High-reliability soldering for surface-mount and mixed-technology printed-circuit boards

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ABSTRACT

The rigorous standards set by this specification ensure the high reliability of soldered electrical connections to surface mounted devices 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. Acceptance and rejection criteria are stated and some workmanship standards are included to permit discrimination between proper and improper work.
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SECTION 1: SCOPE

This specification defines the technical requirements and Quality Assurance provisions for the manufacture of high reliability electronic circuits based on Surface Mounted Device* (SMD) and Mixed Technology, intended for use in ESA spacecraft and associated equipment.

This specification does not cover SMD technology in connection with Micro-strip or Stripline Circuit boards for microwave applications.

The printed circuit board substrates covered by this document are placed into five classes in accordance with their average X and Y coefficient of thermal expansion (CTE).

It is the responsibility of the contractor to demonstrate verification for each combination of laminate class, SMD type and the soldering technique employed to assure the necessary environmental survival capability.

**"Component" or "part" is acceptable alternative terminology for "device".**
SECTION 2: GENERAL

2.1 INTRODUCTION

This specification prescribes requirements for electrical connections of leadless and leaded surface mounted devices (SMD) on ESA spacecraft and associated equipment, utilising a range of printed circuit board assemblies and employing solder as the interconnection media.

2.2 PRINCIPLES OF RELIABLE SOLDERED CONNECTIONS

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

(b) The basic design concepts to ensure reliable connections and to avoid solder joint failure are as follows:
- Stress relief shall be inherent in the design, so that detrimental thermal and mechanical stresses on the solder connections are avoided.
- Where adequate stress relief is not possible, a method of solder joint reinforcement is necessary.
- Materials shall be so selected that the mismatch of thermal expansion coefficients is at a minimum at the constraint points in the device mounting configuration.
- The design shall permit ready inspection of soldered connections.

2.3 PREREQUISITES

(a) Each contractor is responsible for maintaining a documented soldering programme which meets the requirement of this specification for the types of soldered connections employed in the articles involved. The soldering programme shall include procedures for training, certification, maintenance of certified status, recertification and revocation of certified status for soldering and inspection personnel.

The contractor shall also prepare and have readily available workmanship standards consisting of satisfactory work samples or visual aids which clearly illustrate the quality characteristics for all soldered connections involved. Also, the applicable illustrations in this specification, supplemented as necessary, shall be utilised for visual standards.
(b) Records shall be kept to provide identification of the finished product and the relevant operator. Records of the training, testing and certification status of soldering operators shall also be maintained. Records shall be retained for at least one year, or longer if this is a specific ESA project requirement.

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

(d) For soldering requirements not covered in this document, the contractor shall submit a process procedure including all pertinent quality requirements to the relevant ESA Project office for approval in accordance with ESA PSS-01-70 and ESA PSS-01-700.

(e) The methods of preparing and assembling the devices to be joined by soldering, and the selection and use of tools shall conform to this specification.

(f) Devices, terminals and conductors shall be mounted and supported as prescribed herein. These requirements apply to assemblies designed to be stored and operated within the temperature limits of -55 °C and +80 °C. More extreme temperatures or other unusual environmental applications will require special design measures and verification/qualification testing to ensure the necessary environmental survival capability. Special thermal heat sinks must be applied to devices having high junction temperatures (e.g. 125 °C) in order to ensure that solder joints do not exceed 80°C.

(g) Solder joint configurations not shown in this document shall be verification tested (See Section 10) by means of fully representative samples, before acceptance by ESA for flight equipment.
2.4 APPLICABLE DOCUMENTS

The following documents are applicable to the extent specified herein:

ESA PSS-01-20  Quality Assurance Requirements for ESA Space Systems
ESA PSS-01-70  Material and Process Selection and Quality Control for ESA Space Systems and Associated Equipment
ESA PSS-01-201 Contamination and Cleanliness Control
ESA PSS-01-605 The Capability Approval Programme for Thin Film Hybrid Microcircuits
ESA PSS-01-606 The Capability Approval Programme for Hermetic Thick-Film Hybrid Microcircuits
ESA PSS-01-608 Generic Specification for Hybrid Microcircuits
ESA PSS-01-610 Design Guidelines for Thin Film Hybrid Microcircuits
ESA PSS-01-700 The Technical Reporting and Approval Procedure for Materials and Processes
ESA PSS-01-702 A Thermal Vacuum Test for the Screening of Space Materials
ESA PSS-01-707 The Evaluation and Approval of Automatic Machine Wave Soldering for ESA Spacecraft Hardware
ESA PSS-01-708 The Manual Soldering of High-reliability Electrical Connections
ESA PSS-01-710 The Qualification and Procurement of Two Sided Printed Circuit Boards (Gold Plated or Tin-Lead Finish).
ESA PSS-01-728 The Repair and Modification of Printed-circuit Boards and Solder Joints for Space Use.

US Federal Specification defining the composition of:

LL-R-626 Rosin, Gum, Wood and Tall Oil
SECTION 3: PREPARATORY CONDITIONS

3.1 FACILITY CLEANLINESS

(a) Unless classified as a clean room (ESA PSS-01-201), the area in which SMD soldering is to be carried out shall be maintained in a neat orderly fashion with no loose material (dirt, dust, solder particles, oils, clipped wires etc.) that can cause contamination of the soldered connection. Furniture shall be kept to a minimum in the work areas and be arranged to allow easy and thorough cleaning of the floor. Outside and recirculated air shall be filtered to remove dust particles; the filters shall have a minimum arrestance of 65%.

(b) A washroom and eating, drinking and smoking facilities should be located close to, but outside, the soldering areas.

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

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

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

(f) Handling and storage of electronic devices etc. shall be in accordance with Sections 5.3 and 5.4 of this specification.

3.2 ENVIRONMENTAL CONDITIONS

ESA PSS-01-708, Section 3.2 applies.

3.2.1 Vapour Control

Areas used for cleaning parts and areas where toxic or volatile vapours are generated or released shall include a local exhaust system for removing air contaminants. As a minimum, the exhaust unit used shall be in accordance with the recommendations or guidelines of National Vapour Controls or National Health and Safety Controls.

3.3 PRECAUTIONS AGAINST STATIC CHARGES

ESA PSS-01-708, Section 3.3 applies.
3.4 LIGHTING REQUIREMENTS

ESA PSS-01-708, Section 3.4 applies.

3.5 EQUIPMENT AND TOOLS

3.5.1 Brushes

ESA PSS-01-708, Section 3.5.1 applies.

3.5.2 Pliers

ESA PSS-01-708, Section 3.5.3 applies.

3.5.3 Bending Tools

ESA PSS-01-708, Section 3.5.4 applies.

3.5.4 Clinching Tools

ESA PSS-01-708, Section 3.5.5 applies.

3.5.5 Insulation Strippers

ESA PSS-01-708, Section 3.5.6 applies.

3.5.6 Soldering Equipment

Soldering irons, soldering machines and systems and associated process equipment (including fluxers, preheaters, solder pots, cleaning systems, and cleanliness test equipment) shall be of a type that does not inject electrical energy to the item being processed to the extent that the functional integrity of the item is compromised.

Resistance between items processed and ground shall be no greater than 2 ohms measured between the tip of the hot soldering iron and the carrier of any soldering or cleaning equipment.

Potential differences between ground and items being processed, and between ground and the tip of the hot soldering iron, shall be no greater than 2mV RMS.
3.5.7 Soldering Irons and Resistance Soldering Equipment

(a) Selection of soldering irons. The size and shape of the soldering iron and bit shall permit soldering with maximum ease and control without causing damage to adjacent areas or connections. Temperature-controlled irons are required and they shall be calibrated at regular intervals. The tip shape, such as spade, chisel or pyramid, should be appropriate for the workpiece and an assortment of spare bits shall be maintained. The soldering iron or resistance-heated electrode shall heat the joint area to the solder liquidus temperature within 2 seconds and maintain proper soldering temperature at the joint throughout the soldering operation. For normal soldering of electronic devices a soldering-bit temperature of 280°C is recommended, but it shall in no instance exceed 320°C.

Soldering equipment shall not produce magnetic fields that induce detrimental electrical energy in the item being soldered.

NOTE: The use of solder guns is forbidden. Transformer-type soldering irons are acceptable provided that the transformer is screened and situated at least 0.5 metres from the work.

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

(c) Soldering iron tips. Soldering iron tips shall have a surface metal that prevents degradation of the tip in molten solder. The tip base metals and plating may be, but are not limited to, commercially-pure copper, tellurium copper, or lead copper plated with nickel or other platings. A soldering iron tip shall be deemed unusable when the plating degrades to a point where leaching of the base metal affects the solder joint.

3.5.8 Noncontact Heat Sources

ESA PSS-01-708, Section 3.5.8 applies.

3.5.9 Soldering Tools

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

Thermal shunts (heat sinks) shall be used to protect heat sensitive components such as semiconductors, transistors, ceramic capacitors and insulation materials from heat damage while soldering.

Thermal shunts so utilised shall not damage the device being soldered.

3.5.11 Solder Pots and Baths

Solder pots shall be of the temperature controlled type, controlled within 5°C of the preselected temperature and be grounded.

3.6 SOLDERING MACHINES AND EQUIPMENT

Machines and equipment used to surface mount:

- leadless and leaded devices specifically designed for surface mounting
- components initially designed for insertion mounting

shall be of a type incorporating dynamic single or dual solder wave, or shall be of the solder reflow type.

Automatic wave soldering machines shall meet the requirements of ESA PSS-01-707.

For other types of machine:

- the system shall not produce electrostatic discharges which would damage devices or assemblies,
- the suitability of device types to withstand the rigours of the soldering method must be established with a qualification programme.

3.6.1 Dynamic Wave-solder Machines

Dynamic soldering machines shall be of the automatic type and of a design offering the following:

(a) The capability of preheating the printed circuit board assembly to within a delta temperature difference of 100°C at the board surface which is to be in contact with the wave prior to contact with molten solder.
(b) The capacity to maintain the solder temperature at the printed circuit board assembly to within 5°C of the established bath temperature throughout the duration of any continuous soldering run when measured 3.0 mm below the surface of the wave.

(c) A wave system which limits shadowing and promotes proper filleting of all connections; e.g. dual, turbulent, vibrative wave systems etc.

(d) A method to limit the occurrence of bridging.

(e) Carriers to be made of such materials and have such a design configuration that they shall in no way contaminate, degrade or otherwise damage the printed circuit board or substrate, nor shall they transmit vibration or shock stress from the conveyors to a degree permitting physical, functional or electrostatic damage to devices, board or substrate during transport through preheating, soldering and cooling stages.

(f) An exhaust system, either integral or separate, adequate to conform to the requirements of Section 3.2.

### 3.6.2 Condensation Reflow Systems

Condensation reflow systems (which may include offline preheat systems, inline preheaters and part handling equipment) shall conform to the following requirements:

(a) The system shall not produce excessive movement or vibration into the assemblies being soldered such that any part misalignment or unacceptable solder joints result.

(b) The system shall be capable of preheating an assembly with solder paste to between 70 and 100°C prior to soldering.

(c) The system shall be capable of using a reflow fluid whose boiling point is a minimum of 12°C above the melting point of the solder being used.

(d) The system shall be capable of maintaining the preselected temperature to within ± 6°C in the reflow zone during soldering.

(e) The system shall include a ventilation system which complies with Section 3.2.
3.6.3 Hot Gas Reflow Systems

Hot gas reflow systems (which may include offline preheaters and part handling equipment) shall meet the following requirements:

(a) The system shall not produce excessive movement or vibration in the assemblies being soldered such that part misalignment or unacceptable solder joints result.

(b) The system shall be capable of preheating the area of the assembly to be soldered to between 70 and 100°C prior to soldering.

(c) The system shall be capable of heating the area of the assembly to be soldered to a preselected temperature between 260 and 320°C as measured on the laminated surface. The system shall be capable of preventing reflow of adjacent components.

(d) The system shall be capable of maintaining the preselected reflow temperature within ±6 °C as measured at the surface of the laminate or substrate.

3.6.4 Shorted Bar and Parallel Gap Resistance Reflow Equipment

Resistance reflow equipment shall be of a design that meets the following requirements:

(a) The system shall not impart mechanical damage to the component leads.

(b) The system shall provide "time at temperature" control type of power supply.

(c) The system shall be capable of maintaining the shorted bar or component lead to a preselected temperature that is a minimum of 12°C above the melting point of the solder being used.

(d) The system shall provide the capacity to maintain the dwell time at temperature to within 5% of the preset value.

(e) The system shall provide a repeatable thermode down force to within 15% of the preset value.
(f) The system shall provide an optical feature or other equivalent system to assure the shorted bar or electrode alignment with the component lead foot is within 20% of the nominal lead foot length.

3.6.5 Convection/Radiation Reflow Systems

Convection/radiation reflow systems (which may include offline preheat systems, inline preheaters and part handling equipment) shall conform to the following requirements:

(a) The system shall be mechanised to provide a temperature transition and shall not produce movement or vibration into the assembly being soldered such that part misalignment or unacceptable solder joints are produced.

(b) The system shall be capable of preheating an assembly with solder paste to between 70 and 100 °C prior to soldering.

(c) The system shall be capable of heating the area of the assembly to be soldered using focussed or unfocussed energy as appropriate, to a preselected temperature that is a minimum of 12 °C above the melting point of the solder being used as measured at the surface of the laminate or substrate.

(d) The system shall be capable of maintaining the preselected temperature to within 6 °C in the reflow zone during soldering.

3.6.6 Other Equipment for Reflow Soldering

When approved, other solder reflow systems shall be acceptable for use provided that as a minimum they provide the same degree of control as systems already approved and described in the previous sections of this standard.

3.7 ANCILLARY EQUIPMENT

The placement of equipment shall in no way generate, induce or transmit detrimental electrostatic charges to devices being placed.
3.7.1 Solder Deposition Equipment

Equipment used to deposit solder pastes may be of a screening, stencilling, dispensing, roller coating or dotting type. The equipment shall be capable of applying pastes of a viscosity and quantity satisfactorily to retain the positioned device to the board before and during soldering operations, to ensure accurate/uniform coverage, self-centering and solder filleting.

The equipment used to apply solder preforms shall be capable of assuring accurate/uniform positioning or alignment of the preform with the land or device lead/termination as appropriate.

3.7.2 Automatic Device Placement Equipment

Automatic or computer controlled equipment used for device placement may be of the co-ordinate-driven pick-and-place type or of the robotics type.

The placement equipment used shall be of a type that prevents device or board damage, properly indexes devices with respect to the circuit array and aligns the device leads or castellations with the board terminal areas.

3.7.3 Cleaning Equipment and Systems

Equipment and systems to clean solder connections of surface mounted devices and assemblies incorporating surface mount devices may be of the manual or automated multiple zone types that is:

(a) a vapour degreasing type designed to accommodate the particular solvent to be used,

(b) an aqueous system which may be combined to include neutralisers, surfactants, saponifiers and sequestering agents that will dissolve multivalent ions,

(c) a combination of the two systems.

Mechanisms used to transport units from one zone to another or throughout the system shall be of a material and configuration that precludes contamination, degradation or other damage to the unit or device.
3.7.4 Cleanliness Testing Equipment

Equipment used for cleanliness testing shall be of a type which measures the resistivity/conductivity of a test solution (a mixture of 75 ± 1% propan-2-ol and 25 ± 1% deionised water) in which contaminants from the surface of the test specimen are dissolved. Such equipment shall be of a type readily calibrated to a standard solution. See also Section 4.2.6.

The range of measurement (dynamic range) of such equipment shall be up to a maximum of 20 MΩ/cm (or equivalent conductivity if referenced to micrograms of sodium chloride) per 0.645 mm² of specimen surface.

Allowable contamination of assemblies shall be less than 1.6 μg/cm² ionisable flux residues.

3.7.5 Magnification Aids

For inspection requirements other than for solder connections, magnification aids referred to in this document shall have a power between 2X and 4X.

To inspect solder joints, magnification aids shall have a power of 4X as a minimum and, for land widths less than 0.63 mm and for observation of suspected anomalies or defects, a higher power shall be used as necessary. The magnification to be used for inspection shall be specified on the assembly drawing.

For inspection of solder connections, magnification aids of a type that permits simultaneous viewing with both eyes are preferred; however, single eye viewing devices shall be acceptable.

Fixed power single-eyed devices, when used, shall have an eye to object distance not less than 57 mm and an object to lens working distance not less than 55% of the focal length of the magnifier.

Magnification aids shall:

(a) utilize a light source designed to provide shadowless illumination by emitting light from several points distributed around the perimeter of the viewed area,
(b) provide a field of view suitable to permit inspection of any one solder connection in its entirety but shall in no instance be less than ±10 degrees apparent field of view angle from the centre of the field of view as seen by the observer,

(c) utilise optical elements which not only render true colour and proportional dimensions but also provide resolution characteristics permitting the viewer to clearly discriminate 68 line pairs per millimetre at 10 power magnification to 25 line pairs per millimetre at 4 power magnification in the centre 10% of the field of view.
SECTION 4: MATERIALS SELECTION

4.1 SOLDER

4.1.1 Form
Only alloys produced from virgin metals may be used. Solder paste, ribbon, wire and preforms may be used provided that the alloy and flux meet the requirements of this specification. Alloy for use in solder baths shall be supplied as ingots (without flux).

4.1.2 Composition
See Table 4.1.

4.1.3 Melting Temperatures and Choice
See Table 4.2.

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<td></td>
</tr>
<tr>
<td>96 tin silver</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>70 indium lead</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>50 indium lead</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>10 tin lead</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>


### TABLE 4.2 Guide for choice of solder types

<table>
<thead>
<tr>
<th>Solder type</th>
<th>Solidus (°C)</th>
<th>Liquidus (°C)</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>63 tin solder</td>
<td>183</td>
<td>183</td>
<td>Soldering printed circuit boards where temperature limitations are critical and in applications where an extremely short melting range is required. Preferred solder for surface mounted devices.</td>
</tr>
<tr>
<td>(eutectic)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>62 tin silver</td>
<td>175</td>
<td>189</td>
<td>Soldering of components having a silver-plate or silver metallisation (i.e. ceramic capacitors without barrier layer). This solder composition is saturated with silver and prevents the scavenging of silver surfaces.</td>
</tr>
<tr>
<td>loaded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 tin solder</td>
<td>183</td>
<td>188</td>
<td>Soldering electrical wire/cable harnesses or terminal connections and for coating or pretinning metals.</td>
</tr>
<tr>
<td>96 tin silver</td>
<td>221</td>
<td>221</td>
<td>May be used for special applications such as soldering terminal posts.</td>
</tr>
<tr>
<td>(eutectic)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70 indium lead</td>
<td>160</td>
<td>174</td>
<td>Recommended for use when soldering gold and gold plated finishes when impractical to degold. This solder has a low gold leaching characteristic.</td>
</tr>
<tr>
<td>50 indium lead</td>
<td>180</td>
<td>209</td>
<td></td>
</tr>
<tr>
<td>10 tin lead</td>
<td>268</td>
<td>290</td>
<td>Recommended for use in step-soldering operations where the initial soldered joint must not be reflowed on making the second joint (see Note).</td>
</tr>
</tbody>
</table>

**NOTE:** For step soldering using this solder, it is permissible to exceed the 320 °C maximum soldering bit temperature (refer to paragraph 3.5.7 (a)). However, this temperature should in no circumstances exceed 345 °C.

#### 4.1.4 Solder Paste

Solder paste shall conform to the requirements of this standard and shall be of composition 63 tin solder except that, when specified on the assembly drawing, the paste composition shall be 96 tin-silver for high temperature step soldering applications. The metal purity shall be as required in Table 4.1. The powder mesh size and flux percentage shall be suitable for the process employed, i.e. screen, stencil or needle application.
Alternative solder alloys, as shown in Table 4.2 may be permitted but they shall have the composition defined in Table 4.1 and must be individually approved by means of the project Declared Materials List (ESA PSS-01-700).

4.1.5 Maintenance of Paste Purity

When purchased pre-mixed or mixed in house, the purity of solder paste shall be maintained as defined:

(a) Unopened containers of solder paste purchased pre-mixed shall be stored in the manner and at the temperature recommended by the paste manufacturers.

(b) Before use, if refrigerated, solder paste shall be permitted to warm to room temperature in the unopened container.

(c) Neither paste purchased pre-mixed nor paste mixed in-house shall be utilised if the use-by date or shelf life recommended by the manufacturer of the paste or paste constituents has expired.

(d) Tools used for removing solder paste from the container shall not contaminate the paste dispensed or that remaining within.

4.2 FLUX

4.2.1 Rosin Based Fluxes

ESA PSS-01-708, Section 4.2.1 applies.

4.2.2 Corrosive Acid Fluxes

ESA PSS-01-708, Section 4.2.2 applies.

4.2.3 Flux Controls for Multi-programme Equipment

Controls shall be established and maintained for soldering machines and associated solder related processing equipment used alternatively for assembly to the requirements of this standard and the requirements of commercial, industrial or military contracts which authorise flux other than that permitted by this standard. The controls shall prevent intermixing or blending of any non-authorised flux with any specified in this standard.

Before fabrication to the requirements of this standard, the flux used in, or in conjunction with, processing equipment and the residues of vaporised flux shall be removed from the equipment. The equipment shall be cleaned and the equipment cleanliness verified prior to refilling with the approved flux.

Records shall be maintained and shall, as appropriate, identify or provide:
(a) the type of flux used in or with the equipment prior to use for assembly to the requirements of this standard,
(b) the date of flux removal,
(c) data verifying cleanliness of the equipment,
(d) the date of cleanliness verification,
(e) type of flux substituted for that removed,
(f) the date the new flux was added to the machine.

Records shall include a signature or initials of the individual performing each of the described actions and shall be available for audit by the ESA representative as required.

4.2.4 Removal of Flux Residue
ESA PSS-01-708, Section 9.1 applies.

4.2.5 Monitoring
ESA PSS-01-708, Section 9.3 applies. See also Section 3.7.4 of this specification.

4.3 SOLVENTS

4.3.1 Acceptable Solvents
The solvents which may be used for the removal of grease, oil, dirt, flux and flux residues shall be nonconductive and noncorrosive, and shall not dissolve or degrade the quality of parts or materials or remove their identification markings. Solvents shall be properly labelled and maintained in a clean and uncontaminated condition.

Those showing evidence of contamination or decomposition shall not be used.

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

The following solvents are acceptable when properly used for cleaning in soldering operations:

- Ethanol, 99.5% or 95% pure by volume.
- Propan-2-ol, best commercial grade, 99% pure.
- Any mixtures of the above.
- Deionised water at 40 °C maximum may be used for certain fluxes. Items used shall be thoroughly dried directly after the use of deionised water.
- Trichloroethane.

4.3.2 Cleaning
ESA PSS-01-708, Section 4.3.2 applies.
4.4 FLEXIBLE INSULATION MATERIALS

ESA PSS-01-708, Section 4.4 applies.

4.5 TERMINALS

ESA PSS-01-708, Section 4.5 applies.

4.5.1 Preferred Terminals

ESA PSS-01-708, Section 4.5.1 applies.

4.5.2 Tin-, Silver- and Gold-Plated Terminals

ESA PSS-01-708, Section 4.5.2 applies.

4.5.3 Shape of Terminals

ESA PSS-01-708, Section 4.5.3 applies.

4.6 WIRES

ESA PSS-01-708, Section 4.6 applies.

4.7 PRINTED CIRCUIT SUBSTRATES

Printed circuit boards and substrates described in this standard shall be selected from the classes given in Table 4.3.

TABLE 4.3 Classes of circuit board and substrates

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>CTE, ppm/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-compensated printed board</td>
<td>&gt; 13</td>
</tr>
<tr>
<td>2</td>
<td>Ceramic</td>
<td>5 - 7</td>
</tr>
<tr>
<td>3</td>
<td>Compensated printed board</td>
<td>11 - 13</td>
</tr>
<tr>
<td>4</td>
<td>Compensated printed board</td>
<td>9 - 11</td>
</tr>
<tr>
<td>5</td>
<td>Compensated printed board</td>
<td>5 - 9</td>
</tr>
</tbody>
</table>
The operational characteristics shall be evaluated based on the service life of the equipment.

The class of board selected should have a CTE characteristic compatible with the CTE of the devices which are to be mounted on it. The structure on which devices are mounted must compensate for the CTE mismatch to the largest degree possible so that the impact of stresses from the environment is minimised. Annex D shall be consulted for CTE match between device types and substrate classes for a qualification temperature range (delta-t) of -55 °C to +100 °C. The table in Annex D will be expanded in later issues of this document as more devices are evaluated for the space environment.

4.7.1 Class 1 - Non-compensated Printed Circuit Board
Boards shall be made from materials according to, and shall be manufactured to, the requirements of ESA PSS-01-710.

4.7.2 Class 2 - Ceramic Substrates
Thick-film hybrid microcircuits shall meet the requirements of ESA PSS-01-606 and ESA PSS-01-608.

Thin-film hybrid microcircuits shall meet the requirements of ESA PSS-01-605 and ESA PSS-01-610.

4.7.3 Class 3 - Compensated Printed Circuit Board
CTE compensated boards shall use standard resins in accordance with ESA PSS-01-710.

These boards may be reinforced with low CTE fibres such as aramid, quartz or carbon and shall be approved prior to use on ESA projects.

The board characteristics shall have been evaluated in accordance with the requirements of ESA PSS-01-710.

4.7.4 Class 4 - Compensated Printed Circuit Board
CTE compensated boards shall use standard construction and be compensated with materials such as a distributed plane consisting of a low CTE material and shall be approved prior to use on ESA projects.

The board characteristics shall have been evaluated in accordance with the requirements of ESA PSS-01-710.

4.7.5 Class 5 - Compensated Printed Circuit Board
CTE compensated boards shall use standard construction with compensated materials such as low CTE substrate/cores and shall be approved prior to use on ESA projects.
The board characteristics shall have been evaluated in accordance with the requirements of ESA PSS-01-710.

4.8 COMPONENTS

Device leads and terminations shall be solder coated with a tin/lead alloy (see Table 4.2). Solder may be applied to the leads by hot dipping or by plating from a solution. Plated solder terminations shall be subjected to a post plating reflow operation to fuse the solder.

Solder finish applied over sintered-metal-on-ceramic terminations shall have a diffusion barrier layer between the metallisation and the solder finish. The barrier layer should be a nickel or an equivalent diffusion barrier.

Devices shall be capable of withstanding five cycles through a vapour phase reflow system operating at 215 °C. Each cycle shall consist of a minimum of 60 seconds exposure.

Devices must also be capable of withstanding a minimum of 10 seconds immersion in molten solder at 260 °C.

Devices must be capable of withstanding cleaning processes currently used in ESA Space Projects.

Annex D shall be consulted for device selection.

4.8.1 Active Devices
Transistors, thyristors, diodes, integrated circuit devices (including dual-in-line and leadless chip carrier devices) and other active devices shall be of a configuration incorporating sintered metal-on-ceramic terminations, solid-metal reflow termination pads integrated to the device body. Axial leads, wire or ribbon non-axial leads shall be hermetically sealed.

4.8.2 Passive Components
Resistors, capacitors, inductors, switches, transformers, chokes, connectors, and other passive components shall conform to the relevant ESA specification and specifications applicable for the type of component. They shall be of a style specifically designed for surface mounting or of a style that, although initially designed for insertion-mount application, can be surface-mount adapted to provide conformance with the requirements of this standard without functional or physical degradation of the component or the substrate to which the adapted component is to be attached.
Connectors shall be of a configuration incorporating either male or female quick-disconnect contacts, integral alignment provisions, provisions for appropriate mounting hardware, and stress relief provision for the soldered connection of each individual male or female contact when such connections are completed.

4.8.3 Special Finish Coatings
If the design of the assembly necessitates step-soldering as may be required for soldering one side of the assembly prior to soldering the second side at a lower temperature, or as may be required for one or more of the mixed technology processes, the first coating shall be 96 tin-silver or a tin-lead alloy conforming to SN10 rather than the SN60, SN62 or SN63 alloys specified. Table 4.2 refers.

4.9 ENCAPSULANTS, CONFORMAL COATINGS AND ADHESIVES

4.9.1 Encapsulants and Conformal Coatings
Encapsulants and conformal coatings shall be suitable for the application and shall be chemically, physically, environmentally and electrically compatible with the materials used. They shall conform to the outgassing requirements of ESA PSS-01-702.

The encapsulant and conformal coating materials shall not cause deterioration of materials used on the printed board assemblies or devices mounted or connected thereon. This must be demonstrated by means of a verification test programme according to Section 10.

Stress relief of device leads shall not be impeded by the improper selection and application of encapsulants and conformal coatings particularly at low service temperatures.

4.9.2 Adhesives
Adhesives should be readily dispensable, non-stringing, and have a reproducible dot profile after application. Adhesives must be non-corrosive to devices and printed circuit boards. The uncured strength shall be sufficient to hold devices during handling prior to cure. They shall conform to the outgassing requirements of ESA PSS-01-702.

The adhesives used shall be such that they shall have no adverse effects upon materials used on the substrate, or devices attached thereon. Adhesives shall be formulated from resins, elastomers, plasticisers, catalysts and other ingredients which meet the requirements of this standard.
Where appropriate, the dielectric properties such as dielectric constant and dissipation factor shall be considered.

Adhesives used under devices for thermal reasons, for achieving stand-off heights or mechanical support during vibration shall have their coefficient of expansion, glass transition temperature and modulus evaluated to ensure that the additional stress put on the solder joint does not degrade the solder joint reliability. This must be demonstrated by means of a verification test programme according to Section 10.
SECTION 5: PREPARATION FOR SOLDERING

5.1 PREPARATION OF DEVICES AND TERMINALS

5.1.1 Cleaning of Surfaces to be Soldered

All conducting surfaces to be soldered shall be clean before the soldering operation. Cleaning solvents are specified in Paragraph 4.3.1. Unauthorised abrasives, including pumice and emery paper, shall not be used for surface preparation.

Gold-plated metallisation and gold metallisation when present on ceramic substrates or devices, may require some form of mechanical abrasion to ensure a better de-golding action or solderability. In this case, brush cleaning with a trichloroethylene degreasing solution or a pumice impregnated eraser is acceptable.

THERE SHALL BE NO SOLDERING TO GOLD USING TIN-LEAD ALLOY SOLDER.

NOTE: Only indium-lead solder alloys shall be employed if soldering to gold is necessary for R.F. reasons.

5.1.2 Degolding and Pretinning of Conductors

ESA PSS-01-708, Section 5.1.6 (a) to (d) applies.

5.2 PREPARATION OF SOLDER BIT

ESA PSS-01-708, Section 5.2 applies.

5.3 HANDLING, WORK STATIONS

ESA PSS-01-708, Section 5.4 applies.

5.4 STORAGE, WORK STATIONS

ESA PSS-01-708, Sections 5.5.1 to 5.5.4 apply.

5.4.1 Storage Boxes and Bags

These must be made of materials which will not degrade the solderability of the components. Unacceptable materials are those that include silicones, sulphur and polysulphides.
SECTION 6: MOUNTING OF DEVICES

6.1 GENERAL REQUIREMENTS

ESA PSS-01-708, Sections 6.1.1 to 6.1.13 apply.

6.2 SURFACE MOUNT REQUIREMENTS

6.2.1 Mounting Devices

Planar mounted devices may be mounted on either or both sides of a printed circuit assembly. Devices to be mounted shall be designed for, and capable of withstanding, soldering temperatures associated with the particular process being used for fabrication of the assembly. When design restrictions require mounting devices incapable of withstanding soldering temperatures, these devices shall be mounted and hand soldered to the assembly as a separate operation or shall be processed using localised reflow technology approved for use.

6.2.2 Stress Relief

When Class 1 boards are employed (i.e. glass fibre epoxy resin with no CTE compensation) every individual device must incorporate some form of stress relief. This is no problem for axial leaded devices, flat-packs, leaded capacitors, etc. Leadless devices with end cap terminations, metallisations etc. must have some stress relief such as additional foil or wire leads, possibly attached by welding or high melting point solder.

Stand-off height will permit stress relief; in this situation, the CTE mismatch strain is taken up by the ductile solder.

NOTE: Only pure eutectic tin-lead solder or indium-lead solder is sufficiently ductile; solder alloys with additional elements such as silver, antimony, gold etc. do not comply.

All leadless devices that do not incorporate stress relief shall be individually selected to match the substrate. CTE compensated substrates/laminates of Classes 2-5 are listed in Table 4.3.

6.2.3 Mixed Technologies

On mixed technology printed circuit assemblies, through hole components shall be mounted on the upper side of the board only, in accordance with the requirements of ESA PSS-01-708.
Surface mounted devices mounted on the lower side and/or on the same side of the printed circuit assembly shall be capable of withstanding the soldering temperatures without electrical performance degradation and shall be bonded to the side of the board with an adhesive, compatible with both the board and device, covering no more than 25% of the bottom face of the device.

6.2.4 Registration of Devices and Pads

Devices shall be mounted on their associated terminal pads (lands). In no case shall misregistration between the device and the pad reduce the space between conductive elements below the minimum electrical spacing required.

6.2.5 Lead Forming

The leads of leaded surface mount devices shall be formed to their final configuration prior to mount. This forming shall in no way degrade the solderability or cause loss of plating adhesion to the leads, nor shall any mechanical damage to the leads or attachment seals occur. When bonded to the board surface the leads shall be free from compression loads. When required, the leads of dual-in-line and gull-wing packages, flat-packs and other multileaded devices shall be dressed to ensure alignment.

6.2.6 Mounting Devices in Solder Paste

Both leaded and leadless surface mounted devices may be mounted in solder paste for temporary device retention prior to reflow soldering. As a process check after device mount, the solder paste may extend beyond the edge of the pad less than 40% of the conductor separation. Once all applicable devices have been mounted in the solder paste, the solder paste shall be dried prior to reflow. The drying process may be either a passive air drying process or an active baking (oven or infra-red) drying process.

6.3 LEAD BENDING AND CUTTING REQUIREMENTS

ESA PSS-01-708, Section 6.2 applies.

6.4 MOUNTED DEVICES

6.4.1 Leadless Devices

Leadless devices, end capped chip resistors, end capped chip capacitors and similar leadless end capped discrete components used in miniature and standard assemblies shall be mounted in accordance with the following paragraphs:
(a) Devices shall be mounted only to printed circuit boards; the devices shall not be stacked nor shall they bridge spacing between other parts or components such as terminals or other properly mounted devices.

(b) The device shall be positioned such that it shall not overhang the terminal pad more than 10% of the device width. It is preferred that the device be positioned with no overhang. The minimum conductor spacing shall be maintained.

(c) The end cap of the device shall extend onto the terminal area a minimum of 0.13 mm.

(d) Mispositioning of devices shall not reduce the specified minimum spacing to adjacent printed wiring or other metallised elements.

(e) The device shall be mounted flat and parallel with the surface of the printed circuit board within 10 degrees.

(f) The space between the body of the soldered device and the terminal pads shall not be less than 0.1 mm and not exceed 0.4 mm.

Reference shall be made to the illustrations in Annex B.1 for mounting requirements.

6.4.2 End Capped Ceramic Devices

In addition to the requirements of Paragraphs 6.4.1 (a) to (f), leadless chip components of end cap configurations, as illustrated in Figure 6.1, shall be mounted only if the components are in accordance with the following paragraphs (a) to (h). If the chip component is secured to the printed circuit board using an adhesive bonding resin, the area of resin coverage shall be limited to 25% of the bonded surface of the chip after mounting.

(a) There shall be no discontinuities in the metallised terminal areas of leadless devices for reflow applications.

(b) Discontinuities in the metallised end caps shall not reduce the effective width (W) by more than 20% nor the area by more than 30%; see Figure 6.2.

(c) The body of the device shall not be cracked, scored, chipped, broken or otherwise damaged.
(d) Devices with electrical elements deposited on an external surface (such as resistors) shall be mounted with that surface facing away from the printed circuit board or substrate; see Figure 6.3.

(e) Solder shall cover and blend smoothly to the complete substrate land or terminal area and shall fillet to, and blend smoothly with, the metallised end cap. There shall be no pits, voids or other discontinuities in the solder fillet. Reference shall be made to the illustrations in Annex B.1 and visual standards in Annex C for acceptable solder fillet profiles.
(a) End face termination

(b) Three face termination

(c) Five face termination

Figure 6.1 End cap configurations of leadless chip components
Figure 6.2  Discontinuities in metallised end caps

Figure 6.3  Exposed elements
(f) There shall be no discernible discontinuities in the solder coverage of the terminal areas of devices of the reflow configuration. Solder shall not encase any nonmetallised portion of the body of the device following reflow.

(g) The appearance of the solder joint shall be smooth, non-porous, non-crystalline and shall have a finish which may vary from satin to bright. There shall be no discontinuities exceeding that permitted under sub-paragraph (b) of this paragraph, nor hairline fractures, cracks or dewetting.

(h) There shall be no visible evidence of contamination of the solder such as flux residue, grease, foreign material or discoloration.

6.4.3 Castellated Chip Carrier Devices

Castellated chip carrier devices shall be mounted in accordance with the following paragraphs (a) to (f).

(a) Devices shall be mounted only to printed circuit boards; the devices shall not be stacked nor shall they bridge spacing between other parts or components such as terminals or other properly mounted devices.

(b) The device shall be positioned such that the device shall not overhang the terminal area of the substrate width nor shall the device be skewed such that it overhangs the terminal area. The minimum conductor spacing shall be maintained.

(c) Mispositioning of devices shall not reduce the specified minimum spacing to adjacent printed wiring or other metallised elements.

(d) The device shall be mounted flat and parallel with the surface of the printed circuit board within 10 degrees.

(e) The space between the body of the soldered-in-place device and the terminal areas shall not exceed 0.4 mm and shall not be less than 0.1 mm.

(f) If the device is secured to the printed circuit board using an adhesive bonding resin, the area of resin coverage shall be limited to 25% of the bonded surface of the device after mounting, unless the material is being used for thermal management.

(g) There shall be no discontinuities in the metallised terminal areas on the mounting pattern of the device.
(h) Discontinuities in the metallised castellations shall not reduce the effective width (W) by more than 20% nor the area by more than 30%.

(i) The body of the device shall not be cracked, scored, chipped, broken or otherwise damaged.

Reference shall be made to Annex B.2 for acceptable solder fillet profiles.

6.4.4 Bottom Terminated Chip Carrier Devices, Reflow Configuration

Leadless chip components of the Reflow Configuration, as illustrated in Figure 6.4, shall be mounted only if the components are in accordance with Paragraph 6.4.2 (a) to (h). If the vertical dimension (V) is greater than the thickness dimension (T), then the Reflow Configuration chips shall not be used.

Reference shall be made to Annex B.3 for mounting requirements. Solder shall not overhang the pad and shall not bulge at the device body.

6.4.5 End Capped Discrete Axial Components (MEF's)

These components shall meet the requirements of Paragraph 6.4.2 (a) to (h).

Reference shall be made to the illustrations in Annex B.4 for mounting requirements.

6.4.6 Axial Leaded Components

Axial leaded (round, flattened or rectangular cross section) discrete components shall be planar mounted in accordance with the following:

(a) Planar mounting shall be utilised only if the component weighs less than 1.5 grams and is mounted parallel to the board surface.

(b) Components with axial leads of rectangular cross section shall be mounted in accordance with Section 6.4.8.

(c) It is preferred that the leads be in contact with the terminal area for the full length of the foot. Any separation between the foot and terminal area shall be limited to 10 degrees.

(d) The requirements of ESA PSS-01-708, Section 6.4.7.

(e) After soldering, the toe shall still be discernible and there shall be no solder overhang, of the terminal pad.
6.4.7 Non-axial Leaded Devices
Non-axial leaded devices with leads extending from more than a single surface, flat-packs, dual-in-line packages and similar devices shall be mounted with all leads seated on a terminal area.

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Figure 6.4 Leadless chip component of the reflow configuration (lower side)
6.4.8 Flatpacks and Quadpacks

Flatpacks, quadpacks and other ribbon multi-leaded devices shall be formed and terminated as required in the following paragraphs:

(a) The device shall be mounted flat on approved electrical insulation that has been firmly fixed to the circuit board such that moisture traps are precluded, or shall be spaced a minimum of 0.1 mm and a maximum of 0.7 mm from the board surface.

(b) Lead configuration and mounting of these devices shall be in accordance with ESA PSS-01-708, Section 6.2.3 and 6.4.7. Reference shall also be made to Annex B.5 (Ribbon, "L" and Gullwing Leads) and Annex B.6 ("J" and "V" Leads).

(c) Leads on opposite sides of planar mounted devices shall be formed such that device tilt is minimal and in no instance shall this cause a nonconformance with the maximum or minimum limits of the device.

(d) It is preferred that leads be seated in contact with the terminal area for the full length of the foot.

(e) Leads shall be formed such that they will meet the lead contact requirements without constraining prior to soldering.

6.4.9 TO Can Devices

TO type canned devices weighing more than 1.5 grams shall be bonded to the board or shall be retained to minimise shock and vibration loading on the device leads without reducing the existing device lead stress relief.

6.4.10 Tall Profile Devices

Devices taller than 12 mm in height shall be bonded or secured to the board to minimise shock and vibration loading on the part leads without reducing the existing lead stress relief.

6.4.11 Transformers

Devices weighing more than 1.5 grams shall be bonded or secured to the board to minimise shock and vibration loading on the leads without reducing the existing lead stress relief.
SECTION 7: PROCESS IDENTIFICATION DOCUMENT (P.I.D.) AND PRODUCTION CONTROL

7.1 P.I.D.

The purpose of the P.I.D. is to ensure that a precise reference is established for the assembly processes approved in accordance with this specification. The reference shall comprise the assembly design configuration, materials and components used in manufacture, all manufacturing processes and production controls, and completely define all inspection steps and methods for performing such inspections. This will ensure that all future assemblies supplied by the manufacturer will be identical to those for which approval was granted. The P.I.D. shall also provide a standard reference against which any anomalies occurring after the approval can be examined and resolved.

A copy of the P.I.D. shall be kept by ESA and treated as proprietary information.

7.2 P.I.D. Updating

A P.I.D. shall represent the current accepted manufacturing processes and production controls. Any intended modification of the P.I.D. or its applicable documents, together with any quality and reliability implications, shall be brought to the attention of ESA for review and approval before implementation. Such modifications shall require a re-issue of the P.I.D. and the relevant applicable documents.

7.3 Production Control

A Production Flow Chart shall identify all piece parts and all process, assembly, inspection and test operations applicable to production of the assembly. The points of application of quality controls shall be clearly indicated. The chart shall present these schematically in their correct sequence and, for each operation, make reference to the relevant identification, process, assembly or inspection document. The issue and data of documents applicable at the time of preparation of the flow chart shall be stated.
The following symbols are preferred for preparing the chart:

- for process and assembly operations

- for inspection and test operations

- for quality control operations
SECTION 8: SOLDERING TO TERMINALS AND PRINTED CIRCUIT BOARDS

8.1 GENERAL

8.1.1 Securing Conductors
ESA PSS-01-708, Section 8.1.1 applies.

8.1.2 Insulation Sleeve, Potting or Coating
ESA PSS-01-708, Section 8.1.2 applies.

8.1.3 Thermal Shunts
ESA PSS-01-708, Section 8.1.3 applies.

8.1.4 High Voltage Connections
ESA PSS-01-708, Section 8.1.4 applies.

8.2 SOLDER APPLICATION TO TERMINALS

8.2.1 Soldering of Swaged Terminals onto PCB's
ESA PSS-01-708, Section 8.2.1 applies.

8.2.2 Soldering of Conductors onto Terminals (except cup)
ESA PSS-01-708, Section 8.2.2 applies.

8.2.3 Soldering of Conductors onto Cup Terminals
ESA PSS-01-708, Section 8.2.3 applies.

8.3 SOLDER APPLICATION TO PCB

8.3.1 Solder Coverage
ESA PSS-01-708, Section 8.3.1 applies.

8.3.2 Solder Fillets
ESA PSS-01-708, Section 8.3.2 applies.

8.3.3 Soldering of Component Leads to Plated Through Holes
ESA PSS-01-708, Section 8.3.3 applies.

8.4 WICKING
ESA PSS-01-708, Section 8.4 applies.

8.5 SOLDER REWORK
ESA PSS-01-708, Section 8.5 applies.
SECTION 9: FINAL INSPECTION

9.1 GENERAL

Each soldered connection shall be visually inspected in accordance with the criteria specified in this Chapter. Inspection shall be aided by magnification appropriate to the size of the connections; see Section 3.7.5.

Parts and conductors shall not be physically disturbed to aid inspection.

Inspection standards for typical soldered connections are shown in Annex B and Annex C.

9.2 ACCEPTANCE CRITERIA

Acceptable solder connections will be characterised by:

(a) clean, smooth, bright undisturbed surface,

(b) solder fillets between conductor and termination areas being as described and illustrated herein,

(c) contour of wire being sufficiently visible to determine the presence of the wire, the direction of the bend and the termination end of the wire,

(d) complete wetting as evidenced by a low contact angle between the solder and the joined surfaces,

(e) proper amount and distribution of solder,

(f) absence of the defects mentioned in Section 9.3.

9.3 REJECTION CRITERIA

The following are some characteristics of unsatisfactory conditions, any of which is cause for rejection:

(a) charred, burned or melted insulation of parts,

(b) conductor pattern separation from circuit board,

(c) burns on base materials,

(d) discoloration which is continuous between two conductor patterns (e.g. measling, delamination, halo effect etc.).
(e) excessive solder (including peaks, icicles and bridging),

(f) flux residue, solder splatter, solder balling, or other foreign matter on circuitry, beneath components or adjacent areas,

(g) dewetting,

(h) insufficient solder,

(i) pits, holes or voids, or exposed base metal in the soldered connection,

(j) granular or disturbed solder joints,

(k) fractured or cracked solder connection,

(l) cut, nicked, gouged or scraped conductors or conductor pattern,

(m) improper conductor length or direction on circuit terminal area,

(n) damaged conductor pattern,

(o) bare copper or base metal,

(p) soldered joints made directly to gold-plated terminals or conductors using Tin/Lead solders.
SECTION 10: VERIFICATION

10.1 GENERAL

The manufacturer seeking ESA approval shall design surface mount verification samples using well-defined printed circuit board substrates (e.g. basic materials, number of layers, thickness etc). The range of surface mounted components shall be well-documented (e.g. Passive components: nature, types, sizes, termination finishes. Active components: type of package, sizes, number of I/O, pitch, termination finishes). Five verification samples shall be assembled according to the P.I.D. and Production Controls defined in Chapter 7.

The configuration is considered verified if there are no cracked solder joints or component damage after 500 thermal cycles in accordance with temperature and vibration testing (listed below) when examined under 15X minimum magnification.

10.2 TEMPERATURE CYCLING

ESA PSS-01-708, Section 11.2 applies.

10.3 VIBRATION

ESA PSS-01-708, Section 11.3 applies.

10.4 FAILURES

In the case of failures, an analysis shall be performed to identify the cause: component or soldering process. In the case of cracked joints, microsections shall be made to evaluate their depth and origin. Surface cracks that penetrate less than 5% of the solder fillet or less than 20 micrometres depth are considered acceptable.
SECTION 11: QUALITY ASSURANCE

The quality assurance requirements are defined in ESA PSS-01-20. However, particular attention shall be paid to the following points:

11.1 DATA

ESA PSS-01-708, Section 12.1 applies.

11.2 NONCONFORMANCE

ESA PSS-01-708, Section 12.

11.3 CALIBRATION

All solder processing and ancillary equipment shall be periodically calibrated and the manufacturer shall keep records of this calibration. Any suspect or actual equipment failures must be notified to ESA so that previous results may be examined to ascertain whether re-inspection/retesting is required.

11.4 TRACEABILITY

ESA PSS-01-708, Section 12.4 applies.

11.5 WORKMANSHP STANDARDS

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

11.6 INSPECTION

During all stages of the process, the inspection points shall be observed; attention shall be paid to Section 9 of this specification.
ANNEX B

TYPICAL SATISFACTORY AND UNSATISFACTORY SOLDER CONNECTIONS

The illustrations in this Annex depict typical satisfactory and unsatisfactory solder connections and are to be used in conjunction with the visual workmanship standards given in Annex C.
### B.1 Chip Components

Table B.1 Mounting limits

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference</th>
<th>Dimension limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum side overhang</td>
<td>A</td>
<td>B.1 (a)</td>
</tr>
<tr>
<td>Minimum lap contact</td>
<td>L</td>
<td>B.1 (b)</td>
</tr>
<tr>
<td>Minimum end joint width</td>
<td>B</td>
<td>B.1 (a)</td>
</tr>
<tr>
<td>Minimum joint height</td>
<td>M</td>
<td>B.1 (c)</td>
</tr>
<tr>
<td>Elevation</td>
<td>X</td>
<td>B.1 (d)</td>
</tr>
<tr>
<td>Maximum tilt limit</td>
<td>C</td>
<td>B.1 (e)</td>
</tr>
<tr>
<td>Minimum solder coverage of edges on terminal pad</td>
<td>-</td>
<td>(Annex C.1)</td>
</tr>
</tbody>
</table>
Figure B.1(a)  Acceptable overhang

Figure B.1(b)  Minimum lap contact
Figure B.1(c) Minimum joint height

Figure B.1(d) Chip elevation limits
Figure B.1(e)  Chip tilt limits
### B.2 LCC with Castellated Terminals

Table B.2  Mounting limits

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference</th>
<th>Dimension</th>
<th>Figure</th>
<th>Dimension limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum side overhang</td>
<td>A</td>
<td>B.2 (a)</td>
<td></td>
<td>Zero</td>
</tr>
<tr>
<td>Maximum fillet length</td>
<td>E</td>
<td>B.2 (a)</td>
<td></td>
<td>P</td>
</tr>
<tr>
<td>Minimum joint height</td>
<td>M</td>
<td>B.2 (a)</td>
<td></td>
<td>0.25 x H</td>
</tr>
<tr>
<td>Elevation</td>
<td>X</td>
<td>B.2 (b)</td>
<td></td>
<td>0.1 to 0.4 mm</td>
</tr>
</tbody>
</table>
NOTE: Acceptable maximum solder - solder may cover entire pad and termination area but shall not overhang front and sides of pad.

Figure B.2(a) Mounting of castellated chip carrier devices
Figure B.2(b) Satisfactory solder connection - side view
### B.3 Bottom Terminated Devices, Reflow Configuration

Table B.3 Mounting limits

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference</th>
<th>Dimension</th>
<th>Figure</th>
<th>Dimension limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum lap contact</td>
<td>L</td>
<td>B.3 (a)</td>
<td></td>
<td>0.75 x W</td>
</tr>
<tr>
<td>Maximum overhang</td>
<td>E</td>
<td>B.3 (b)</td>
<td></td>
<td>Zero</td>
</tr>
<tr>
<td>Elevation</td>
<td>X</td>
<td>B.3 (b)</td>
<td></td>
<td>0.1 to 0.4 mm</td>
</tr>
</tbody>
</table>
Figure B.3(a) Minimum lap contact

Figure B.3(b) Mounting limits - side view
ACCEPTABLE, MINIMUM SOLDER
Solder fillet flows to top of termination.

ACCEPTABLE, MAXIMUM SOLDER
Solder covers entire pad but does not overhang. Solder does not bulge at the component body.

UNACCEPTABLE, EXCESSIVE SOLDER
Solder overhangs pad. Solder bulges at component body.

Figure B.3(c) Satisfactory and unsatisfactory solder connections
### B.4 MELF and SOD Components

**Table B.4 Mounting limits**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference</th>
<th>Dimension</th>
<th>Figure</th>
<th>Dimension limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum side overhang</td>
<td>A</td>
<td></td>
<td>B.4 (a)</td>
<td>0.25 x D</td>
</tr>
<tr>
<td>Minimum fillet width</td>
<td>B</td>
<td></td>
<td>B.4 (a)</td>
<td>0.5 x D</td>
</tr>
<tr>
<td>Minimum side fillet length</td>
<td>L</td>
<td></td>
<td>B.4 (a)</td>
<td>0.5 x T</td>
</tr>
<tr>
<td>Elevation</td>
<td>X</td>
<td></td>
<td>B.4 (a)</td>
<td>0.1 to 0.75 mm</td>
</tr>
</tbody>
</table>
NOTE: As a minimum, there shall be a properly wetted solder fillet evident on the end and along the side of the metallised cap.

Figure B.4(a) Mounting of MELF and SOD components
END VIEW - SOLDER PROFILE

END CAP

SOLDER

TERMINAL PAD

ACCEPTABLE, MINIMUM SOLDER
Properly wetted end and side fillet, 25% of component diameter.

END VIEW - SOLDER PROFILE

SOLDER

ACCEPTABLE, MAXIMUM SOLDER
Solder covers entire pad and cap, but does not overhang. The toe of the end cap still discernible.

END VIEW - SOLDER PROFILE

SOLDER

UNACCEPTABLE, EXCESSIVE SOLDER
Solder overhangs the pad. The toe is not discernible.

Figure B.4(b) Satisfactory and unsatisfactory solder connection
B.5 Ribbon, "L" and Gull-wing Leaded Devices

ACCEPTABLE, MINIMUM SOLDER
Solder fillet reaches the mid-point of the heel and flows up to the top of the lead and covers it.

ACCEPTABLE, MAXIMUM SOLDER
Solder covers the lead and entire pad, but does not overhang. The toe is still discernible.

UNACCEPTABLE, EXCESSIVE SOLDER
Solder overhangs pad. Toe is not discernible.

Figure B.5 Satisfactory and unsatisfactory solder connections
### B.6 "J" and "V" leaded devices

Table B.6 Mounting limits

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference</th>
<th>Dimension</th>
<th>Figure</th>
<th>Dimension limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum side overhang</td>
<td>A</td>
<td></td>
<td>B.6 (a)</td>
<td>Zero</td>
</tr>
<tr>
<td>Minimum side joint length</td>
<td>L</td>
<td></td>
<td>B.6 (a)</td>
<td>0.75 x D</td>
</tr>
<tr>
<td>Minimum heel fillet</td>
<td>M</td>
<td></td>
<td>B.6 (a)</td>
<td>Mid-point</td>
</tr>
<tr>
<td>Maximum joint thickness</td>
<td>X</td>
<td></td>
<td>B.6 (a)</td>
<td>0.75 mm</td>
</tr>
</tbody>
</table>
Figure B.6 (a) Mounting of "J" and "V" leaded devices
ACCEPTABLE, MINIMUM SOLDER
Solder wets total lead contact area with fillet reaching mid-point of heel.

ACCEPTABLE, MAXIMUM SOLDER
Solder fillet reaches beyond mid-point of heel but toe is still discernible.

UNACCEPTABLE, EXCESSIVE SOLDER
Solder fillet totally covers lead form.

Figure B.6 (b) Satisfactory and unsatisfactory solder connections
ANNEX C

VISUAL STANDARDS

The visual standards in this Annex shall be used in conjunction with the illustrations given in Annex B.
C.1 Chip components

PREFERRED SOLDER  (See also Annex B.1)

ACCEPTABLE, MAXIMUM SOLDER  (See also Annex B.1)

UNACCEPTABLE - POOR WETTING
UNACCEPTABLE - LESS THAN 75% WETTING OF TERMINAL EDGE
C.2 MELF Components

ACCEPTABLE, MINIMUM SOLDER - TERMINAL WETTED ALONG END FACE AND SIDES (See also Annex B.4)

PREFERRED SOLDER

UNACCEPTABLE - EXCESSIVE SOLDER
C.3 Ribbon, "L" and Gullwing leaded devices

ACCEPTABLE, MINIMUM SOLDER - ARROWED "A"
(See also Annex B.5)

MAXIMUM "B" AND INSUFFICIENT "C"

UNACCEPTABLE - EXCESSIVE SOLDER (Middle joint)
C.4 Miscellaneous soldering defects

**UNACCEPTABLE - CONTAMINATED JOINT**

**UNACCEPTABLE - SOLDER BALLS**

**UNACCEPTABLE - SOLDER BRIDGE BETWEEN TERMINALS**

**UNACCEPTABLE - SOLDER BRIDGE BETWEEN DEVICES**
## ANNEX D

### CTE MATCH TABLE

(Example)

<table>
<thead>
<tr>
<th>SMD class</th>
<th>SMD type</th>
<th>Max. body dim., mm</th>
<th>Diagonal dim. (leaded or non-leaded), mm</th>
<th>Board/substrate class* or thermal environment $\Delta t = 155$ °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistor, ceramic</td>
<td>RC 0X05</td>
<td>2.21</td>
<td>N/A</td>
<td>1-5</td>
</tr>
<tr>
<td></td>
<td>RC 1206/1210</td>
<td>3.40</td>
<td>N/A</td>
<td>1-5</td>
</tr>
<tr>
<td>Capacitor, ceramic</td>
<td>CC 0805</td>
<td>2.21</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td></td>
<td>CC 1206/1210</td>
<td>3.40</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td></td>
<td>CC 1812</td>
<td>4.83</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td></td>
<td>CC 1825</td>
<td>6.81</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td>Capacitor, tantalum</td>
<td>3216</td>
<td>3.40</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td></td>
<td>3528</td>
<td>3.71</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td></td>
<td>6032</td>
<td>6.15</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td></td>
<td>7243</td>
<td>7.59</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td>Chip Ind., wirewound (Ferrite)</td>
<td>MELF (glass)</td>
<td>-</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td></td>
<td>MLL 34 (SOD-80)</td>
<td>3.71</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td></td>
<td>MLL 41</td>
<td>5.21</td>
<td>N/A</td>
<td>1/5</td>
</tr>
<tr>
<td>Flat pack</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quad-flat pack</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N/A = Not Applicable
* See Section 4.7
CTE MATCH TABLE (Continued)

EXAMPLE

| SMD class       | SMD type | Max. body dim., mm | Diagonal dim. (leaded or non-leaded), mm | Board/substrate class* or thermal environment $\Delta t = 155^\circ C$
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaded cer. chip carrier</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leadless CC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N/A = Not Applicable

*See Section 4.7