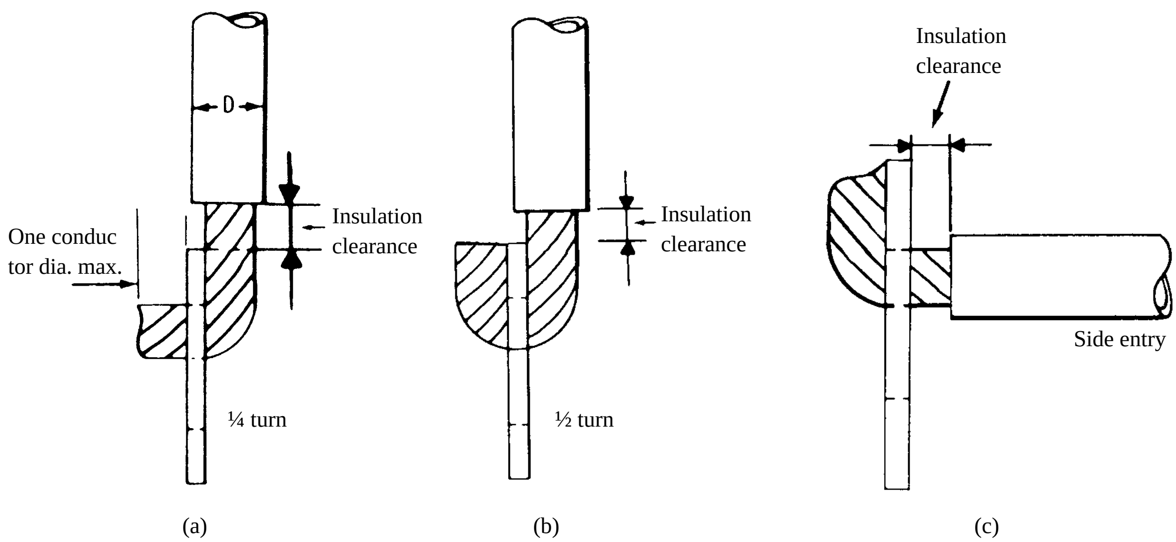


Figure 18: Connections to pierced terminals

9.7 Solder cups (connector type)

a. Conductors shall enter the solder cup as shown in Figure 19.

b. Conductors shall be bottomed in the cup.

c. Conductors shall be in contact with the inner wall of the cup.

d. Multiple conductors may be inserted provided that each is in contact with the full height of the inner wall of the cup.

e. Flux shall not be trapped within the solder cup.

f. Conductors shall not misalign floating contacts.

Example Solid, rigid conductor wire into connectors.

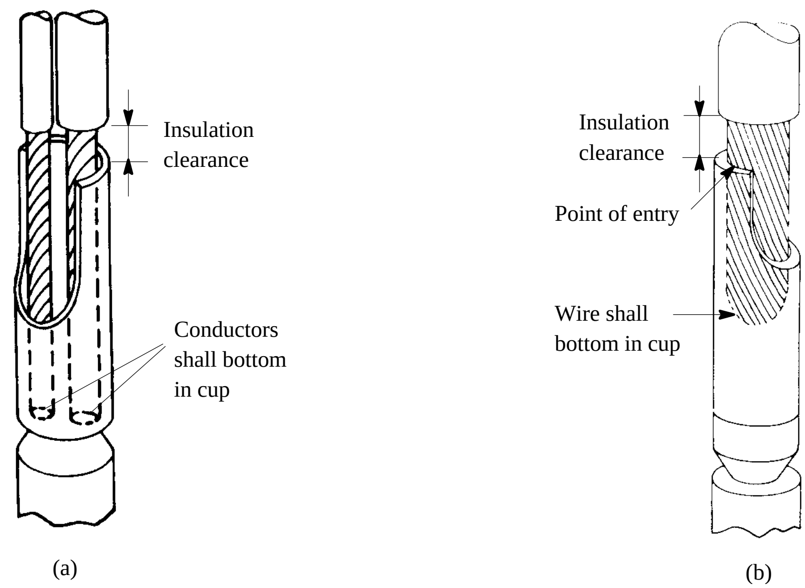


Figure 19: Connections to solder cups (connector type)

9.8 Insulation sleeving

a. Connections that are not protected by insulation grommets, potting, or conformal coating shall be protected by insulating sleeving.

Example Hook terminals, solder cups and bus wires.

b. Insulation sleeving shall be transparent and heat–shrinkable.

c. A component shall not move within the sleeving when the sleeving is mechanically supported.

d. Heat shrinking of the sleeve shall not damage the assembly.

9.9 Wire and cable interconnections

9.9.1 General

a. Interconnection methods shall not use fluxed solder preforms within heat-shrinkable sleeves.

b. Soldered wire interconnection methods shall enable the removal of flux and flux residue.

c. Soldered wire interconnection methods shall enable visual inspection of the interconnection and surrounding materials.

d. After soldering, conductors shall be covered with heat–shrinkable sleeving.

e. Fluorocarbon sleeves shall not be used.

NOTE Fluorocarbon sleeves have high shrinkage temperatures that can damage or reflow soldered connections.

9.9.2 Preparation of wires

a. Wire insulation shall be removed using insulation strippers in accordance with subclause 5.6.6.

b. Wire insulation clearances shall be in accordance with subclause 7.2.1.4.

9.9.3 Preparation of shielded wires and cables

a. The area of exposed shield shall be either:

1. at the end of the wire or cable (end termination),or
2. at any position along the length of a wire or cable (centre splice).

b. The insulation jacket shall be removed for:

1. a minimum length of 5 mm.
2. a maximum length of 12 mm.

c. The insulation jacket shall be scored and removed using a sharp cutting tool.

Example A scalpel.

d. The preparation process shall not damage the exposed shield material in accordance with subclauses 7.2.1.2 and 7.2.1.3.

e. The shield material shall be of good solderability.

f. The shield material shall not be pretinned.

g. The shield material shall be cleaned using a solvent in subclause 6.4.

9.9.4 Pre–assembly

9.9.4.1 Heat-shrinkable sleeving

a. The heat–shrinkable sleeving shall provide electrical insulation and mechanical support to the finished interconnection.

b. The sleeving shall be cut to a length that covers the finished soldered joint and extends over the remaining insulation of each conductor for a distance of 5 mm ± 2 mm.

c. The cut sleeving shall be threaded over one of the wires to be joined.

9.9.4.2 Conductors

a. Conductors shall be secured to prevent disturbance during soldering and solidification using one, or a combination of, the following methods:

1. A holding fixture that clamps the wires ensuring correct alignment.
2. A strand of binding wire as shown in Figure 20 (a).

Example Bare, tinned-copper wire.

3. Rings of heat–shrinkable sleeving positioned over the ends of the wire insulations, see Figure 20 (b) and (c).
4. A twist-splice around the braid, see Figure 20 (c).

b. The conductors to be joined shall lie parallel and in contact.

c. Conductors may be preformed when the cable insulation prevents a parallel lay.

d. Bending tools for the preforming of conductors shall be in accordance with subclause 5.6.4.

e. Wires shall be spliced using lap joints.

f. For shield terminations, the conductor of the grounding wire shall be positioned on the exposed shield.

g. Insulation overlap shall not be greater than the diameter of the largest conductor of the interconnection.

9.9.5 Soldering procedures

a. The soldering iron shall be selected in accordance with subclause 5.6.8.

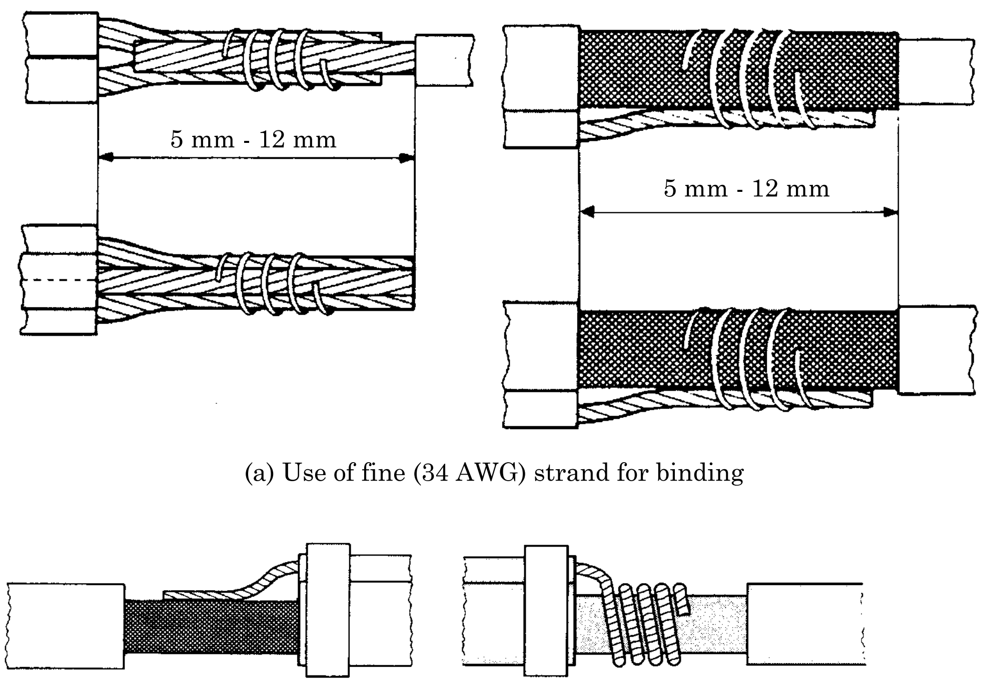
b. The solder alloy shall be in accordance with subclause 6.2.

c. The flux shall be in accordance with subclause 6.3.

d. Soldering aids shall be used to restrict wicking of flux or solder under the insulation in accordance with subclause 5.6.9.

e. After solder solidification, the contour of each wire conductor shall be visible.

f. After solder solidification, adjacent conductors shall be connected by concave solder fillets.



(a) Use of fine (34 AWG) strand for binding

(b) Securing with shrink sleeving

(c) Twisted wire around braid

Figure 20: Methods for securing wires

9.9.6 Cleaning

The removal of flux and residues shall be in accordance with Clause 11.

9.9.7 Inspection

Interconnections shall be inspected in accordance with Clause 12.

9.9.8 Workmanship

a. Joints shall have a smooth, bright appearance.

b. The workmanship of solder joints shall be in accordance with Clause 16.

NOTE The configurations in Clause 16 can be applied to similar interconnections.

9.9.9 Sleeving of interconnections

a. The heat–shrinkable insulation sleeving (see subclause 9.9.4.1) shall be centred over the cleaned and inspected interconnection.

b. The sleeving shall be shrunk using heated gas or radiant energy.

c. Heat shall not be applied for more than 8 seconds.

d. The heat-shrinking temperature shall not be exceed 140 ºC.

9.10 Connection of stranded wires to PCBs

a. Stranded wires shall be soldered to PCB terminations using lap joints or plated–through holes in accordance with Figure 21 (a), (b) and (c).

b. The dimensions shown in Figure 21 shall be in accordance with Table 5.

c. Stress relief shall be provided.

d. For PTFE-insulated wire, the minimum distance between the insulation and the solder fillet shall be 1 mm.

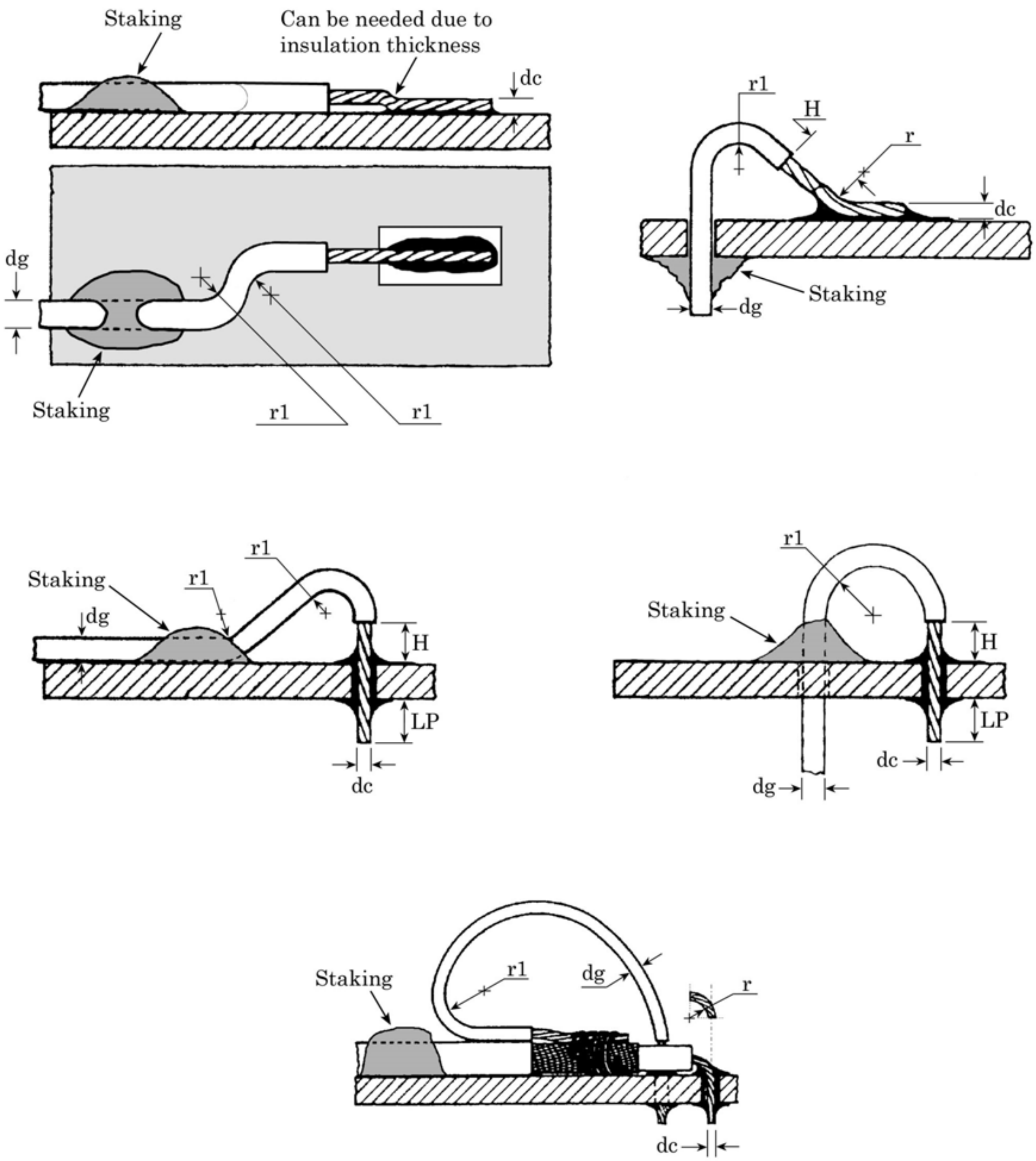


Figure 21: Connection of stranded wires to PCBs

Table 5: Dimensions for Figure 20

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

10
Soldering to terminals and PCBs

10.1 General

10.1.1 Securing conductors

a. There shall be no relative motion between conductors and terminals during soldering or solder solidification.

b. Conductors shall not be temporarily constrained against spring–back force during solder solidification.

NOTE Residual stresses are produced in the lead material or solder joint.

10.1.2 Thermal shunts

Thermal shunts shall be used to protect thermally-sensitive components.

Example Conductors, insulation, components and previously soldered connections.

10.1.3 High–voltage connections

a. Soldered joints for corona suppression shall be performed in two stages with an intermediate inspection:

1. The first soldering stage shall produce a standard soldered connection in accordance with Clause 12.
2. This connection shall be inspected for compliance with subclause 12.2 and subclause 12.3.
3. The joint shall then have additional solder alloy added.
4. The second soldering stage shall produce a final joint, see Figure 22 (new fig from Carole Villette and Bill), having:
   (a) smooth convex fillets,
   (b) no discontinuities,
   (c) no severe changes in contour,
   (d) no sharp edges or points.

Figure 22: NEW FIGURE Carole Villette and Bill High voltage connections

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 terminals)

a. A concave fillet of solder shall be present between the terminal and the sides 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 workmanship shall be in accordance with subclause 16.6.

b. The solder shall form a fillet between the conductor and the cup entry slot.

c. The fillet shall follow the contour of the cup opening.

d. Solder spillage may be present on the outside surface of the solder cup provided that it does not interfere with the function or the assembly of the connector.

10.3 Solder application to PCBs

10.3.1 Solder coverage

a. The molten solder shall flow around the conductor and over the termination area.

b. Except for high–voltage connections, the quantity of solder shall be in accordance with Clause 16.

c. The solder for high–voltage connections shall be in accordance with subclause 10.1.3.

d. Solder shall not obscure the contour of the conductor at the end of the insulation.

10.3.2 Solder fillets

a. Solder fillets shall be in accordance with subclause 16.1 and subclause 16.2.

b. A conductor mounted as a lap termination shall have a heel fillet where it bends away from the pad.

c. On lap terminations where one side of a conductor 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.

d. The conductor shall have a fillet of solder to a minimum height of 1/2 the thickness (ribbon lead) or 1/2 the diameter (wire conductor).

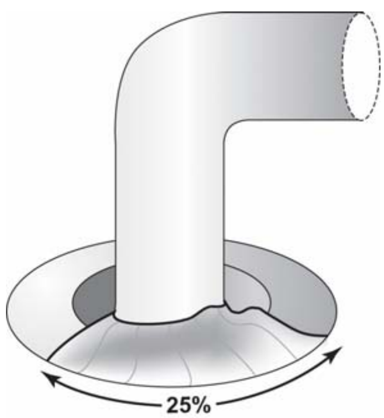
10.3.3 Soldering of component leads to plated–through holes

a. **Heat and solder side**: Solder fillets shall be in accordance with subclause 16.1 and subclause 16.2.

b. **Component side**:

1. The terminal pad shall show evidence of solder flow–through and bonding of the lead to the pad.
2. Absence of component-side pad wetting shall be acceptable when solder is visible in the plated-through hole, see Figure 23 (a).
3. The minimum circumferential wetting between the lead and the pad, where solder is not visible in the plated-through hole, shall be 25%, see Figure 23 (b).

a.



b.

Figure 23: Minimum acceptable wetting on component side

10.3.4 Solder application

a. Solder shall be applied only to the solder side of a plated–through hole.

b. The soldering iron bit shall be pretinned.

c. The heated soldering iron bit shall be applied to the joint.

d. Solder shall be introduced:

1. Initially at the junction of the soldering iron bit and the joint.

NOTE Liquid solder between the tip and the connection promotes heat transfer.

2. Once heat transfer has been achieved, only to the joint.

e. Additional heating:

1. Where the rate of heat loss from the joint is high, additional heat may be simultaneously applied to both sides of the plated–through hole.

Example High thermal masses or adjacent heat sinks.

2. This process shall not damage components or materials.
3. The process shall be documented.

10.4 Wicking

Soldering aids may be used to restrict the wicking of flux or solder under insulation in accordance with subclause 5.6.9.d.

10.5 Solder rework

a. Rework of soldered PCB assemblies shall be done in accordance with this standard.

b. A joint shall not be reworked more than three times.

c. For reworking the solder may be completely removed from the termination.

d. Tools and aids shall be in accordance with ECSS-Q-70-28A.

e. Any repairs or modifications shall be in accordance with ECSS-Q-70-28A.

11
Cleaning of PCB assemblies

11.1 General

a. When the solder has solidified and cooled, flux and residue shall be removed from soldered connections using a solvent in subclause 6.4.

b. Solvent shall be applied in such a manner that avoids its penetration under wire insulation and prevents its entry into the interior of parts.

c. Flux and residue shall be removed within a maximum period of 8 hours after soldering operations.

NOTE It is good practice to remove flux as soon as possible because even rosin fluxes are difficult to remove after longer ageing.

d. PCB assemblies shall not be immersed in cleaning solvents for more than 30 minutes.

NOTE Long immersion times can promote galvanic corrosion between adjacent metallic surfaces.

11.2 Ultrasonic cleaning

Ultrasonic cleaning shall not be used for PCBs populated with components.

11.3 Monitoring for cleanliness

11.3.1 Cleanliness testing

a. The effectiveness of the cleaning process employed for PCB assemblies (post–soldering) shall be tested using a sodium chloride (NaCl) equivalent ionic contamination test in accordance with subclause 11.3.4.

b. Cleanliness testing may be omitted for solder assemblies using only pure rosin (ROL0) fluxes, see subclause 7.3.1.

11.3.2 Testing frequency

a. For fluxes, other than pure rosin, cleanliness testing shall be done:

1. at maximum intervals of six months.
2. following a change in flux materials.
3. following a change in process parameters.

4. following actions affecting cleanability.

NOTE c. Statistical control methods can be used to control continuous solvent cleaning processes.

b. The supplier shall implement and maintain records of test results.

NOTE The records can aid early detection of a trend towards nonconformance.

c. When a test result is unacceptable, all PCB assemblies cleaned since the last successful test shall be subject to review by the Approval authority in accordance with ECSS-Q-20.

11.3.3 Test limits

The sodium chloride (NaCl) ionic contamination equivalence value shall be less than 1,56 $\mu g/cm^2$ of PCB surface area.

11.3.4 Test method

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

   1. Use a solution of 75 % isopropyl alcohol and 25 % deionized water for the sodium chloride (NaCl) equivalent ionic contamination test.
   2. Calibrate the equipment using a sodium chloride solution of known quantity and composition.

b. Testing shall be performed according to the equipment manufacturer's specification.

c. The cleanliness test values shall be as follows:

   1. Starting resistivity: greater than $20 \times 10^6\ \Omega$ cm.
   2. Ending value: less than 1,56 $\mu g/cm^2$.

12 Final inspection

12.1 General

a. Component mountings and soldered connections shall be visually inspected for compliance with subclause 12.2, subclause 12.3 and the workmanship standards of Clause 16.

b. Magnification between 4 times and 10 times shall be used for inspection.

c. Additional magnification may be used.

Example To aid the identification of suspected anomalies or defects.

d. Components and conductors shall not be physically disturbed during inspection.

12.2 Acceptance criteria

a. Solder connections shall have:

1. A clean, smooth and homogeneous satin to bright undisturbed surface.
2. Solder fillets between conductor and termination areas in accordance with subclause 16.1 and subclause 16.2.
3. For solder fillets of plated–through hole connections, the criteria in subclause 10.3.3 shall apply.
4. The wire contour visible (except for the final soldered joint of high–voltage connections) to confirm:
   (a) the presence of the wire,
   (b) the direction of the bend,
   (c) the position of the termination end of the wire.
5. High–voltage connections in accordance with subclause 10.1.3.
6. Complete wetting.

   NOTE Wetting exhibits a low contact angle between the solder and the joined surfaces.

7. An amount and distribution of solder in accordance with Clause 16.

8. Stress relief.

b. Acceptable solder connections shall not have any of the defects stated in subclause 12.3.

12.3 Rejection criteria

Solder connections shall not have any of the following defects:

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

b. Conductor pattern separation from PCB.

c. Burns on base materials.

d. Continuous discoloration between two conductors.

Example Measling, delamination, halo effect.

e. Incorrect amount of solder in accordance with Clause 16.

Example Peaks, icicles, bridging, excessive solder, insufficient solder.

f. Foreign matter on the circuitry, beneath components or on adjacent areas.

Example Flux residue, solder splatter, solder balls.

g. Dewetting.

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

i. Granular solder joints.

j. Disturbed solder joints.

k. Cracks or fractures.

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

m. Incorrect conductor length.

n. Incorrect direction of clinch or lap termination on a PCB.

o. Damaged conductor pattern.

p. Bare copper or base metal, excluding the end of cut wire or leads or edges of tracks and solder pads on substrates.

q. Soldered joints made to gold–plated terminals or gold-plated conductors using tin-lead solder.

r. Cold solder joints.

s. Component body embedded within the solder fillet.

t. Impaired stress relief.

13 Verification

13.1 General

a. Any soldering configuration not covered by this standard shall be verification tested in accordance with this Clause.

b. The supplier shall submit the verification programme to the Approval authority.

c. The verification programme shall be approved by the Approval authority.

b. Test specimens shall be tested in flight configurations.

Example Encapsulants, adhesives and conformal coatings declared for flight are present.

c. Verification testing shall comprise the following:

1. Vibration testing in accordance with subclause 13.3.

NOTE Vibration testing can be performed before or after thermal testing.

2. 200 thermal cycles in accordance with subclause 13.2

3. Final optical examination using a minimum of 15 times magnification.

e. There shall be no cracked solder joints or damaged parts.

13.2 Temperature cycling

a. The test specimen shall be temperature cycled in an air circulating oven.

b. The temperature cycle shall be as follows:

1. Room temperature to –55 °C.
2. –55 °C to +100 °C.
3. +100 °C to room temperature.

b. The rate of temperature change during the temperature cycle shall be less than 10 °C per minute.

c. The soak time at each temperature extreme shall be 15 minutes.

d. The temperature cycling test may be modified to meet particular mission requirements.

13.3 Vibration

a. The test specimen shall be vibration tested.

b. The test levels, frequencies and durations shall be derived from the system requirements.

c. The severity of the vibration testing shall not be inferior to that shown in Table 6.

d. 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 Hz to 70 Hz at 1,5 mm**
	Frequency range:	**70 Hz to 200 Hz at 15 g** **(70 Hz to 2000 Hz at 15 g for launch vehicles)**
	Sweep speed:	**1 octave per minute**
	Duration:	**1 cycle from 10 Hz to 2000 Hz to 10 Hz**
Random vibration	**Frequency range:**	**20 Hz to 200 Hz at 15 g r.m.s.** **(20 Hz to 2000 Hz at 15 g r.m.s. for launch vehicles)**
	Power spectral density:	**0,1 g^2 Hz^{-1}**
	Duration:	**10 minutes per axis**

14 Quality assurance

14.1 General

a. Quality assurance shall be in accordance with ECSS-Q-20B.

b. Clause 15 shall be integrated into the quality assurance plan and documentation.

14.2 Data

a. Quality records shall be retained for at least ten years, or in accordance with the project contract.

Example Travellers log, work orders.

b. Quality records shall contain as a minimum:

1. A copy of the final inspection documentation.
2. Nonconformance reports.
3. Records of corrective actions.
4. A copy of the reference of the procedures, tools, solders.
5. The name and batch number of the adhesive, coating and encapsulant used.
6. Inspection reports.
7. Identification of the operators and inspectors.

14.3 Nonconformance

Nonconformance in the soldering process shall be dispositioned in accordance with ECSS-Q-20-09B.

14.4 Calibration

a. Insulation strippers, soldering irons, measuring equipment and reference standards shall be calibrated.

b. A suspected or confirmed equipment failure shall be recorded as a project nonconformance.

NOTE The records can aid early detection of a trend towards nonconformance.

c. Defective or out of calibration equipment or tools shall be labelled or removed from work areas.

d. The Approval authority shall be notified of the nonconformance.

14.5 Traceability

ECSS-Q-20B, subclause 5.4 shall apply.

14.6 Workmanship standards

a. Visual standards shall be prepared.

b. The visual standards shall be available to each operator and inspector.

Example Satisfactory work samples or visual aids which illustrate the quality characteristics of all types of soldered connection involved in the task.

c. The workmanship standards in Clause 16 shall be included.

14.7 Inspection

a. During all stages of the process, the inspection points shall be implemented.

b. Inspection shall be in accordance with Clause 13.

14.8 Operator and inspector training and certification

a. Trained and certified personnel shall be employed for soldering operations and inspections.

b. A training programme shall be developed, maintained and implemented by the supplier to provide excellence of workmanship and personnel skill in manual soldering.

c. The training programme shall include procedures for the training, certification, maintenance of certified status, recertification and revocation of certified status for soldering and inspection personnel.

d. Trained personnel performing soldering operations and inspections shall be certified.

NOTE Certification is based on objective evidence of soldering quality, resulting from test and inspection of soldered joints.

e. Personnel shall be retrained or re–assessed in the following circumstances:

1. Repeated quality non-conformance.
2. Change in soldering techniques.
3. Change in soldering parameters.
4. Additional process skills

f. Records of the training, testing and certification status of soldering operators and inspection personnel shall be implemented and maintained.

NOTE The records are generally kept for a period of at least 10 years.

g. Operators performing hand soldering and inspectors shall be trained and certified at a school authorized by the Approval authority.