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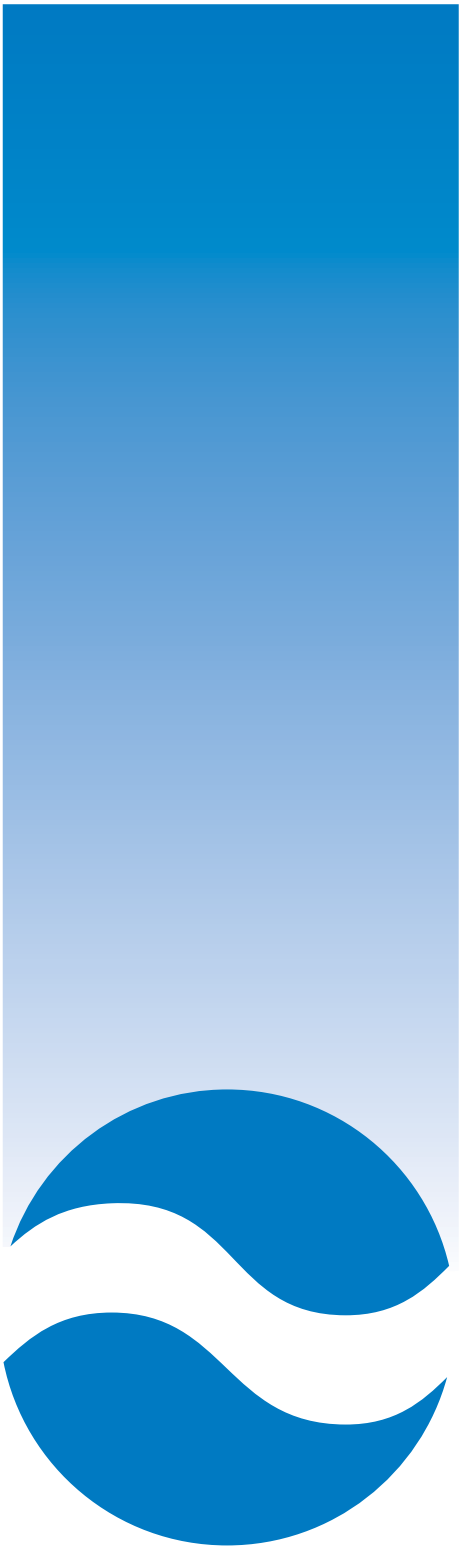
JOINT INDUSTRY STANDARD

Space and Military Applications Electronic Hardware Addendum to IPC J-STD-001H Requirements for Soldered Electrical and Electronic Assemblies



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- Include a feedback system on use and problems for future improvement

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IPC J-STD-001HS

Space and Military Applications Electronic Hardware Addendum to IPC J-STD-001H Requirements for Soldered Electrical and Electronic Assemblies

Developed by the J-STD-001 Space and Military Electronic Assemblies Task Group (5-22as) of the Assembly & Joining Committee (5-20) of IPC

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Users of this publication are encouraged to participate in the development of future revisions.

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Space and Military Applications Electronic Hardware Addendum to IPC J-STD-001H Requirements for Soldered Electrical and Electronic Assemblies

Table of Contents

The following topics are addressed in this Addendum.

Table of Contents for Table 1 Space and Military Applications Requirements

0.1 Scope This Addendum provides requirements to be used in addition to, and in some cases, in place of, those published in J-STD-001H to ensure the reliability of soldered electrical and electronic assemblies that must survive the vibration and thermal cyclic environments in space and military applications.

0.1.1 Purpose When required by procurement documentation/engineering documentation, this Addendum supplements or replaces specifically identified requirements of J-STD-001H.

0.1.2 Precedence The contract takes precedence over this Addendum, referenced standards and User-approved drawings. In the event of a conflict between this Addendum and the applicable documents cited herein, this Addendum takes precedence. Where referenced criteria of this Addendum differ from the published J-STD-001H, this Addendum takes precedence. In the event of conflict between the requirements of this Addendum and the applicable assembly drawing(s)/documentation, the applicable User approved assembly drawing(s)/documentation take precedence. See Table 1 of this Addendum 1.7 Order of Precedence.

0.1.3 Existing or Previously Approved Designs This Addendum **shall not** constitute the sole cause for the redesign of previously approved designs. When drawings for existing or previously approved designs undergo revision, they should be reviewed and changes made that allow for conformance with the requirements of this Addendum.

0.1.4 Use This Addendum is not to be used as a stand-alone document.

Where criteria are not modified through change or addition, the Class 3 requirements of J-STD-001H **shall** apply. Where J-STD-001H criteria are altered or new criteria are added by this Addendum, the clause is listed in J-STD-001HS, Table 1, Space and Military Applications Requirements, and the entire J-STD-001H clause is replaced by this Addendum except as specifically noted. Clauses found only in this Addendum will have ‘‘[NEW]’’ after the clause number in the table.

Clauses, Tables, Figures, etc., in J-STD-001H that are not listed in this Addendum **shall** be used as-published.

0.1.5 Red Plague (Cuprous Oxide Corrosion) Red Plague can develop in silver-coated soft or annealed copper conductors (component leads, single and multistranded wires and printed board conductors) when a galvanic cell forms between the copper base metal and the silver coating in the presence of moisture (H2O) and oxygen (O2). Once initiated, the sacrificial corrosion of the copper base conductor can continue indefinitely in the presence of oxygen. The color of the corrosion by-product (cuprous oxide crystals) may vary depending on the different levels of oxygen available, but is commonly noted as a red/reddish-brown discoloration on the silver coating surface.

The use of silver coating over any form of copper, e.g., component leads, printed board traces, wire/cable **shall** require the implementation of a User-approved Red Plague Control Plan (RPCP). See IPC-WP-113, Guidance for the Development and Implementation of a Red Plague Control Plan (RPCP), for technical guidance and a generic RPCP template.

0.1.6 Materials and Processes Traceability When required, the traceability of materials and processes used in the manufacture of electrical/electronic hardware **shall** be in compliance with IPC-1782, Standard for Manufacturing and Supply Chain Traceability of Electronic Products. Traceability Level **shall** be determined between the Manufacturer and the User.

J-STD-001HS Table 1 Space and Military Applications Requirements

<table>
<tr><th>J-STD-001H Reference</th><th>Space and Military Applications Requirements (as changed by this Addendum)</th></tr>
<tr><td>1.1</td><td>Scope This Standard describes materials, methods and acceptance criteria for producing soldered electrical and electronic assemblies. The intent of this document is to rely on process control methodology to ensure consistent quality levels during the manufacture of products. It is not the intent of this Standard to exclude any procedure for component placement or for applying flux and solder used to make the electrical connection.

The soldering operations, equipment, and conditions described in this document are based on electrical/electronic circuits designed and fabricated in accordance with the specifications listed in J-STD-001HS Table 1-1.

J-STD-001HS_Table 1-1 Design, Fabrication and Acceptability Specifications
<table>
<tr><th>Board Type</th><th>Design</th><th>Fabrication/Acceptability Specification</th></tr>
<tr><td>Generic Requirements</td><td>IPC-2221</td><td>IPC-6011</td></tr>
<tr><td>Rigid Printed Boards</td><td>IPC-2222</td><td>IPC-6012 Space & Military Addendum</td></tr>
<tr><td>Flexible Circuits</td><td>IPC-2223</td><td>IPC-6013</td></tr>
<tr><td>Rigid Flex Board</td><td>IPC-2223</td><td>IPC-6013</td></tr>
</table></td></tr>
<tr><td>1.2</td><td>Note: This clause is unchanged from J-STD-001H. It is included here to clarify that the Purpose of the Space and Military Applications Addendum does not replace nor alter the Purpose of the base document.

Purpose This Standard prescribes material requirements, process requirements, and acceptability requirements for the manufacture of soldered electrical and electronic assemblies. For a more complete understanding of this document's recommendations and requirements, one may use this document in conjunction with IPC-HDBK-001, IPC-AJ-820 and IPC-A-610. Standards may be updated at any time, including with the addition of amendments. The use of an amendment or newer revision is not automatically required.</td></tr>
<tr><td>1.5.3.2</td><td>High Frequency Applications High frequency applications, i.e., radio wave and microwaves, may require part clearances, mounting systems, and assembly designs which vary from the requirements stated herein. When high frequency design requirements prevent compliance with the design and part mounting requirements contained herein, Manufacturers may use alternative designs. These alternative designs' acceptance criteria shall be approved by the User prior to use.</td></tr>
<tr><td>1.5.3.3</td><td>High Voltage Applications High voltage applications may require part clearances, mounting systems, and assembly designs which vary from the requirements stated herein. When such design requirements prevent compliance with the design and part mounting requirements contained herein, Manufacturers may use alternative designs. These alternative designs' acceptance criteria shall be approved by the User prior to use.</td></tr>
<tr><td>1.6.2</td><td>Statistical Process Control The use of statistical process control is encouraged but not mandatory, see 1.6 Process Control Requirements. When a statistical process control system process is used, it shall include the following elements as a minimum:
a. Training is provided to personnel with assigned responsibilities in the development, implementation, and utilization of process control and statistical methods that are commensurate with their responsibilities.
b. Quantitative methodologies and evidence is maintained to demonstrate that the process is capable and in control. Improvement strategies define initial process control limits and methodologies leading to a reduction in the occurrence of process indicators in order to achieve continuous process improvement.
c. Sampling inspection shall be prohibited unless approved by the User prior to use.
d. When sampling is pre-approved by the User, any defect(s) identified in the lot sample exceeding the limit(s) allowed by the sampling plan, requires the entire lot to be 100% inspected for the occurrence(s) of the identified defect(s).
e. A system is in place to initiate corrective action(s) for the occurrence of process indicators, out-of-control process(es), and/or discrepant assemblies.
f. A documented audit plan is defined to monitor process characteristics and/or output at a prescribed frequency.
g. Objective evidence of process control may be in the form of control charts or other tools and techniques of statistical process control derived from application of process parameter and/or product parameter data, see IPC-HDBK-001.</td></tr>
<tr><td>1.7</td><td>Order of Precedence The contract shall take precedence over this Addendum, J-STD-001H, referenced standards and User approved drawings, see 0.1.2 Precedence of this Addendum.

In the event of conflict between the requirements of this standard and the applicable assembly drawing(s)/documentation, the applicable User approved assembly drawing(s)/documentation govern. Some examples of documentation include the contract, purchase order, technical data package, engineering specification or performance specification. In the event of a conflict between the text of this standard and the applicable documents cited herein, the text of this standard takes precedence. In the event of conflict between the requirements of this standard and an assembly drawing(s)/documentation that has not been User approved, this standard governs. See 0.1.2 Precedence of this Addendum.

When J-STD-001 is cited or required by contract, the requirements of IPC-A-610 do not apply unless separately or specifically required. When IPC-A-610 or other related documents are cited along with J-STD-001, the order of precedence should be defined in the procurement documents.</td></tr>
</table>

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
1.10	**Personnel Proficiency** All instructors, operators, and inspection personnel **shall** be proficient in the tasks to be performed. Objective evidence, e.g., records of training to the applicable job functions being performed, work experience, testing to the requirements of this Addendum, or results of periodic reviews on proficiency **shall** be maintained and be available for review. Training **shall** be in accordance with the J-STD-001 Training and Certification Program or a Manufacturer developed program that **shall** be made available for review and approval upon request by the User. All training **shall** be traceable to a J-STD-001 Master IPC Trainer (MIT).
1.11	**Acceptance Requirements** All products **shall** meet the requirements of the assembly drawing(s)/documentation and the requirements specified herein. Unless otherwise specified in the contract, Manufacturers **shall** perform 100% inspection (see 1.6.2.c Statistical Process Control of this Addendum) using either visual inspection or nondestructive evaluation (NDE). Nondestructive verification techniques **shall** be approved by the User prior to use. The User has the responsibility to specify acceptance criteria. If no criteria are specified, criteria **shall** be established and agreed upon between the Manufacturer and User.
1.12.2	**Inspection** After the soldering and cleaning process is complete, all assemblies **shall** be evaluated by 100% visual or by nondestructive inspection. Nondestructive inspection requires User approval per 1.11 Acceptance Requirements of this Addendum, including solder connections as specified in 4.15.3 Partially Visible or Hidden Solder Connections, 7.5.14 Surface Mount Area Array Packages, 7.5.15 Bottom Termination Components (BTC), and 7.5.16 Components with Bottom Thermal Plane Terminations (D-Pak), and 7.5.19 Vertical Cylindrical Cans with Outward L-Shaped Lead Terminations of this Addendum. When assemblies are to be conformally coated and/or staked or encapsulated, the coating, encapsulation, and/or staking **shall** be evaluated by 100% visual inspection. Inspection of soldering and cleanliness **shall** be performed prior to all conformal coating operations, and any staking or encapsulation operations that prevent visual access to solder connections.
3.1	**Materials** The materials and processes used to assemble/manufacture electronic assemblies **shall** be selected such that their use, in combination, produce products acceptable to this standard. When an element of the proven process is changed which may affect the form, fit, or function of the final product, e.g., flux, solder paste, cleaning media or system, solder alloy or soldering system, validation of the change(s) **shall** be performed and documented. Acceptance criteria for the tests **shall** be agreed upon between the Manufacturer and User. Implementation of the change(s) **shall** be approved by the User prior to use. Element changes may also pertain to a change in bare boards (including supplier), solder mask, or metallization. Limited shelf life items **shall** be stored and controlled in accordance with material supplier's recommendations or in accordance with the Manufacturer's documented procedures for controlling shelf life. Limited shelf life items **shall** be traceable, e.g., lot number, date code and/or expiration date. Solders, component leads, and all other surfaces containing Pb-free tin as defined in 3.2.1 Solder – Pb-Free of this Addendum, **shall** be processed in accordance with 3.2.1 Solder – Pb-Free of this Addendum.
3.2	**Solder** Solder alloys **shall** be Sn60Pb40, Sn62Pb36Ag2, Sn63Pb37, or Sn96.3Ag3.7 in accordance with J-STD-006 or User approved equivalent standard. Other solder alloys that provide the service life, performance, and reliability required of the product may be used if all other conditions of this standard are met and objective evidence of such is reviewed and approved by the User prior to use. High temperature solder alloys, e.g., Sn96.3Ag3.7, **shall** only be used where specifically indicated by approved drawings. Flux that is part of flux-cored solder wire or solder paste **shall** meet the requirements of 3.3 Flux of this Addendum. Flux percentage is optional.
3.2.1	**Solder – Pb-Free** For the purpose of this document, Pb-free tin is defined as pure tin or any tin alloy containing less than 3% Pb by weight as an alloying constituent. The use of Pb-free tin solder alloys/Pb-free tin for either the assembly of, or existing on, the external surfaces (platings, metallization, etc.) of components, sub-assemblies, packaging technologies, mechanical hardware **shall** be prohibited unless documented and controlled through a User approved Pb-Free Control Plan (LFCP). Solder alloy Sn96.3Ag3.7 is exempt from this requirement, i.e., inclusion in a User approved LFCP is not required. See 3.2 Solder of this Addendum.

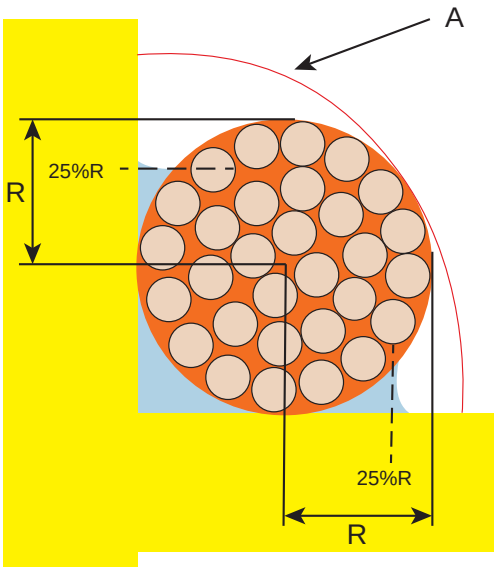
J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
3.3	**Flux** Flux **shall** be in accordance with J-STD-004 or User approved equivalent standard. Flux **shall** conform to flux activity levels L0 or L1 of flux materials rosin (RO) or resin (RE). When other activity levels or flux materials are used, data demonstrating material and process compatibility through testing agreed upon between the Manufacturer and User **shall** be provided. Use of any other flux **shall** be approved by the User prior to use. **Note:** Flux or soldering process combinations previously tested or qualified in accordance with other specifications do not require additional testing. Type H or M fluxes may be used for tinning of insulated solid wires with insulation bonded to the wire, e.g., magnet wire. When an external flux is used in conjunction with flux cored solders, the fluxes **shall** be compatible. For all fluxing applications where adequate cleaning is not practical, only flux types RO or RE of the L0 flux activity level, or equivalent, **shall** be used.
3.6.1	**Component and Seal Damage** Minor surface flaws, discoloration, meniscus cracks, or chips in component bodies are acceptable. However, they **shall not** expose the component substrate or active element nor affect structural integrity. Components **shall not** be charred. Component damage in excess of that determined to be a minor surface flaw **shall not** degrade the component below the part specification requirements, or as otherwise determined, to meet form, fit, function and life expectancy requirements. This may be determined through documented analysis.
4.3	**Removal of Component Surface Finishes** Certain surface finishes on component terminations or printed board lands may impact the quality of the solder connection. Under either of the following conditions, the printed boards or parts are exempt from the requirements for finish removal stated in 4.3.1 Gold Removal of this Addendum and J-STD-001H 4.3.2 Other Metallic Surface Finishes Removal: • If there is documented objective evidence, available for review and approved by the User prior to use, that there are no gold related solder embrittlement issues, or other metallic surface finish solder joint integrity problems, e.g., with Sn or SnBi, associated with the soldering process being used, see IPC-HDBK-001 or IPC-AJ-820 handbook for guidance. • For electroless nickel immersion gold (ENIG), nickel-palladium-gold (NiPdAu), or electroless nickel electroless palladium immersion gold (ENEPIG) finishes.
4.3.1	**Gold Removal** Except as noted in 4.3 Removal of Component Surface Finishes of this Addendum, gold **shall** be removed from at least 95% of the surfaces to be soldered of all component leads, component terminations, and solder terminals. A double tinning process or dynamic solder wave may be used for gold removal prior to mounting the component on the assembly.
4.5	**Rework of Nonsolderable Parts** A component lead, termination, or board not conforming to the solderability requirements of 4.1 Solderability may be reworked, e.g., by dipping in hot solder, before soldering. A reworked part **shall** conform to the requirements of 4.1 Solderability, less conditioning.
4.7	**General Part Mounting Requirements** When design restrictions mandate mounting components incapable of withstanding soldering temperatures incident to a particular process, such components **shall** be mounted and soldered to the assembly as a separate operation. If cleaning is required, parts should be mounted with sufficient clearances between the body and the printed board to assure adequate cleaning and cleanliness testing. Assemblies should be cleaned after each soldering operation so that subsequent placement and soldering operations are not impaired by contamination. Parts should be mounted such that part markings and reference designators are visible, see 9.2 Marking. Minimum electrical clearance **shall not** be violated. When sleeving is required as protection for glass, ceramic, or hermetic components that will be coated, encapsulated or staked, the sleeving **shall** be placed on the component prior to installation. Uninsulated parts mounted over exposed circuitry or which are in close proximity with other conductive materials **shall** be separated by suitable insulation. There **shall** be a documented process for torquing of threaded fasteners, including, but not limited to, standard torque values (when not specified in other engineering documentation), workmanship requirements, installation procedures, quality assurance provisions, and tool control. When components are mounted to the assembly using fasteners, the fasteners **shall** be tightened/torqued prior to soldering.
4.7.2	**Lead Deformation Limits** Leads **shall not** have any nicks, scrapes or gouges. Smooth indentations up to 10% of the diameter, width, or thickness of the lead, e.g., tooling marks, and as allowed for intentionally flattened leads, are acceptable. See 4.15.1 Exposed Surfaces of this Addendum, 4.5 Rework of Nonsolderable Parts of this Addendum, and 7.1.6 Flattened Leads.

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
4.13.3	**Drying/Degassing** Prior to soldering, the printed board **shall** be treated to remove moisture and other volatiles using a documented process. Treated assemblies/printed boards do not need to be re-treated if they are stored in a controlled atmosphere of 5% RH or less prior to any subsequent soldering operations. **Note:** See IPC-1602 for further information on moisture sensitive printed boards.
4.15.1	**Exposed Surfaces** Except as noted elsewhere in J-STD-001H or this Addendum, the following requirements apply to exposed surfaces: a. Exposed basis metal **shall not** prevent the formation of an acceptable solder connection. b. Exposed Organic Solderability Preservatives (OSP) **shall not** prevent the formation of an acceptable solder connection. c. Iron based material, e.g., Alloy 42, Kovar®, **shall not** be exposed on component leads or bodies.
4.15.2	**Solder Connection Anomalies** The following solder joint conditions **shall** be considered defects: a. Fractured solder connections. b. Disturbed solder connections. c. Incomplete reflow of solder paste. d. Cold or rosin solder connections. e. Evidence of dewetting that causes the solder connection to not meet the solder fillet requirements. f. Solder has not wetted to the land or termination where solder is required. g. Solder that violates minimum electrical clearance. h. Solder that contacts the component body (except as noted in other clauses). i. Does not comply with wetting criteria of J-STD-001H 4.15 Solder Connection. j. Solder bridging except when path is present by design. k. Blowholes and pinholes (where the bottom and all sides are not visible). l. Solder that obscures the stress relief bend of through-hole components. (Solder in the bend radius is not cause for rejection provided the lead is properly formed, the topside bend radius is discernible, and the solder does not extend to within 1 lead diameter of the part body or end seal).
4.15.3	**Partially Visible or Hidden Solder Connections** Partially visible or hidden solder connections **shall** meet the following conditions: a. The design does not restrict solder flow to any connection element on the solder destination side lands, e.g., PTH component, of the assembly. b. The visible portion, if any, of the connection on either side of the PTH solder connection (or the visible portion of the SMD connection) is acceptable. c. Process controls are maintained in a manner assuring acceptable and repeatable process results. For solder connections that do not meet any of the above conditions, NDE **shall** be used. For nondestructive evaluation, see 1.11 Acceptance Requirements of this Addendum.
5.1.2	**Strand Damage** J-STD-001H Table 5-1 does not apply; there **shall** be no nicked, scraped or broken wire strands. See 4.7.2 Lead Deformation Limits of this Addendum for damage requirements applicable to solid conductor wires/leads. For plated wires, a visual anomaly that does not expose basis metal is not considered to be strand damage. Smooth indentations such as tooling marks up to 10% are allowed. Disturbed wire strands should be restored to approximate their original lay. Wire strands **shall not** have separation exceeding one strand diameter or extend beyond wire insulation outside diameter. Wire strands **shall not** be altered or cut to fit terminals.
5.3.6	**Terminal Mounting – Soldering** Terminals mounted and soldered to the printed board **shall** meet the requirements shown in Table 5-2 of this Addendum. **Table 5-2 Terminal Mounting Minimum Soldering Requirements** A. Circumferential fillet and wetting – solder source side: 360° B. Percentage of solder source side land area covered with wetted solder: 75%

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
5.5	**Soldering to Terminals** A solder fillet **shall** join the wire/lead to the terminal for 100% of the lead to terminal contact area. Wetted solder depression in the lead/wire to terminal contact area **shall not** be more than 25% R. See J-STD-001HS Figure 5-1.  **J-STD-001HS Figure 5-1 Solder Depression** **A. Maximum** **R. Radius**
5.6.3	**Wire Staking** Staking applied to wires **shall not** be allowed to touch any moving parts. Staking should be applied such that it is sufficient to secure the wire with no spillover onto component leads above the foot, adjacent lands, component bodies, or end seals that may be sensitive, e.g., glass, ceramic. Wires longer than 25 mm [1 in] **shall** be staked at intervals not more than 25 mm [1 in] and at every change of direction. Staking material **shall not** overhang the board edge(s) or violate edge spacing requirements. Staking adhesive, when used, **shall** comply with 10.0 Coating, Encapsulation, Staking and Bonding of this Addendum.
6.1	**Through-Hole Terminations – General** Axial leaded components, when mounted horizontal to the board surface, should be approximately centered between the mounting holes. The entire length of the component body should be in contact with the board surface. The maximum space between the component body and the board **shall not** exceed 0.7 mm [0.03 in]. Components that are required to be mounted off the board **shall** be elevated at least 1.5 mm [0.06 in]. Components mounted in unsupported holes and required to be elevated **shall** be provided with lead forms at the board surface, or other mechanical support. For axial leaded components, at least one component lead **shall** have stress relief provided the component is not clip or adhesive mounted, or otherwise constrained, see J-STD-001H Figure 6-1. All axial leads **shall** have stress relief when the component is clipped or adhesive mounted or otherwise constrained. Axial leaded components mounted vertically in unsupported holes **shall** be mounted with lead forms or other mechanical support. Axial lead components mounted vertically in supported holes **shall** have component height in accordance with the design. Component clearance (C) from the land to the body or weld bead **shall** meet the requirements of J-STD-001H Table 6-1. Clearance of radial leaded components that are mounted freestanding, e.g., supported by leads only, **shall** be between 0.3 mm [0.01 in] and 2 mm [0.08 in]. The spacing between the component and printed board **shall not** violate minimum electrical clearance. When spacers are used with radial leaded components, the mounting **shall** meet the requirements of J-STD-001H Table 6-2.

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

<table>
<tr><th>J-STD-001H Reference</th><th>Space and Military Applications Requirements (as changed by this Addendum)</th></tr>
<tr><td>6.1.1</td><td>
Lead Forming Part and component leads should be preformed to the final configuration excluding the final clinch or retention bend before assembly or installation. The lead forming process shall not damage lead seals, welds, or connections internal to components, see 4.7.2 Lead Deformation Limits in this Addendum. Leads shall not be reformed except for minor adjustments to bend angles.

Leads shall extend at least one lead diameter or thickness but not less than 0.8 mm [0.03 in] from the body or weld before the start of the bend radius, see J-STD-001H Figure 6-2.

Note: Measurement is made from the end of the part. (The end of the part is defined to include any coating, solder seal, solder or weld bead, or any other extension.)

The lead bend radius shall be in accordance with Table 6-3 of this Addendum.

Table 6-3 Lead Bend Radius
<table>
<tr><th>Lead Diameter or Thickness</th><th>Minimum Bend Radius (R)</th></tr>
<tr><td>Less than 0.8 mm [0.03 in]</td><td>1 diameter or thickness</td></tr>
<tr><td>0.8 to 1.2 mm [0.03 to 0.05 in]</td><td>1.5 diameters or thickness</td></tr>
<tr><td>Greater than 1.2 mm [0.05 in]</td><td>2 diameters or thickness</td></tr>
</table>
</td></tr>
<tr><td>6.1.2</td><td>
Termination Requirements Component leads may be terminated using a straight through, partially clinched, or clinched configuration. The clinch should be sufficient to provide mechanical restraint during the soldering process. The orientation of the clinch relative to any conductor is optional. DIP leads should have at least two diagonally opposing leads partially bent outward.

If a lead or wire is clinched, the lead shall be wetted in the clinched area. The outline of the lead should be discernible in the solder connection.

Tempered leads shall not be terminated with a full-clinched configuration.

Lead protrusion shall not violate minimum electrical clearance requirements. Lead protrusion shall be in accordance with Table 6-4 of this Addendum for supported holes or Table 6-5 of this Addendum for unsupported holes. The presence of a lead shall be verified prior to soldering, see Table 6-4 Note 1 of this Addendum.

Table 6-4 Protrusion of Leads in Supported Holes
<table>
<tr><td>(L) min.</td><td>End is discernible in solder, Note 1</td></tr>
<tr><td>(L) max.</td><td>2.25 mm [0.09 in]</td></tr>
</table>
Note 1. For components having pre-established lead lengths that are less than board thickness, and the components or lead shoulders are flush to the board surface, the lead end is not required to be visible in the subsequent solder connection.

Table 6-5 Protrusion of Leads in Unsupported Holes
<table>
<tr><td>(L) min.</td><td>Sufficient to clinch, or 0.75 mm [0.03 in] for straight through terminations</td></tr>
<tr><td>(L) max., Note 1 - clinched</td><td>Note 2</td></tr>
<tr><td>(L) max., Note 1 - partial clinch or straight through</td><td>2.25 mm [0.09 in], Note 2</td></tr>
</table>
Note 1. Lead protrusion should not exceed 2.5 mm [0.1 in] if there is a possibility of violation of minimum electrical spacing, damage to soldered connections due to lead deflection or penetration of static protective packaging during subsequent handling or operating environments.
Note 2. No danger of shorts.

Connector leads, relay leads, tempered leads and leads greater than 1.3 mm [0.05 in] diameter are exempt from the maximum length requirement provided that they do not violate minimum electrical clearance.
</td></tr>
</table>

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

<table>
<tr><th>J-STD-001H Reference</th><th>Space and Military Applications Requirements (as changed by this Addendum)</th></tr>
<tr><td>6.2.2</td><td>Through-Hole Component Lead Soldering When soldering component leads into PTH connections, the goal of the process is to accomplish 100% fill of the PTH with solder and good wetting to the lands, lead, and barrel top and bottom. The solder connection shall meet the requirements of Table 6-6 of this Addendum, regardless of the soldering process, e.g., hand soldering, wave soldering, intrusive soldering, etc.
Table 6-6 Supported Holes with Component Leads, Minimum Acceptable Conditions[1]
<table>
<tr><td>A.</td><td>Vertical fill of solder. Note 2 and Figure 6-4 of J-STD-001H.</td><td>75%</td></tr>
<tr><td>B.</td><td>Circumferential wetting of lead and barrel on solder destination side.</td><td>360°</td></tr>
<tr><td>C.</td><td>Percentage of land area covered with wetted solder on solder destination side.</td><td>0%</td></tr>
<tr><td>D.</td><td>Circumferential fillet and wetting of lead and barrel on solder source side.</td><td>360°</td></tr>
<tr><td>E.</td><td>Percentage of land area covered with wetted solder on solder source side.</td><td>75%</td></tr>
</table>
Note 1. Wetted solder refers to solder applied by any solder process including intrusive soldering. For intrusive soldering, there may not be an external fillet between the lead and the land.
Note 2. The 25% unfilled height includes the sum of both source and destination side depressions.</td></tr>
<tr><td>6.3.1</td><td>Lead Termination Requirements for Unsupported Holes Lead protrusion for unsupported holes shall meet the requirements of Table 6-5 of this Addendum. Solder shall meet the requirements of Table 6-7 of this Addendum.
Table 6-7 Unsupported Holes with Component Leads, Minimum Acceptable Conditions[1]
<table>
<tr><td>A. Circumferential wetting and fillet lead to land</td><td>360°</td></tr>
<tr><td>B. Percentage of land area covered with wetted solder</td><td>75%</td></tr>
</table>
Note 1. Wetted solder refers to solder applied by the solder process.
Note 2. Criteria A and B apply to double-sided boards with a soldered land on one side only.</td></tr>
<tr><td>7.0</td><td>Surface Mounting of Components
Designs with via in land may preclude meeting fillet criteria. If this condition exists, solder acceptance criteria shall be defined between the User and the Manufacturer.
Solder should not extend under the body of surface mount components whose leads are made of Alloy 42 or similar iron (Fe)-based alloys.
Note: The technical data sheets for high density termination and area-array-devices, e.g. QFN, often specify unique pre-design, processing and inspection requirements. These should be observed in order to ensure fault-free function.</td></tr>
<tr><td>7.1.2</td><td>Forming Leads shall be formed in such a manner that the lead-to-body seal is not damaged or degraded, see J-STD-001H Figure 7-1. When lead forming is required during the assembly process, leads shall be formed such that there is an available minimum lead length for contact to the solder pad as shown in Table 7-1 of this Addendum, see J-STD-001H Figure 7-2.
The leads of surface mounted components shall be formed to their final configuration prior to soldering.
Note: Where severe loading conditions exist such as Coefficient of Thermal Expansion (CTE) mismatches or severe operational environments, extra consideration should be given to the minimum available contact length.
Table 7-1 SMT Lead Forming Minimum Lead Length
<table>
<tr><td>A. Two lead widths for flat leads.</td></tr>
<tr><td>B. Two lead widths for coined leads.</td></tr>
<tr><td>C. Two lead diameters for round leads.</td></tr>
</table></td></tr>
<tr><td>7.1.3</td><td>Unintentional Bending There shall be no unintentional lead deformation beyond the limits defined in 4.7.2 Lead Deformation Limits of this Addendum.</td></tr>
</table>

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
7.5.5	**Cylindrical End Cap Terminations** This component is sometimes referred to as MELF (metal electrode leadless face). Solder connections to components having cylindrical end cap terminations **shall** meet the dimensional and solder fillet requirements of Tables 7-5 and 7-5A, see Figures 7-5 and 7-5A of this Addendum.

Table 7-5 Dimensional Criteria – Cylindrical End Cap Terminations

Feature	Dim.	Requirement
Maximum Side Overhang	A	25% (W) or 25% (P), whichever is less, Note 1
End Overhang	B	Not permitted
Minimum End Joint Width, Note 2	C	50% (W) or 50% (P), whichever is less
Minimum Side Joint Length	D	75% (R) or 75% (S), whichever is less, Note 6
Maximum Fillet Height	E	Note 5
Minimum Fillet Height (end and side)	F	(G) + 25% (W) or (G) + 1.0 mm [0.04 in], whichever is less
Solder Thickness	G	Note 4
Minimum End Overlap	J	75% (R), Note 6
Land Width	P	Note 3
Termination Length	R	Note 3
Land Length	S	Note 3
Termination Diameter	W	Note 3

Note 1. Does not violate minimum electrical clearance.
Note 2. (C) is inspected at the narrowest point of the required fillet.
Note 3. Unspecified parameter or variable in size as determined by design.
Note 4. Wetting is evident.
Note 5. The maximum fillet may overhang the land or extend onto the top metallization but does not touch the top of the component. Solder may touch the bottom half of the component body.
Note 6. Does not apply to components with end-only terminations.

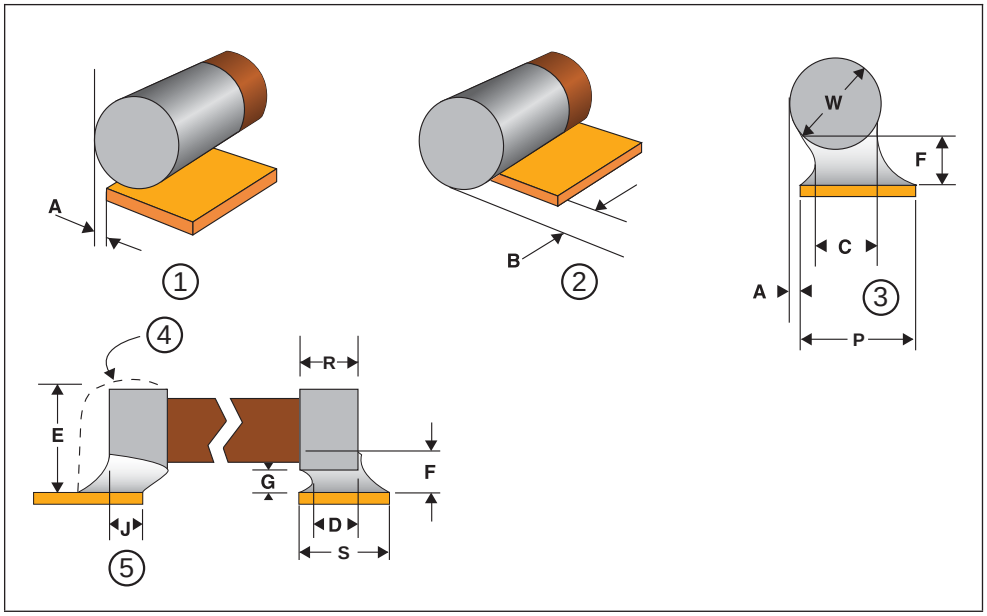


Figure 7-5 Cylindrical End Cap Terminations
1. Side overhang
2. End overhang
3. End joint width
4. See Note 5, Table 7-5
5. Side joint length and end overlap

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
7.5.5 (cont.)	**Table 7-5A Dimensional Criteria – Center Termination (When Present) – Cylindrical End Cap Terminations**

Feature	Dim.	Requirement
Maximum Side Overhang	A	25% (Cw) or 25% (Cp), whichever is less
Minimum Side Joint Length, Note 2	D	75% (Cw) or 75% (Cp), whichever is less
Maximum Fillet Height	E	Note 5
Minimum Fillet Height	F	Note 4
Solder Thickness	G	Note 4
Termination Width	Cw	Note 3
Termination Height	Ch	Note 3
Land Width	Cp	Note 3

Note 1. Does not violate minimum electrical clearance.
Note 2. (C) is inspected at the narrowest point of the required fillet.
Note 3. Unspecified parameter or variable in size as determined by design.
Note 4. Wetting is evident.
Note 5. The maximum fillet may overhang the land or extend onto the top metallization but does not touch the top of the component. Solder may touch the bottom half of the component body.

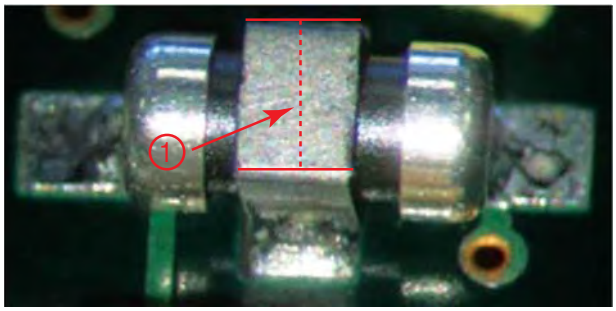


Figure 7-5A Cylindrical End Cap Terminations Center Termination (When Present)
1. Center Termination

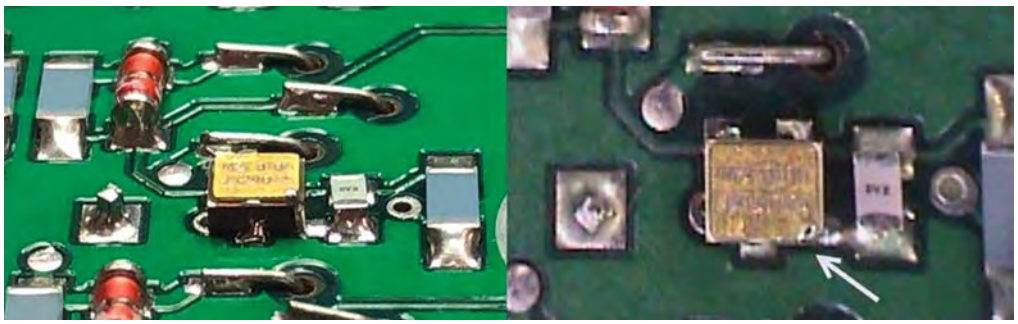
J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
7.5.6	**Castellated Terminations** If parts with castellated terminations are chosen by design, their use **shall** be approved by the User. Connections formed to castellated terminations **shall** meet the dimensional and solder fillet requirements of Table 7-6 of this Addendum, see Figure 7-6 of J-STD-001H.

Table 7-6 Dimensional Criteria – Castellated Terminations

Feature	Dim.	Requirement
Maximum Side Overhang	A	25% (W), Note 1
End Overhang	B	Not permitted
Minimum End Joint Width	C	75% (W), Note 5
Minimum Side Joint Length	D	Depth of castellation
Maximum Fillet Height	E	Notes 1, 4
Minimum Fillet Height	F	(G) + 50% (H)
Solder Thickness	G	Note 3
Castellation Height	H	Note 2
Land Length	S	Note 2
Castellation Width	W	Note 2

Note 1. Does not violate minimum electrical clearance.
Note 2. Unspecified parameter or variable in size as determined by design.
Note 3. Wetting is evident.
Note 4. The maximum fillet may extend past the top of the castellation provided it does not contact the body. For castellations that extend to the component lid, solder may extend beyond the top of the castellation and make contact with the component body, including the braze seal, and extend to the top of and wet the metallic lid. See J-STD-001HS Figure 7-1. If solder is present on the lid or its seal, no effort should be made to remove it.
Note 5. (C) is measured at the narrowest point of the required fillet.



J-STD-001HS Figure 7-1

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
7.5.7	**Flat Gull Wing Leads** Connections formed to flat gull wing shaped leads **shall** meet the dimensional and solder fillet requirements of Table 7-7, see Figure 7-7 of this Addendum. Toe down is the formed condition of the foot where the heel and the toe are not planar to the board, with the toe biased downward. The angle can be from a few degrees up to 45 degrees, see Figure 7-7 of this Addendum. Angles over 45 degrees are considered butt/I leads, see 7.3 Parts Configured for Butt/I Lead Mounting.

Table 7-7 Dimensional Criteria – Flat Gull Wing Leads

Feature	Dim.	Requirement
Maximum Side Overhang	A	25% (W) or 0.5 mm [0.02 in], whichever is less, Note 1
Maximum Toe Overhang	B	Not permitted when (L) is less than 2 (W), Note 1
Minimum End Joint Width	C	75% (W), Note 6
Minimum Side Joint Length	D	100% of available lead to land interface or 2 (W), whichever is less, Note 7
Maximum Heel Fillet Height	E	Note 4
Minimum Heel Fillet Height	F	(G) + (T), Note 5
Solder Thickness	G	Note 3
Formed Foot Length	L	Note 2
Lead Thickness	T	Note 2
Lead Width	W	Note 2

Note 1. Does not violate minimum electrical clearance.
Note 2. Unspecified parameter or variable in size as determined by design. When lead forming is required, see 7.1.2 Forming of this Addendum.
Note 3. Wetting is evident.
Note 4. Solder does not touch package body or end seal, see J-STD-001H 7.1.1 Plastic Components for exceptions.
Note 5. In the case of a toe-down lead configuration, the Minimum Heel Fillet Height (F) extends at least to the mid-point of the outside lead bend.
Note 6. (C) is inspected at the narrowest point of the required fillet.
Note 7. If Side Overhang (A) is present, then the Side Joint Length (D) on the overhanging portion of the lead may not be inspectable.

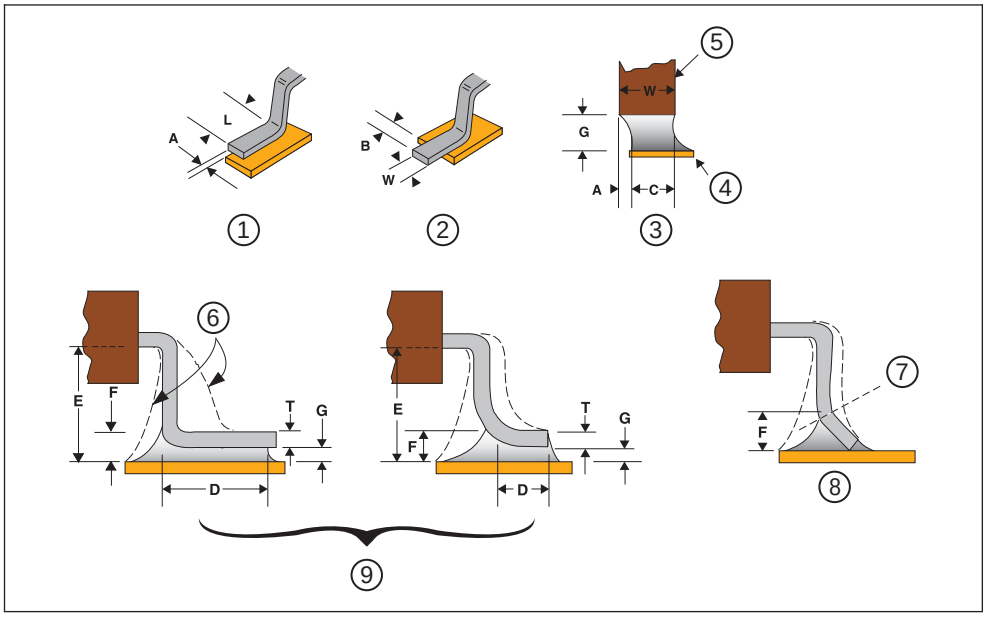


Figure 7-7 Flat Gull Wing Leads

1. Side overhang
2. Toe overhang
3. End joint width
4. Land
5. Lead
6. Solder fillet may extend through the top bend.
7. Line bisecting lower bend
8. Toe down heel fillet height
9. Side joint length

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

<table>
<tr><th>J-STD-001H Reference</th><th>Space and Military Applications Requirements (as changed by this Addendum)</th></tr>
<tr><td>7.5.8</td><td>
Round or Flattened (Coined) Gull Wing Leads Connections formed to round or flattened (coined) leads shall meet the dimensional and fillet requirements of Table 7-8 of this Addendum and J-STD-001H Figure 7-8.

Table 7-8 Dimensional Criteria – Round or Flattened (Coined) Gull Wing Leads
<table>
<tr><th>Feature</th><th>Dim.</th><th>Requirement</th></tr>
<tr><td>Maximum Side Overhang</td><td>A</td><td>25% (W) or 0.5 mm [0.02 in], whichever is less, Note 1</td></tr>
<tr><td>Maximum Toe Overhang</td><td>B</td><td>Not permitted when (L) is less than 2 (W), Note 1</td></tr>
<tr><td>Minimum End Joint Width</td><td>C</td><td>75% (W)</td></tr>
<tr><td>Minimum Side Joint Length</td><td>D</td><td>100% of available lead to land interface, Note 6</td></tr>
<tr><td>Maximum Heel Fillet Height</td><td>E</td><td>Note 4</td></tr>
<tr><td>Minimum Heel Fillet Height</td><td>F</td><td>(G) +(T), Note 5</td></tr>
<tr><td>Solder Thickness</td><td>G</td><td>Note 3</td></tr>
<tr><td>Formed Foot Length</td><td>L</td><td>Note 2</td></tr>
<tr><td>Minimum Side Joint Height</td><td>Q</td><td>(G) + 50% (T), Note 6</td></tr>
<tr><td>Thickness of Lead at Joint Side</td><td>T</td><td>Note 2</td></tr>
<tr><td>Flattened Lead Width or Diameter of Round Lead</td><td>W</td><td>Note 2</td></tr>
</table>
Note 1. Does not violate minimum electrical clearance.
Note 2. Unspecified parameter or variable in size as determined by design. When lead forming is required, see 7.1.2 Forming of this Addendum and J-STD-001H 7.1.6 Flattened Leads.
Note 3. Wetting is evident.
Note 4. Solder fillet may extend through the top bend. Solder does not touch package body or end seal, see J-STD-001H 7.1.1 Plastic Components for exceptions.
Note 5. In the case of a toe-down lead configuration, the Minimum Heel Fillet Height (F) extends at least to the mid-point of the outside lead bend.
Note 6. A Side Fillet (and corresponding Dimensions (D) & (Q)) may not be visually inspectable on a side where acceptable Side Overhang (A) is present.
</td></tr>
<tr><td>7.5.14</td><td>
Surface Mount Area Array Packages Process development and control is essential for continued success of assembly methods and implementation of materials. The area array criteria defined herein assumes an inspection process is established to determine compliance for either X-Ray or visual inspection processes.

Visual inspection:

• When visual inspection is the method used to verify product acceptance, the appropriate magnification table(s) from J-STD-001H 1.12.2.2 applies.

• The solder terminations on the outside row (perimeter) of the area array component shall be visually inspected.

• The area array component should align in both X & Y directions with the corner markers on the printed board (if present).

Absence of leads, e.g., solder ball or columns, are defects unless specified by design.

Evaluation of X-Ray images shall be used to allow assessment of characteristics that cannot be accomplished by normal visual means.

Note: See 1.11 Acceptance Requirements of this Addendum for NDE User concurrence prior to the use of X-Ray.

Process validation and control may be used in lieu of X-Ray/visual inspection provided objective evidence is approved by the User prior to use.

Note: X-Ray equipment not intended for electronic assemblies or not properly set up can damage sensitive components.

Area array process guidance is provided in IPC-7095, which contains recommendations developed from extensive discussion of process development issues.

Surface mount area array packages shall meet the dimensional and solder fillet requirements of J-STD-001H Table 7-15 for components with collapsing balls, J-STD-001H Table 7-16 for components with noncollapsing balls, and J-STD-001H Table 7-17 for column grid arrays.

When underfill is required, process and acceptance criteria shall be agreed upon between the Manufacturer and User.
</td></tr>
</table>

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

<table>
<tr><th>J-STD-001H Reference</th><th>Space and Military Applications Requirements (as changed by this Addendum)</th></tr>
<tr><td>7.5.15</td><td>
Bottom Termination Components (BTC) These criteria are also applicable to Small Outline Integrated Circuit No Leads (SOICNL).

Criteria for nonvisible part of thermal plane solder connections (including voids) are not described in this document and shall be established by agreement between the Manufacturer and the User. The thermal transfer plane acceptance criteria are design and process related. Issues to consider include, but are not limited to, the component supplier's application notes, solder coverage, voids, solder height, maximum junction temperature, etc. When soldering these types of components, voiding in the thermal plane is common. Solder, when required, shall meet documented requirements.

Connections formed to components having no significant external lead form shall meet the dimensional and solder fillet requirements of Table 7-18 of this Addendum and J-STD-001H Figure 7-16.

There are some package configurations that have no toe exposed or do not have a continuous solderable surface on the exposed toe on the exterior of the package. A toe fillet will not form.

Bottom Termination Component (BTC) process guidance is provided in IPC-7093, which contains recommendations developed from extensive discussion of BTC process development issues.

Process development and control is essential for continued success of assembly methods and implementation of materials. Evaluation of X-Ray images shall be used to allow assessment of characteristics that cannot be accomplished by normal visual means, e.g., when criteria for voids and thermal plane solder coverage are established.

Note: See 1.11 Acceptance Requirements of this Addendum for NDE User concurrence prior to the use of X-Ray.

Thermal plane voids shall comply with criteria established between the Manufacturer and User.

Table 7-18 Dimensional Criteria – BTC
<table>
<tr><th>Feature</th><th>Dim.</th><th>Requirement</th></tr>
<tr><td>Maximum Side Overhang</td><td>A</td><td>25% (W), Note 1</td></tr>
<tr><td>Toe Overhang (outside edge of component termination)</td><td>B</td><td>Not permitted</td></tr>
<tr><td>Minimum End Joint Width</td><td>C</td><td>75% (W) Note 6</td></tr>
<tr><td>Minimum Side Joint Length</td><td>D</td><td>Note 4</td></tr>
<tr><td>Minimum Toe (End) Fillet Height</td><td>F</td><td>Notes 2, 5</td></tr>
<tr><td>Solder Thickness</td><td>G</td><td>Note 3</td></tr>
<tr><td>Termination Height</td><td>H</td><td>Note 5</td></tr>
<tr><td>Land Width</td><td>P</td><td>Note 2</td></tr>
<tr><td>Termination Width</td><td>W</td><td>Note 2</td></tr>
</table>
Note 1. Does not violate minimum electrical clearance.
Note 2. Unspecified parameter or variable in size as determined by design.
Note 3. Wetting is evident.
Note 4. Not a visually inspectable attribute. See 4.15.3 of this Addendum.
Note 5. (H) = height of solderable surface of lead, if present. Some package configurations do not have a continuous solderable surface on the sides and do not require a toe (end) fillet.
Note 6. (C) is measured at the narrowest point of the required fillet.
</td></tr>
</table>

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

<table>
<tr><th>J-STD-001H Reference</th><th>Space and Military Applications Requirements (as changed by this Addendum)</th></tr>
<tr><td>7.5.16</td><td>
Components with Bottom Thermal Plane Terminations (D-Pak) Criteria for nonvisible parts of thermal plane solder connections are not described in this document and shall be established between the Manufacturer and the User. The thermal transfer plane acceptance criteria are design and process related. Issues to consider include, but are not limited to, component supplier's application notes, solder coverage, voids, solder height, etc. When soldering these types of components, voiding in the thermal plane is common.

Evaluation of X-Ray images shall be used to allow assessment of characteristics that cannot be accomplished by normal visual means.

Note: See 1.11 Acceptance Requirements of this Addendum for NDE User concurrence prior to the use of X-Ray.

The mounting and solder requirements for SMT terminations shall meet the criteria for the type of lead termination being used.

Connections formed to components with bottom thermal plane terminations, see J-STD-001H Figure 7-17, shall meet the dimensional and solder fillet requirements of Table 7-19 of this Addendum.

Table 7-19 Dimensional Criteria - Bottom Thermal Plane Terminations
<table>
<tr><th>Feature
(all connections except thermal plane)</th><th>Dim.</th><th>Requirement</th></tr>
<tr><td>Maximum Side Overhang</td><td>A</td><td rowspan="8">Criteria for the type of lead termination being used.</td></tr>
<tr><td>Toe Overhang</td><td>B</td></tr>
<tr><td>Minimum End Joint Width, Note 4</td><td>C</td></tr>
<tr><td>Minimum Side Joint Length</td><td>D</td></tr>
<tr><td>Maximum Heel Fillet Height</td><td>E</td></tr>
<tr><td>Minimum Heel Fillet Height</td><td>F</td></tr>
<tr><td>Solder Thickness</td><td>G</td></tr>
<tr><td>Lead Thickness</td><td>T</td></tr>
<tr><th>Feature
(only for the thermal plane connection)</th><th></th><th>Requirement</th></tr>
<tr><td>Thermal Plane Side Overhang</td><td></td><td>Not greater than 25% of termination width</td></tr>
<tr><td>Thermal Plane End Overhang</td><td></td><td>No overhang</td></tr>
<tr><td>Thermal Plane Minimum End Joint Width, Note 2</td><td></td><td>100% wetting to land in the end-joint contact area</td></tr>
<tr><td>Thermal Plane Side Joint Length</td><td>D</td><td>Note 1</td></tr>
<tr><td>Thermal Plane Solder Fillet Thickness</td><td>G</td><td>Wetting is evident when a fillet is present</td></tr>
<tr><td>Thermal Plane Voids</td><td></td><td>Note 1</td></tr>
<tr><td>Thermal Plane Termination Width</td><td>W</td><td>Note 3</td></tr>
<tr><td>Thermal Plane Land Width</td><td>P</td><td>Note 3</td></tr>
</table>
Note 1. As established between the Manufacturer and User.
Note 2. Solder wetting is not required on trimmed edges of a thermal plane that expose non-wettable vertical surfaces.
Note 3. Unspecified parameter or variable in size, as determined by design.
Note 4. (C) is measured at the narrowest point of the required fillet.
</td></tr>
<tr><td>7.5.17</td><td>Flattened Post Terminations If parts with flattened post terminations are chosen by design, their use, including acceptance criteria, shall be approved by the User.</td></tr>
</table>

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

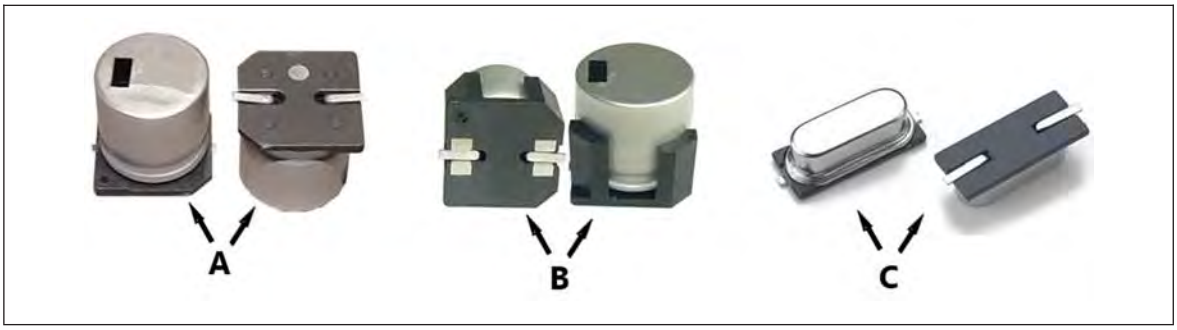
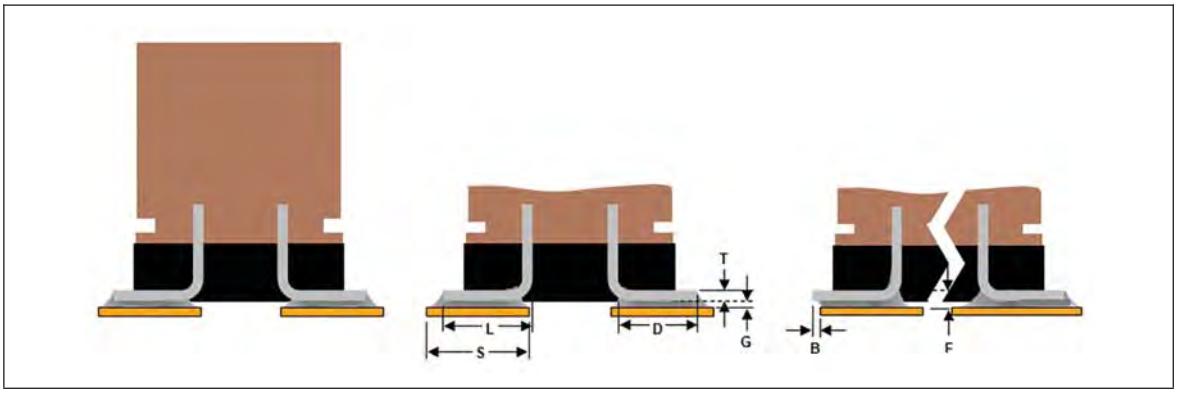
J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
7.5.19	**Vertical Cylindrical Cans with Outward L-Shaped Lead Terminations** The vertical cylindrical cans with outward L-shaped lead termination criteria defined herein assumes an inspection process is established to determine compliance for either x-ray or normal visual inspection processes. To a limited extent, this may involve visual assessment, but more commonly requires evaluation of x-ray images to allow assessment of characteristics that cannot be accomplished by normal visual means. If Vertical Cylindrical Cans with Outward L-Shaped Leads Terminations are chosen by design, acceptance criteria **shall** be approved by the User prior to use. Visual inspection requirements: a. When visual inspection is the method used to verify product acceptance the magnification levels of Tables 1-2 and 1-4 apply. b. The visible portion of the solder connection(s) **shall** meet the requirements of Table 7-22 of this Addendum. Process development and control is essential for continued success. Process validation and control can be used in lieu of x-ray/visual inspection provided objective evidence of compliance is available. **Note:** X-ray equipment not intended for electronic assemblies or not properly set up can damage sensitive components. See Appendix D. Connections formed to vertical cylindrical cans with outward L-shaped lead terminations **shall** meet the dimensional and solder fillet requirements of Table 7-22, see Figures 7-20 and 7-21 of this Addendum. This termination style is typically found on aluminum electrolytic capacitors, or two-pin SMT Crystal Oscillators.

Table 7-22 Dimensional Criteria – Vertical Cylindrical Cans with Outward L-Shaped Lead Terminations

Feature	Dim.	Requirement
Maximum Side Overhang	A	25% (W), Note 1
Maximum Toe Overhang	B	Not permitted
Minimum End Joint Width	C	75% (W)
Minimum Side Joint Length	D	100% (L)
Maximum Heel Fillet Height	E	Note 4
Minimum Heel Fillet Height	F	(G) + (T)
Solder Thickness	G	Note 3
Formed Foot Length	L	Note 2
Land Width	P	Note 2
Land Length	S	Note 2
Lead Thickness	T	Note 2
Lead Width	W	Note 2

Note 1. Does not violate minimum electrical clearance.
Note 2. Unspecified parameter or variable in size as determined by design.
Note 3. Wetting is evident.
Note 4. Solder does not touch package body or end seal, except for the plastic terminal platform/base.

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
7.5.19 (cont.)	 **Figure 7-20 Examples of Vertical Cylindrical Cans with Outward L-Shaped Lead Terminations** **A. Standard Aluminum Electrolytic Capacitors** **B. Vibration Resistant (Ruggedized) Aluminum Electrolytic Capacitors** **C. SMT Two-Pin Oscillators**  **Figure 7-21 Vertical Cylindrical Cans with Outward L-Shaped Lead Terminations**

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
7.5.20	**Wrapped Terminals** Connections formed to wrapped terminals (terminals made by a wire going around a supporting element/wrap that is then metallized) **shall** meet the dimensional requirements of Table 7-23, see Figures 7-22, 7-23, 7-24 and 7-25 of this Addendum.

Table 7-23 Dimensional Criteria – Wrapped Terminals

Feature	Dim.	Requirement
Maximum Side Overhang	A	25% (W), Note 1
End Overhang	B	Not permitted
Minimum End Joint Width	C	150% (R), Note 5
Minimum Side Joint Length	D	75% (R)
Maximum Heel Fillet Height	E	Note 6
Minimum Heel Fillet Height	F	(G) + (T), Note 4
Solder Thickness	G	Note 3
Lead Thickness	T	Note 2
Termination Length	R	Note 2
Termination Diameter	W	Note 2

Note 1. Does not violate minimum electrical clearance.
Note 2. Unspecified dimension or variable in size as determined by design.
Note 3. Wetting is evident.
Note 4. (F) is inspected at the lowest point of the required fillet, see Figure 7-25.
Note 5. (C) is inspected at the narrowest point of the required fillet.
Note 6. Solder may contact the component body.

Figure 7-22 Wrapped Terminal – SMT Inductor – Bottom View

Figure 7-23 Wrapped Terminal – SMT Inductor – Top View

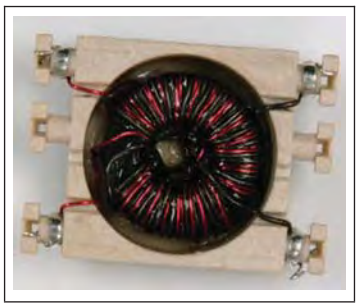


Figure 7-24 Wrapped Terminal – SMT Component

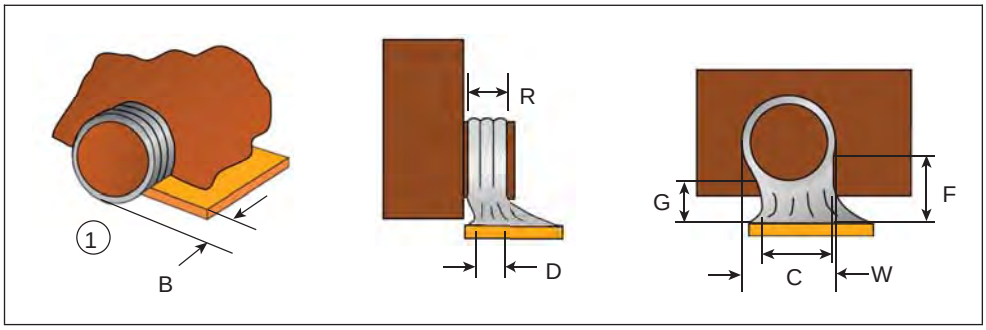


Figure 7-25 Wrapped Terminals

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

<table>
<tr><th>J-STD-001H Reference</th><th>Space and Military Applications Requirements (as changed by this Addendum)</th></tr>
<tr><td>8.0</td><td>Cleaning and Residue Requirements Unless otherwise specified by design, or by the User, the acceptability of the residue condition shall be determined at the point of manufacturing process for each assembly just prior to the application of conformal coating, or on the final assembly if conformal coating is not applied.</td></tr>
<tr><td>8.1</td><td>Qualified Manufacturing Process Unless otherwise specified by the User, the Manufacturer shall qualify soldering and/or cleaning processes that result in acceptable levels of flux and other residues. Objective evidence shall be available for review. See J-STD-001H Appendix C for examples of objective evidence. Rework processes shall be included in the process qualification.

The use of the 1.56 µg/NaCl equivalence/cm2 value for resistivity of solvent extract (ROSE), with no other supporting objective evidence, is not considered an acceptable basis for qualifying a manufacturing process, see IPC-WP-019.</td></tr>
<tr><td>8.1.1</td><td>Cleaning Designator Unless otherwise specified by the User/Design Authority, the Manufacturer should specify a cleaning designator that establishes the cleaning option and process control tests for manufacturing residues. The cleaning designator is a 2-digit (minimum) code that describes the cleaning and process control testing required for assemblies under this standard. The code begins with the letter ‘‘C’’ and then a dash followed by two or more digits. The first digit represents the cleaning option:

Table 8-1 Designation of Surfaces to be Cleaned
<table><tr><td>0</td><td>No surfaces to be cleaned</td></tr><tr><td>1</td><td>One side (solder source side) of assembly to be cleaned</td></tr><tr><td>2</td><td>Both sides of assembly to be cleaned</td></tr></table>
The second and any subsequent digits define the requirements for process control of residues:

Table 8-2 Residue Testing for Process Control
<table><tr><td>0</td><td>No test required</td></tr><tr><td>1</td><td>Test for rosin residues required, see 8.6 Non-Ionic Residues</td></tr><tr><td>2</td><td>Test for ionic residues required, see 8.2 Ionic Process Monitoring</td></tr><tr><td>3</td><td>Test for surface insulation resistance (Note 1)</td></tr><tr><td>4</td><td>Test for surface organic contaminants (Note 1)</td></tr><tr><td>5</td><td>Other testing (Note 1)</td></tr></table>
Note 1. As agreed between Manufacturer and User if required.

In the absence of a specified cleaning designator, the designator C-22 shall apply to printed board assemblies. A Cleaning Designator of C-00 specifies a ‘‘no clean’’ process with no testing for residues. A Cleaning Designator of C-223 specifies a printed board assembly requiring cleaning on both sides, in addition to ionic residue and surface insulation resistance (SIR) testing. Cleanliness designator C-10 and the visual requirements for cleanliness, see 8.4 Foreign Object Debris (FOD) and 8.5 Visible Residues of this Addendum, shall apply to designs incorporating discrete solder terminations, e.g., solder cups, wire splices, or wire/braid, not terminated to a printed board assembly.</td></tr>
<tr><td>8.3.1</td><td>Level 1 – Major Changes Requiring Validation When major elements of the qualified processes are changed, validation of the acceptability of the change(s) shall be performed and documented. Major changes shall be approved by the User prior to use, see 3.1 Materials of this Addendum.

The following are considered major elements impacting residue levels.
• Flux or flux-bearing materials (e.g., flux, solder paste, paste flux, cored wire solder)
• Cleaning agents (e.g., solvents, aqueous detergents, topical cleaners)
• Changes in solder mask type
• Changes in printed board fabrication processes or surface metallization
• Geographic change in manufacturing location</td></tr>
<tr><td>8.4</td><td>Foreign Object Debris (FOD) Assemblies shall be free of foreign particles that are loose, e.g., could be dislodged in the service environment of the product or violate minimum electrical clearance.

Solder balls are allowed if proven secured, i.e., will not come loose during transportation, storage, or operation of the system, with a documented specialized process. The specialized process and acceptance criteria shall be approved by the User prior to use. The approved process shall be applied to 100% of all solder balls. Data generated by the approved process shall be maintained and available for review.</td></tr>
</table>

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
8.5	**Visible Residues** As an exception to J-STD-001H Table 1-4, surfaces cleaned **shall** be inspected between 4X and 10X magnification. Assemblies subjected to cleaning processes **shall** be free of visible residues that violate minimum electrical clearance, unless identified as benign through laboratory analysis or equivalent. All other visible residue requirements **shall** be as established between Manufacturer and User.
9.1.1	**Blistering/Delamination** There **shall** be no blistering or delamination between any of the laminate layers, or between the laminate and the metallization. **Note:** Measling is NOT the same as blistering or delamination. See IPC-T-50 and IPC-A-610 for clarification.
9.1.2	**Weave Exposure/Cut Fibers** There **shall** be no non-wetted exposed glass fibers. There **shall** be no surface damage that cuts into laminate fibers. Exposed fibers may extend onto the top and bottom surfaces of the printed board a maximum of 0.6 mm [0.02 in] around the perimeter of the printed board or around unsupported holes without lands.
9.1.9	**Burns** There **shall** not be any heat-caused discoloration.
9.1.11	**Measles** Measles **shall not** bridge non-common conductors.
10.0	**Coating, Encapsulation, Staking and Bonding** All assemblies **shall** be cleaned before processing. After cleaning, prior to processing, assemblies **shall** be handled in a manner that prevents contamination. Items exposed to uncured silicone material **shall not** be used for processing other material. An authorized exception is allowed only in cases where equipment is used for co-curing processes and the Manufacturer has demonstrated through system tests that non-silicone material properties have not changed and design requirements are met. Objective evidence **shall** be maintained and available for review. a. A mix record **shall** be created for each mixed batch of multi-part polymers used for conformal coating, encapsulating, staking or bonding. At a minimum, this record **shall** include the date mixed, supplier's part number and date/lot code, shelf life expiration date (of all parts of the mix), the mix ratio for all constituents used, traceability to the hardware the material is being applied to, test specimen acceptance test results, and material supplier's datasheet acceptance criteria. As an exception, Manufacturers that use continuous run processes **shall** have a documented process for mixing and traceability. b. For one-part polymers, the supplier's part number and lot/date code, and shelf life expiration date **shall** be documented. c. Non-porous containers and mixing tools **shall** be used. Containers and mixing tools **shall** be selected such that their use in combination cannot introduce contamination into the mix, e.g., a metal stirrer can scrape shavings from a plastic container. d. Fillers, e.g., thickening agents, thermal property enhancers, etc., **shall** be treated to remove detrimental moisture and other volatiles prior to adding to any polymer. e. After assembly and prior to staking, coating, encapsulating or bonding, the assembly **shall** be cleaned. f. After final cleaning and prior to coating or encapsulating, the assembly **shall** be treated to remove detrimental moisture. g. Staking and bonding **shall** be performed prior to conformal coating. h. Tapes and other maskants with conductive material in the adhesive **shall not** be used to mask over printed board conductor patterns. i. When coating, encapsulation, or staking materials are applied to through-hole glass, ceramic, or hermetic components, the components **shall** be protected to prevent cracking unless the material has been selected so as not to damage the components/assembly in its service environment. j. Materials **shall** be cured in accordance with a documented cure schedule and within the thermal limitations of the hardware. Objective evidence of full cure for each batch of material **shall** be documented. A witness sample may be used for this verification. k. When fluorescent conformal coating materials are used, coverage and location **shall** be determined by UV-light examination.
10.1.3	**Application** Conformal coating may be applied by spray, dip, brush, vacuum deposition, or other application methods, but **shall** be applied in accordance with a documented procedure. Coating **shall** be applied only to areas designated for coverage on the assembly drawing/documentation. Assembly drawing/documentation should indicate all areas to be kept free of conformal coating and the tolerance on the keep-out zone.

J-STD-001HS Table 1 Space and Military Applications Requirements (cont.)

J-STD-001H Reference	Space and Military Applications Requirements (as changed by this Addendum)
10.1.11	**Rework or Touchup** Procedures that describe the removal and replacement of conformal coating **shall** be documented and available for review. Chemical stripping processes **shall** be approved by the User prior to use. The coating rework or touchup areas **shall** meet the requirements of the assembly drawing(s)/documentation. If thickness measurements are required in the reworked area, the validation process **shall** be documented and available for review. **Note:** Conformal coating buildup on or around some component types such as glass or ceramic bodied components may cause damage. Coating touch-up should be applied as close to the original coating thickness as possible.
10.3.1.2	**Staking – Application – SMT** The following criteria apply to surface mount components only. **a. Components whose largest dimension is their height –** The staking material **shall** be applied to a minimum height of 25% of each individual component's body height. Slight flow of staking material under the component body is acceptable if it does not violate J-STD-001H 10.3.1 Staking – Application. For closely spaced arrays, fillet height requirements for the two outer end-faces **shall** be the same as for an individual component. In addition, the top inner surfaces **shall** be bonded / staked to each other for at least 50% of the component's width. **b. Components whose largest dimension is their diameter or length, e.g., QFPs –** Rectangular components **shall** be staked with a bead of staking material placed at each corner of the component. For each bead, the staking material **shall** contact a minimum 25% of the height of the component body. Slight flow of staking material under the component body is acceptable if it does not violate J-STD-001H 10.3.1 Staking – Application.
10.4 [NEW]	**Bonding (Adhesive)** The bonding criteria below **shall** be used when criteria are not provided by the engineering documentation. a. The bonding material **shall** adhere to all surfaces to be joined. b. Leads of thermistors, platinum resistance thermometers (PRT), and similar components **shall** be dressed to provide stress relief. For disc-shaped/wafer components, e.g., thermistors, at least one lead **shall not** be embedded in the bonding material. See the staking requirements in 5.6.3 of this Addendum when components have leads longer than 2.5 cm [1 in] or are connected by wires. c. Squeeze-out **shall** be visible unless sheet adhesive is used. Squeeze-out **shall not** negate stress relief of the component and **shall not** preclude the component from meeting other requirements in the standard. **Note:** These criteria are not intended for bonding used for thermal transfer; refer to engineering documentation.
12.2	**Repair** Repair is the act of restoring the functional capability of a defective article in a manner that does not assure compliance of the article with applicable drawings or specifications. A hardware defect **shall not** be repaired until the discrepancy has been documented and only after authorization from the User for each incident. The repair method **shall** be determined by agreement between the Manufacturer and the User.

Standard Improvement Form

IPC J-STD-001HS

The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard.

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1. I recommend changes to the following:

___ Requirement, paragraph number _____

___ Test Method number _____, paragraph number _____

The referenced paragraph number has proven to be:

___ Unclear ___ Too Rigid ___ In Error

___ Other _____

2. Recommendations for correction:

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Company Annual Revenue						
Annual Revenue	**1 Year Membership**		**2 Year Membership (10% discount)**		**3 Year Membership (15% discount)**	
<$1M	☐	$550	☐	$495 per year	☐	$468 per year
$1M - <$5M	☐	$850	☐	$765 per year	☐	$722 per year
$5M - <$25M	☐	$1,450	☐	$1,305 per year	☐	$1,233 per year
$25M - <$50M	☐	$1,700	☐	$1,530 per year	☐	$1,445 per year
$50M - <$100M	☐	$2,050	☐	$1,845 per year	☐	$1,743 per year
$100M - <$250M	☐	$2,400	☐	$2,160 per year	☐	$2,040 per year
$250M - <$500M	☐	$3,000	☐	$2,700 per year	☐	$2,550 per year
$500M - <$1B	☐	$3,500	☐	$3,150 per year	☐	$2,975 per year
$1B - <$2.5B	☐	$4,000	☐	$3,600 per year	☐	$3,400 per year
$2.5B+	☐	$4,600	☐	$4,140 per year	☐	$3,910 per year
Education Institution	☐	$1,700	☐	$1,530 per year	☐	$1,445 per year
Government Agency	☐	$2,400	☐	$2,160 per year	☐	$2,040 per year

Standards Subscription Customer						
Annual Revenue	**1 Year Membership**		**2 Year Membership (10% discount)**		**3 Year Membership (15% discount)**	
<$1M	☐	$2,000.00	☐	$1,800 per year	☐	$1,700 per year
$1M - <$5M	☐	$2,500.00	☐	$2,250 per year	☐	$2,150 per year
$5M - <$25M	☐	$3,000.00	☐	$2,700 per year	☐	$2,550 per year
$25M - <$50M	☐	$3,500.00	☐	$3,150 per year	☐	$2,975 per year
$50M - <$100M	☐	$4,000.00	☐	$3,600 per year	☐	$3,400 per year
$100M - <$250M	☐	$5,000.00	☐	$4,500 per year	☐	$4,250 per year
$250M - <$500M	☐	$6,000.00	☐	$5,400 per year	☐	$5,100 per year
$500M - <$1B	☐	$7,000.00	☐	$6,300 per year	☐	$5,950 per year
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