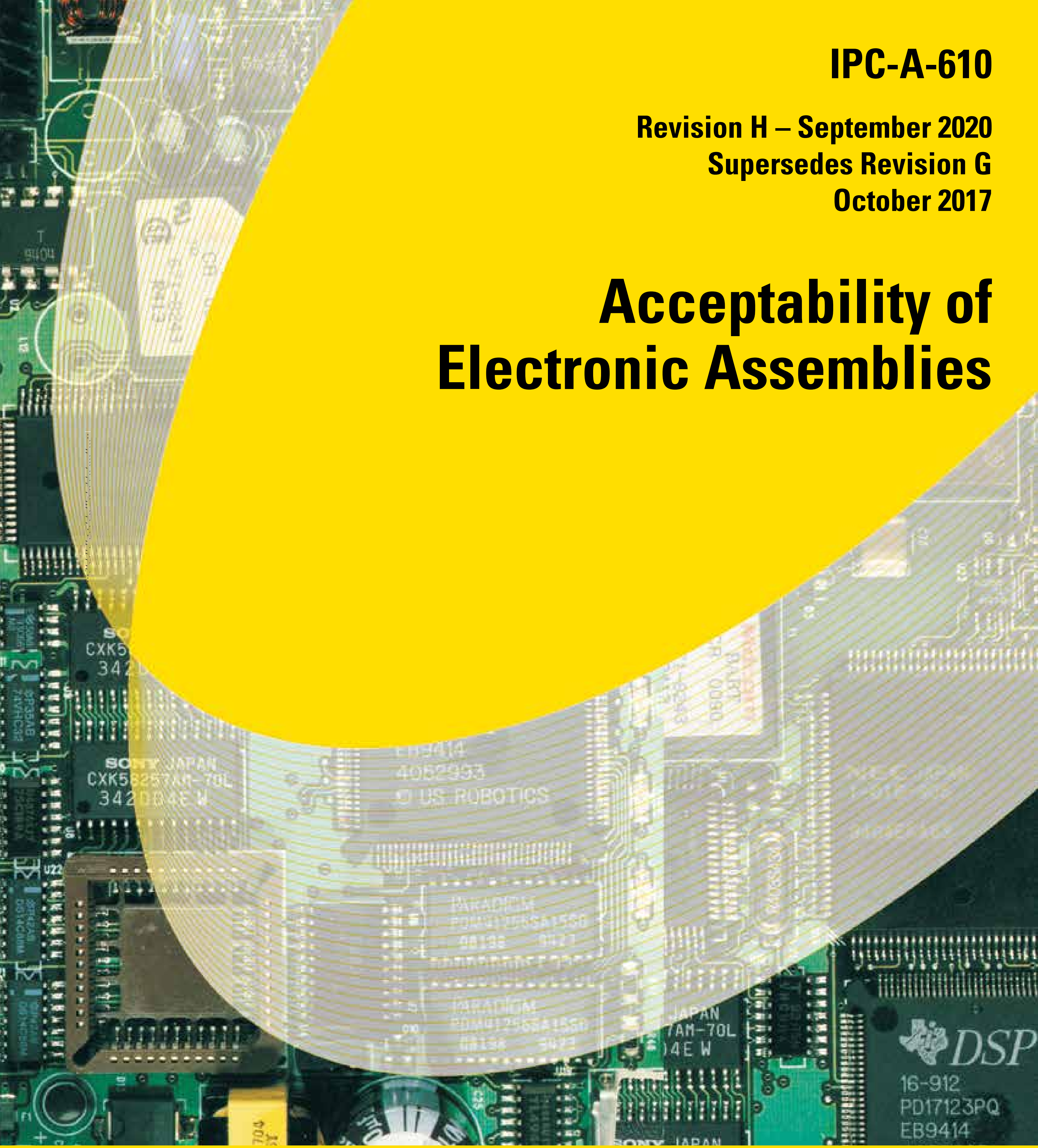

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Acceptability of Electronic Assemblies

Developed by

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BUILD ELECTRONICS BETTER

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1 General

1.1 Scope This standard is a collection of visual quality acceptability requirements for electronic assemblies. This standard does not provide criteria for cross-section evaluation.

This document presents acceptance requirements for the manufacture of electrical and electronic assemblies. Historically, electronic assembly standards contained a more comprehensive tutorial addressing principles and techniques. 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 J-STD-001.

The criteria in this standard are not intended to define processes to accomplish assembly operations nor is it intended to authorize repair/modification or change of the product. For instance, the presence of criteria for adhesive bonding of components does not imply/authorize/require the use of adhesive bonding and the depiction of a lead wrapped clockwise around a terminal does not imply/authorize/require that all leads/wires be wrapped in the clockwise direction.

Users of this standard should be knowledgeable of the applicable requirements of the document and how to apply them, see 1.3 Classification.

IPC-A-610 has criteria outside the scope of J-STD-001 defining mechanical and other workmanship requirements. Table 1-1 is a summary of related documents.

Table_1-1 Summary of Related Documents

Document Purpose	Spec.#	Definition
Design Standard	IPC-2220-FAM IPC-7351 IPC-CM-770	Design requirements reflecting three levels of complexity (Levels A, B, and C) indicating finer geometries, greater densities, more process steps to produce the product. Component and Assembly Process Guidelines to assist in the design of the bare board and the assembly where the bare board processes concentrate on land patterns for surface mount and the assembly concentrates on surface mount and through-hole principles which are usually incorporated into the design process and the documentation.
Printed Board – Requirements	IPC-6010-FAM IPC-A-600	Requirements and acceptance documentation for rigid, rigid flex, flex and other types of substrates.
End Item Documentation	IPC-D-325	Documentation depicting bare board or assembly requirements. Details may or may not reference industry specifications or workmanship standards as well as the User's own preferences or internal standard requirements.
Process Requirement Standard	J-STD-001	Requirements for soldered electrical and electronic assemblies depicting minimum end product acceptable characteristics as well as methods for evaluation (test methods), frequency of testing and applicable ability of process control requirements.
Acceptability Standard	IPC-A-610	Pictorial interpretive document indicating various characteristics of the board and/or assembly as appropriate relating to desirable conditions that exceed the minimum acceptable characteristics indicated by the end item performance standard and reflect various out-of-control (process indicator or defect) conditions to assist the shop process evaluators in judging need for corrective action.
Training Programs (Optional)		Documented training for process, procedures, techniques, and requirements.
Rework and Repair	IPC-7711/7721	Documentation providing the procedures to accomplish conformal coating and component removal and replacement, solder resist repair, and modification/repair of laminate material, conductors, and plated through-holes.

IPC-AJ-820 is a supporting document that provides information regarding the intent of this specification content and explains or amplifies the technical rationale for transition of limits through Acceptable to Defect condition criteria. In addition, supporting information is provided to give a broader understanding of the process considerations that are related to performance but not commonly distinguishable through visual assessment methods.

The explanations provided in IPC-AJ-820 should be useful in determining disposition of conditions identified as Defect, processes associated with Process Indicators, as well as answering questions regarding clarification in use and application for defined content of this specification. Contractual reference to IPC-A-610 does not additionally impose the content of IPC-AJ-820 unless specifically referenced in contractual documentation.

1.2 Purpose The visual standards in this document reflect the requirements of existing IPC and other applicable specifications. For the content of this document to apply, the assembly/product should comply with other existing IPC requirements, such as

1 General (cont.)

IPC-7351, IPC-2220-FAM, IPC-6010-FAM and IPC-A-600. If the assembly does not comply with these or with equivalent requirements, the acceptance criteria **shall** be defined between the User and Supplier.

The illustrations in this document portray specific points noted in the title of each page. A brief description follows each illustration. It is not the intent of this document to exclude any acceptable procedure, such as for component placement or for applying flux and solder used to make the electrical connection, however, the methods used **shall** produce completed solder connections conforming to the acceptability requirements described in this document.

In the case of a discrepancy, the description or written criteria always takes precedence over the illustrations.

Standards may be updated at any time, including with the use of amendments. The use of an amendment or newer revision is not automatically required.

1.3 Classification The User has the ultimate responsibility for identifying the class to which the assembly is evaluated. If the User does not establish and document the acceptance class, the Manufacturer may do so.

Criteria defined in this document reflect three classes, which are as follows:

Class 1 – General Electronic Products
Includes products suitable for applications where the major requirement is function of the completed assembly.

Class 2 – Dedicated Service Electronic Products
Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically the end-use environment would not cause failures.

Class 3 – High Performance Electronic Products
Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support or other critical systems.

1.4 Measurement Units and Applications This standard uses International System of Units (SI) units per ASTM SI10, IEEE/ASTM SI 10, Section 3 [Imperial English equivalent units are in brackets for convenience]. The SI units used in this standard are millimeters (mm) [in] for dimensions and dimensional tolerances, Celsius (°C) [°F] for temperature and temperature tolerances, grams (g) [oz] for weight, and lux (lx) [footcandles] for illuminance.

Note: This standard uses other SI prefixes to eliminate leading zeroes (for example, 0.0012 mm becomes 1.2 µm) or as alternative to powers-of-ten (3.6 x 10^3 mm becomes 3.6 m).

1.4.1 Verification of Dimensions Actual measurement of specific part mounting and solder fillet dimensions and determination of percentages are not required except for referee purposes. For determining conformance to the specifications in this standard, round all observed or calculated values ''to the nearest unit'' in the last right-hand digit used in expressing the specification limit, in accordance with the rounding method of ASTM E29. For example, specifications of 2.5 mm max, 2.50 mm max, or 2.500 mm max, round the measured value to the nearest 0.1 mm, 0.01 mm, or 0.001 mm, respectively, and then compare to the specification number cited.

1.5 Definition of Requirements This document provides acceptance criteria for completed electronic assemblies. Where a requirement is presented that cannot be defined by the acceptable, process indicator, and defect conditions, the word ''**shall**'' is used to identify the requirement. Unless otherwise specified herein, the word ''**shall**'' in this document invokes a requirement for Manufacturers of all classes of product, and failure to comply with the requirement is a noncompliance to this standard.

Many of the examples (illustrations) shown are grossly exaggerated in order to depict the reason for the acceptance criteria.

It is necessary that users of this standard pay particular attention to the subject of each section to avoid misinterpretation.

1 General (cont.)

1.5.1 Acceptance Criteria Criteria are given for each class in three conditions: Acceptable, Defect or Process Indicator. ''Not Established'' means that there are no specified criteria for that class and may need to be established between Manufacturer and User.

1.5.1.1 Acceptable Condition This characteristic indicates a condition that, while not necessarily perfect, will maintain the integrity and reliability of the assembly in its service environment.

1.5.1.2 Defect Condition A defect is a condition that may be insufficient to ensure the form, fit or function of the assembly in its end use environment. Defect conditions **shall** be dispositioned by the Manufacturer based on design, service, and User requirements.

It is the responsibility of the User to define unique defect categories applicable to the product.

A defect for Class 1 automatically implies a defect for Class 2 and 3. A defect for Class 2 implies a defect for Class 3.

Note: This would not be the case where criteria for a particular class have not been established.

1.5.1.2.1 Disposition The determination of how defects should be treated. Dispositions include, but are not limited to, rework, use as is, scrap or repair. Repair or ''use as is'' may require User concurrence.

1.5.1.3 Process Indicator Condition A process indicator is a condition (not a defect) that identifies a characteristic that does not affect the form, fit or function of a product:

- Such condition is a result of material, design and/or operator/machine related causes that create a condition that neither fully meets the acceptance criteria nor is a defect.
- Process indicators should be monitored as part of the process control system. When the number of process indicators indicate abnormal variation in the process or identify an undesirable trend, then the process should be analyzed. This may result in action to reduce the variation and improve yields.
- Disposition of individual process indicators is not required.

1.5.1.4 Combined Conditions Cumulative conditions **shall** be considered in addition to the individual characteristics for product acceptability even though they are not individually considered defective. The significant number of combinations that could occur does not allow full definition in the content and scope of this specification but Manufacturers should be vigilant for the possibility of combined and cumulative conditions and their impact upon product performance.

Conditions of acceptability provided in this specification are individually defined and created with separate consideration for their impact upon reliable operation for the defined production classification. Where related conditions can be combined, the cumulative performance impact for the product may be significant, e.g., minimum solder fillet quantity when combined with maximum side overhang and minimum end overlap may cause a significant degradation of the mechanical attachment integrity. The Manufacturer is responsible for identification of such conditions.

The User is responsible to identify combined conditions where there is significant concern based upon end use environment and product performance requirements.

1.5.1.5 Conditions Not Specified Conditions that are not specified as defective or as a process indicator may be considered acceptable unless it can be established that the condition affects user defined form, fit or function.

1.5.1.6 Specialized Designs IPC-A-610, as an industry consensus document, cannot address all of the possible components and product design combinations. Where uncommon or specialized technologies are used, it may be necessary to develop unique acceptance criteria. However, where similar characteristics exist, this document may provide guidance for product acceptance criteria. Often, unique definition is necessary to consider the specialized characteristics while considering product performance criteria. The development should include User involvement or consent. For Classes 2 and 3 the criteria **shall** include agreed definition of product acceptance.

Whenever possible these criteria should be submitted to the IPC Technical Committee to be considered for inclusion in upcoming revisions of this standard.

1 General (cont.)

1.5.1.7 Should The word ''**should**'' reflects recommendations and is used to reflect general industry practices and procedures for guidance only.

1.6 Process Control Methodologies Process control methodologies should be used in the planning, implementation and evaluation of the manufacturing processes used to produce soldered electrical and electronic assemblies. The philosophy, implementation strategies, tools and techniques may be applied in different sequences depending on the specific company, operation, or variable under consideration to relate process control and capability to end product requirements. The Manufacturer should maintain objective evidence of a current process control/continuous improvement plan that is available for review.

1.7 Order of Precedence When IPC-A-610 is cited or required by contract as a stand-alone document for inspection and/or acceptance, the requirements of J-STD-001 do not apply unless separately and specifically required.

In the event of conflict, the following order of precedence applies:

1. Procurement as agreed and documented between Manufacturer and User.
2. Master drawing or master assembly drawing reflecting the User's detailed requirements.
3. When invoked by the User or per contractual agreement, IPC-A-610.

When documents other than IPC-A-610 are cited, the order of precedence should be defined in the procurement documents. The User has the opportunity to specify alternate acceptance criteria.

1.7.1 Clause References When a clause in this document is referenced, its subordinate clauses also apply.

1.7.2 Appendices Appendices to this standard are not binding requirements unless separately and specifically required by the applicable contracts, engineering documentation or purchase orders.

1.8 Terms and Definitions

1.8.1 Board Orientation The following terms are used throughout this document to determine the board side. The source/destination side **shall** be considered when applying some criteria, such as that in Tables 7-4, 7-5 and 7-7.

1.8.1.1 Primary Side The side of a packaging and interconnecting structure that is so defined on the master drawing. (It is usually the side that contains the most complex or the most number of components.) (This side is sometimes referred to as the component side or solder destination side in through-hole mounting technology.)

1.8.1.2 Secondary Side That side of a packaging and interconnecting structure that is opposite the primary side. (This side is sometimes referred to as the solder side or solder source side in through-hole mounting technology.)

1.8.1.3 Solder Source Side The solder source side is that side of the printed board to which solder is applied. The solder source side is normally the secondary side of the printed board when wave, dip, or drag soldering are used. The solder source side may be the primary side of the printed board when hand soldering operations are conducted.

1.8.1.4 Solder Destination Side The solder destination side is that side of the printed board that the solder flows toward in a through-hole application. The destination is normally the primary side of the printed board when wave, dip or drag soldering is used. The destination side may be the secondary side of the printed board when hand-soldering operations are conducted.

1.8.2 Cold Solder Connection A solder connection that exhibits poor wetting, and that is characterized by a grayish porous appearance. (This is due to excessive impurities in the solder, inadequate cleaning prior to soldering, and/or the insufficient application of heat during the soldering process.)

1.8.3 Common Conductors Electrical conductors, e.g., contacts, printed conductors / traces, surfaces, terminals, wires, etc., that, by design, carry an identical electrical current, frequency, polarity, and/or potential (voltage), or that by design have identical or redundant electrical functions, e.g., signal, status, etc.

1 General (cont.)

1.8.4 Diameter

- **Conductor Diameter** The conductor diameter is the outside diameter of wire, either stranded or solid, without the insulation.
- **Wire Diameter** Wire diameter is the outside diameter of wire, either stranded or solid, including insulation if present.
- **Strand Diameter** The strand diameter is the outside diameter of the individual metal filament used within a stranded wire.

1.8.5 Electrical Clearance Throughout this document the minimum spacing between noncommon uninsulated conductors, e.g., patterns, materials, hardware, or residue, is referred to as ''minimum electrical clearance.'' It is defined in the applicable design standard or on the approved or controlled documentation. In the absence of a known design standard use Appendix A (derived from IPC-2221). Any violation of minimum electrical clearance is a defect condition for all classes.

1.8.6 Engineering Documentation Drawings, specifications, technical illustrations, and other documents, prepared and released by the design activity in any form of media, that establish the design and design requirements.

1.8.7 FOD (Foreign Object Debris) A generic term for a substance, debris, particulate matter or article alien to the assembly or system.

1.8.8 Form, Fit, Function (F/F/F) An identifying characteristic, e.g., a part, solder connection, sub-assembly, or assembly, that, if not met, would adversely impact installation, reliability or operation of adjacent parts, a next level assembly, or an integrated assembly or system.

1.8.9 High Voltage The term ''high voltage'' will vary by design and application. The high voltage criteria in this document are only applicable when specifically required in the drawings/procurement documentation.

1.8.10 Intrusive Solder A process in which the solder paste for the through-hole components is applied using a stencil or syringe to accommodate through-hole components that are inserted and reflow-soldered together with the surface-mount components.

1.8.11 Kink A tight or abrupt bend in a wire or component lead that visibly reduces the diameter (or thickness) of the conductor, and cannot be removed by straightening.

1.8.12 Locking Mechanism A method of preventing loosening or disconnection of a mated part, e.g., a fastener or connector, either by use of a device integral to the part, e.g., a polymer insert, a design feature, e.g., a spring clip, latch, twist detent, or push-pull, or an additive material, e.g., threadlocking adhesive, safety wire.

1.8.13 Manufacturer The individual, organization, or company responsible for the assembly process and verification operations necessary to ensure full compliance of assemblies to this standard.

1.8.14 Meniscus (Component) Sealant or encapsulant on a lead, protruding from the seating plane of the component. This includes materials such as ceramic, epoxy or other composites, and flash from molded components.

1.8.15 Noncommon Conductors Electrical conductors, e.g., contacts, printed conductors / traces, surfaces, terminals, wires, etc., that, by design, carry different electrical currents, frequencies, polarities, and/or potentials (voltages), or that by design have different electrical functions, e.g., signal, status, etc.

From a visual inspection standpoint, it is difficult for an inspector to determine if two or more adjacent conductors are electrically common unless either the start or end point (termination) of each conductor is visually accessible. For this reason, ALL adjacent conductors should be treated as noncommon until identified otherwise by engineering documentation.

1.8.16 Nonfunctional Land A land that is not connected electrically to the conductive pattern on its layer.

1.8.17 Pin-in-Paste See 1.8.10 Intrusive Solder

1 General (cont.)

1.8.18 Solder Balls Solder balls are spheres of solder that remain after the soldering process. This includes small balls of solder paste that have splattered around the connection during the reflow process.

1.8.19 Standard Industry Practice (SIP) A commonly-used engineering design solution, manufacturing process / procedure, or assembly technique that has been accepted by industry as superior to other alternative(s), because repeated use has been demonstrated to produce a repeatable and common end result. Also referred to as ''Industry Standard Practice (ISP)''.

1.8.20 Stress Relief Slack in a component lead or wire that is formed in such a way as to minimize mechanical stresses.

1.8.21 Supplier The individual, organization or company which provides the Manufacturer (assembler) components (electronic, electromechanical, mechanical, printed boards, etc.) and/or materials (solder, flux, cleaning agents, etc.).

1.8.22 Tempered Leads Component terminations or pins heat treated to increase hardness, or incorporating hard, brittle plating layers.

1.8.23 Wire Overlap A wire/lead that is wrapped more than 360° and crosses over itself, i.e., does not remain in contact with the terminal post, Figure 6-57B.

1.8.24 Wire Overwrap A wire/lead that is wrapped more than 360° and remains in contact with the terminal post, Figure 6-57A.

1.8.25 User The individual, organization, company, contractually designated authority, or agency responsible for the procurement or design of electrical/electronic hardware, and having the authority to define the class of equipment and any variation or restrictions to the requirements of this standard, i.e., the originator/custodian of the contract detailing these requirements.

1.9 Requirements Flowdown When this standard is contractually required, the applicable requirements of this standard (including Product Class, see 1.3 Classification) **shall** be imposed on all applicable subcontracts, assembly drawing(s), documentation and purchase orders. Unless otherwise specified the requirements of this standard are not imposed on the procurement of commercial- off-the-shelf (COTS or catalog) assemblies or subassemblies.

When a part is adequately defined by a specification, then the requirements of this standard should be imposed on the Manufacturer of that part only when necessary to meet end-item requirements. When it is unclear where flowdown should stop, it is the responsibility of the Manufacturer to establish that determination with the User.

When an assembly, e.g., daughterboard, is procured, that assembly should meet the requirements of this standard. The connections from the procured assembly to the manufactured assembly **shall** meet the requirements of this standard. If the assembly is manufactured by the same Manufacturer, the solder requirements are as stated in the contract for the entire assembly.

The design and workmanship of COTS items should be evaluated and modified as required to ensure the end-item meets contract performance requirements. Modifications **shall** meet the applicable requirements of this standard.

1.10 Personnel Proficiency All instructors, operators, and inspection personnel **shall** be proficient in the tasks to be performed. Objective evidence of that proficiency **shall** be maintained and available for review. Objective evidence should include records of training to the applicable job functions being performed, work experience, testing to the requirements of this standard, and/or results of periodic reviews of proficiency. Supervised on-the-job training is acceptable until proficiency is demonstrated.

1.11 Acceptance Requirements All products **shall** meet the requirements of the contracts, engineering documentation, applicable standards, and the requirements for the applicable Product Class specified herein.

1.11.1 Missing Parts and Components Missing parts and components **shall** be a defect for all Product Classes.

1.12 Inspection Methodology Accept and/or reject decisions **shall** be based on applicable documentation such as contract, drawings, specifications and referenced documents.

1 General (cont.)

The use of any non-visual inspection methods, other than those already detailed in 8.3.12 Surface Mount Assemblies – Surface Mount Area Array and 8.3.13 Surface Mount Assemblies – Bottom Termination Components (BTC) are not specifically covered by this standard and **shall** be used as agreed between Manufacturer and User.

The inspector does not select the class for the assembly under inspection, see 1.3 Classification. Documentation that specifies the applicable class for the assembly under inspection **shall** be provided to the inspector.

Automated Inspection, e.g., AOI, AXI, is a viable support to visual inspection and complements automated test equipment. Many characteristics in this document can be inspected with an automated system.

If the customer desires the use of industry standard requirements for frequency of inspection and acceptance, J-STD-001 is recommended for further soldering requirement details.

1.12.1 Lighting Lighting **shall** be adequate for the feature being inspected.

Illumination at the surface of workstations should be at least 1000 lux [approximately 93 foot-candles]. Light sources should be selected to prevent shadows.

Note: In selecting a light source, the color temperature of the light is an important consideration. Light ranges from 3000-5000 K enable users to distinguish conditions and colors of various printed board features and contaminates with increased clarity.

1.12.2 Magnification Aids For visual inspection, some individual specifications may call for magnification aids for examining printed board assemblies.

The tolerance for magnification aids is ± 15% of the selected magnification power. Magnification aids, if used for inspection, **shall** be appropriate with the item by the being inspected. Unless magnification requirements are otherwise specified by contractual documentation, the magnifications in Tables 1-2, 1-3, and 1-4 are determined by the feature being inspected.

If the presence of a defect cannot be determined at the appropriate magnification power defined in Tables 1-2, 1-3, or 1-4, the item is acceptable. The referee magnification power is intended for use only after a defect has been determined but is not completely identifiable at the inspection power.

For assemblies with mixed land sizes, the greater magnification power may be used for the entire assembly. For assemblies with mixed wire sizes, the greater magnification power may be used.

Table 1-2 Inspection Magnification (Land Width)

Land Widths or Land Diameters[1]	Magnification Power	
	Inspection Range	Maximum Referee
> 1 mm [0.04 in]	1.5X to 3X	4X
> 0.5 to ≤ 1 mm [0.02 to 0.04 in]	3X to 7.5X	10X
≥ 0.25 to ≤ 0.5 mm [0.01 to 0.02 in]	7.5X to 10X	20X
< 0.25 mm [0.01 in]	20X	40X

Note 1. A portion of a conductive pattern used for the connection and/or attachment of components.

1 General (cont.)

Table 1-3 Magnification Aid Applications For Wires And Wire Connections

Wire Size AWG Diameter mm [inch]	Magnification Power	
	Inspection Range	Maximum Referee
larger than 14 AWG >1.63 mm [0.064 in]	N/A	1.75X
14 to 22 AWG 1.63 – 0.64 mm [0.064 to 0.025 in]	1.5X – 3X	4X
< 22 to 28 AWG < 0.64 mm – 0.32 mm [< 0.025 – 0.013 in]	3X – 7.5X	10X
Smaller than 28 AWG < 0.32 mm [< 0.013 in]	10X	20X

Table 1-4 Magnification Aid Applications – Other

Cleanliness (with or without cleaning processes)	Magnification not required, see Note 1
Cleanliness (no-clean processes)	Magnification not required, see Note 1
Conformal Coating/Encapsulation, Staking	Magnification not required, see Note 2
Marking	Magnification not required, see Note 2
Other (component and wire damage, etc.)	Magnification not required, see Note 1

Note 1. Visual inspection may require the use of magnification, e.g., when fine pitch or high-density assemblies are present, magnification may be needed to determine if contamination affects form, fit or function.

Note 2. If magnification is used it is limited to 4X maximum.

2 Applicable Documents

The following documents of the issue currently in effect form a part of this document to the extent specified herein.

2.1 IPC Documents[1]

IPC-HDBK-001 Handbook and Guide to Supplement J-STD-001

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

IPC-CH-65 Guidelines for Cleaning of Printed Boards and Assemblies

IPC-D-279 Design Guidelines for Reliable Surface Mount Technology Printed Board Assemblies

IPC-D-325 Documentation Requirements for Printed Boards

IPC-A-600 Acceptability of Printed Boards

IPC/WHMA-A-620 Requirements & Acceptance for Cable & Wire Harness Assemblies

IPC-A-640 Acceptance Requirements for Optical Fiber, Optical Cable, and Hybrid Wiring Harness Assemblies

IPC-TM-650 Test Methods Manual

IPC-CM-770 Component Mounting Guidelines for Printed Boards

IPC-SM-785 Guidelines for Accelerated Reliability Testing of Surface Mount Attachments

IPC-AJ-820 Assembly & Joining Handbook

IPC-CC-830 Qualification and Performance of Electrical Insulating Compound for Printed Board Assemblies

IPC-HDBK-830 Guidelines for Design, Selection and Application of Conformal Coatings

IPC-SM-840 Qualification and Performance of Permanent Solder Mask

IPC-1602 Standard for Printed Board Handling and Storage

IPC-2220-FAM Design Standards for Printed Boards

IPC-6010-FAM IPC-6010 Printed Board Performance Specifications

IPC-7093 Design and Assembly Process Implementation for Bottom Termination Components

IPC-7351 Generic Requirements for Surface Mount Design and Land Pattern Standard

IPC-7711/7721 Rework, Repair and Modification of Electronic Assemblies

IPC-9691 User Guide for the IPC-TM-650, Method 2.6.25, Conductive Anodic Filament (CAF) Resistance Test (Electrochemical Migration Testing)

IPC-9701 Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments

2.2 Joint Industry Documents[2]

J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies

EIA/IPC/JEDEC J-STD-002 Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires

J-STD-004 Requirements for Soldering Fluxes

IPC/JEDEC J-STD-020 Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices

IPC/JEDEC J-STD-033 Standard for Handling, Packing, Shipping and Use of Moisture Sensitive Surface Mount Devices

ECA/IPC/JEDEC J-STD-075 Classification of Non-IC Electronic Components for Assembly Processes

1. www.ipc.org
2. www.ipc.org

2.3 Electrostatic Association Documents[3]

ANSI/ESD-S-20.20 Protection of Electrical and Electronic Parts, Assemblies and Equipment

2.4 International Electrotechnical Commission Documents[4]

IEC 61340-5-1 Electrostatics – Part 5-1: Protection of Electronic Devices From Electrostatic Phenomena – General Requirements

IEC 61340-5-2 Electrostatics – Part 5-2: Protection of Electronic Devices From Electrostatic – User Guide

IEC 61340-5-3 Electrostatics – Part 5-3: Protection of Electronic Devices from Electrostatic Phenomena – Properties and Requirements Classification for Packaging Intended for Electrostatic Discharge Sensitive Devices

2.5 ASTM[5]

ASTM E29 Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

ASTM SI 10 American National Standard for Metric Practice

2.6 Military Standards

MIL-STD-1130 Department of Defense Standards Practice: Connections, Electrical, Solderless, Wrapped

MIL-STD-1686 Electrostatic Discharge Control Program For Protection Of Electrical And Electronic Parts, Assemblies And Equipment (Excluding Electrically Initiated Explosive Devices)

MIL-STD-2073 Standard Practice for Military Packaging

2.7 SAE International[6]

AS22759 Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy

AS9146 Foreign Object Damage (FOD) Prevention Program – Requirements for Aviation, Space, and Defense Organizations

3. www.esda.org
4. www.iec.ch
5. www.astm.org
6. www.sae.org

3 Handling Electronic Assemblies

See Appendix B for information on EOS/ESD and Other Handling Considerations.

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4 Hardware

This section illustrates several types of hardware used to mount electronic devices to an assembly or any other types of assemblies requiring the use of any of the following: screws, bolts, nuts, washers, fasteners, clips, component studs, tie downs, rivets, connector pins, etc. This section is primarily concerned with visual assessment of proper securing (tightness), and also with damage to the devices, hardware, and the mounting surface that can result from hardware mounting.

Note: Criteria in this section do not apply to attachments with self-tapping screws.

Visual inspection is performed in order to verify the following conditions:

a. Correct parts and hardware.
b. Correct sequence of assembly.
c. Correct security and tightness of parts and hardware.
d. No discernible damage.
e. Correct orientation of parts and hardware.

The following topics are addressed in this section.

4.1 Hardware Installation

4.1.1 Hardware Installation – Electrical Clearance

Also see 1.8.5 Electrical Clearance.

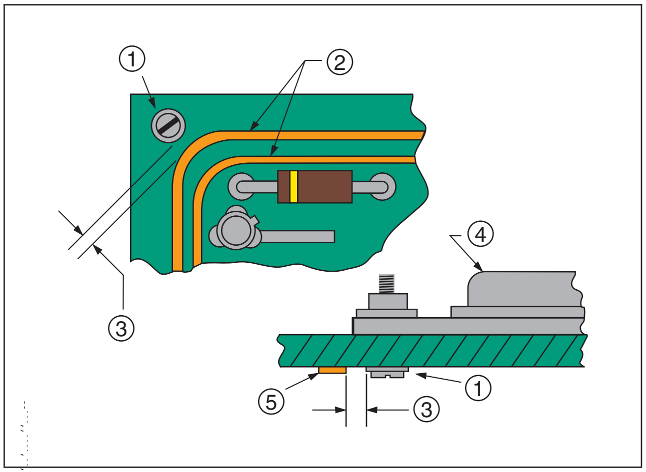

Figure 4-1
1. **Metallic hardware**
2. **Conductive pattern**
3. **Specified minimum electrical clearance**
4. **Mounted component**
5. **Conductor**

Acceptable – Class 1,2,3

- Spacing between noncommon conductors does not violate specified minimum electrical clearance (3). This is shown in Figure 4-1 as the distances between (1) & (2) and (1) & (5).

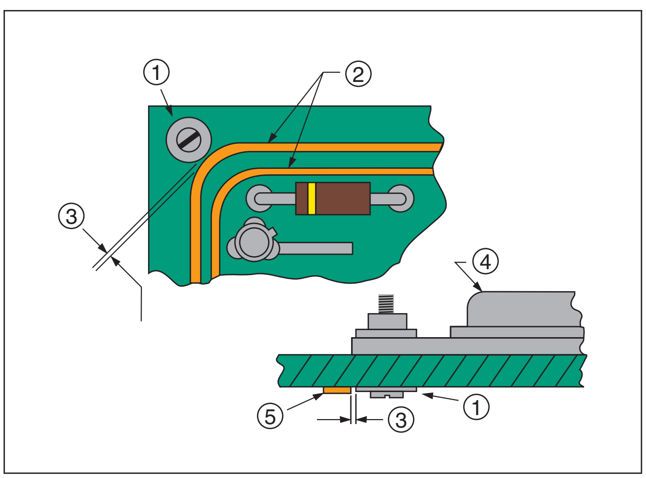

Figure 4-2
1. **Metallic hardware**
2. **Conductive pattern**
3. **Spacing less than electrical clearance requirements**
4. **Mounted component**
5. **Conductor**

Defect – Class 1,2,3

- Hardware reduces spacing to less than specified minimum electrical clearance.

4.1.2 Hardware Installation – Interference

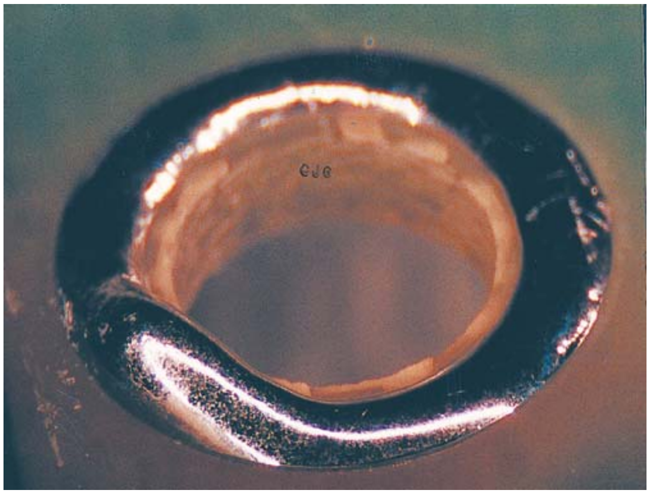

Figure 4-3

Acceptable – Class 1,2,3

- Mounting area clear of obstructions to assembly requirements.

Defect – Class 1,2,3

- Excess solder (uneven) on mounting holes where mechanical assembly will be affected.
- Anything that interferes with mounting of required hardware.

4.1.3 Hardware Installation – Component Mounting – High Power

Figures 4-4 and 4-5 show typical mounting parts.

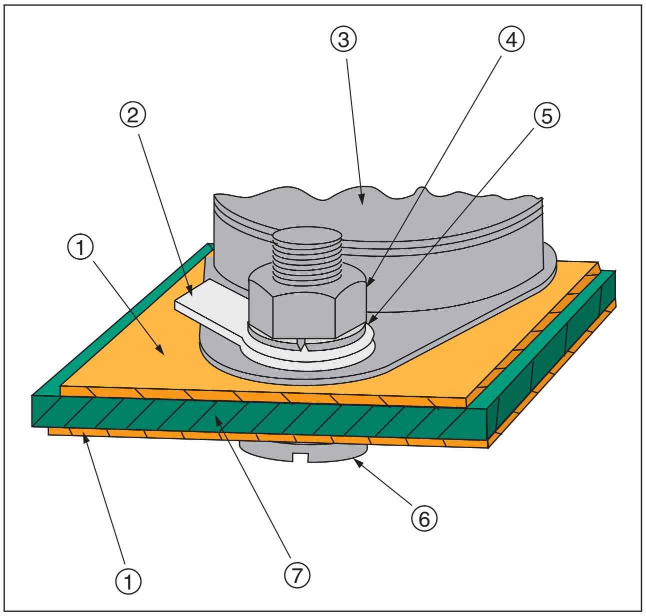

Figure 4-4

1. **Metal**
2. **Terminal lug**
3. **Component case**
4. **Nut**
5. **Lock washer**
6. **Screw**
7. **Nonmetal**

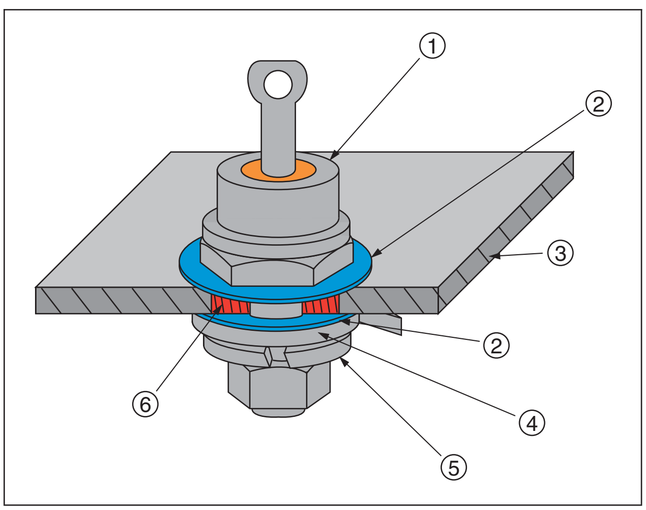

Figure 4-5

1. **High-power component**
2. **Insulating washer (when required)**
3. **Heat sink (may be metal or nonmetal)**
4. **Terminal lug**
5. **Lock washer**
6. **Insulator sleeve**

Acceptable – Class 1,2,3

- Hardware in proper sequence.
- Leads on components attached by fastening devices are not clinched (not shown).
- Insulating washer provides electrical isolation when required.
- Thermal compound, if used, does not interfere with formation of required solder connections.

Note: Where a thermal conductor is specified, it is placed between mating surfaces of the power device and the heat sink. Thermal conductors may consist of a thermally conductive washer or of an insulating washer with a thermally conductive compound.

4.1.3 Hardware Installation – Component Mounting – High Power (cont.)

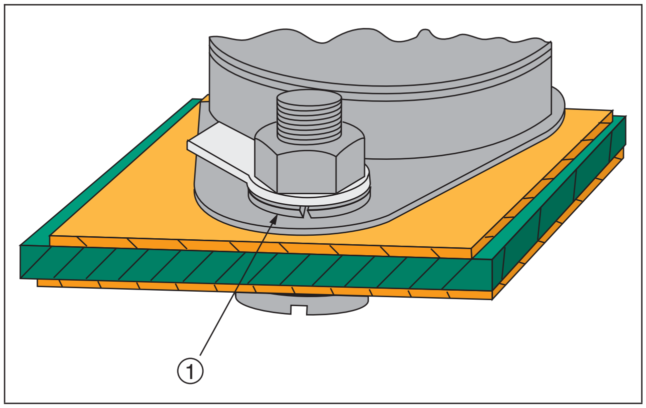

Figure 4-6

1. Lock washer between terminal lug and component case

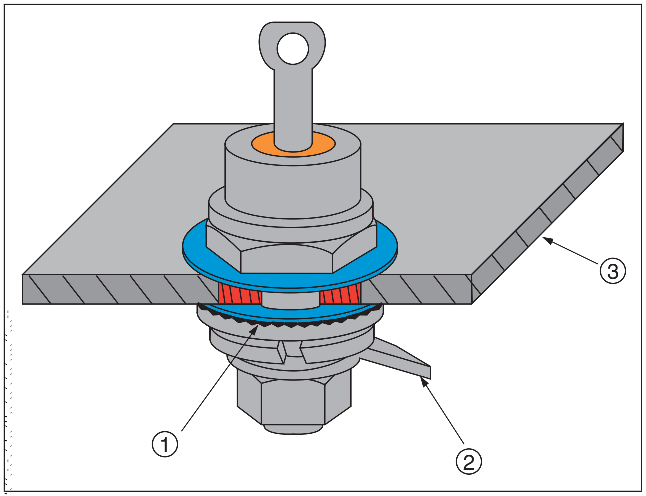

Figure 4-7

1. Sharp edge of washer against insulator
2. Terminal lug
3. Metal heat sink

Defect – Class 1,2,3

- Improper hardware sequence, see Figure 4-6.
- Sharp edge of washer is against insulator, see Figure 4-7.
- Hardware is not secure.
- Thermal compound, if used, does not permit formation of required solder connections.

4.1.4 Hardware Installation – Heatsinks

4.1.4.1 Hardware Installation – Heatsinks – Insulators and Thermal Compounds

This section illustrates various types of heatsink mounting.

Visual inspection includes hardware security, component damage, and correct sequence of assembly.

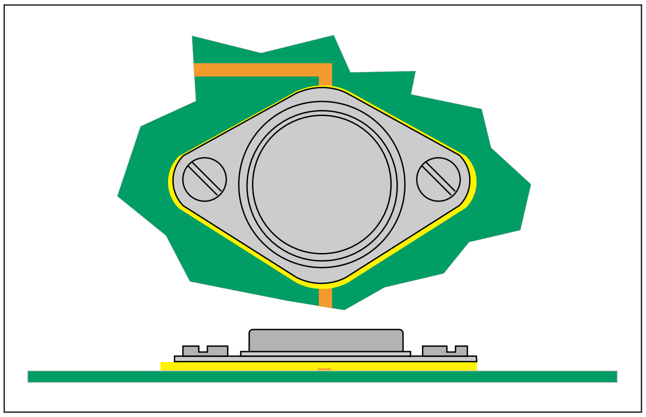

Figure 4-8

Acceptable – Class 1,2,3

- Not uniform but evidence of mica, plastic film or thermal compound showing around edges of component.

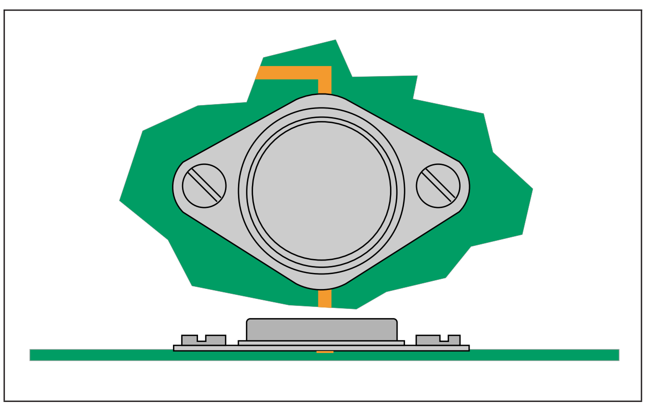

Figure 4-9

Defect – Class 1,2,3

- No evidence of insulating materials, or thermal compound (if required).
- Thermal compound precludes formation of required solder connection.

4.1.4.2 Hardware Installation – Heatsinks – Contact

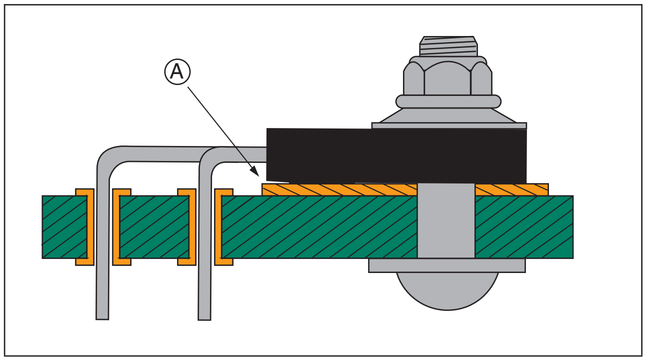

Figure 4-10

Acceptable – Class 1,2,3

- Component not flush, see Figure 4-10-A.
- Minimum 75% contact with mounting surface.

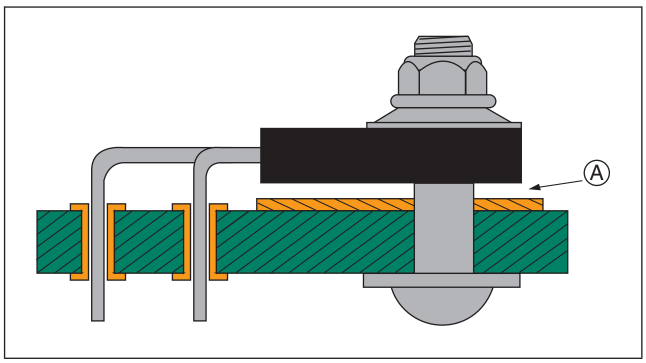

Figure 4-11

Defect – Class 1,2,3

- Component has less than 75% contact with mounting surface, see Figure 4-11-A.
- Hardware is loose.

4.1.5 Hardware Installation – Threaded Fasteners and Other Threaded Hardware

Both the order and orientation of mounting hardware need to be considered during assembly. Devices such as ''star'' or ''tooth'' washers may have one side with sharp edges intended to cut into the mating surface to keep the hardware from coming loose in operation. Figure 4-13 is an example of this kind of lock washer. Unless otherwise specified the sharp edges of the lock washer should be against the flat washer.

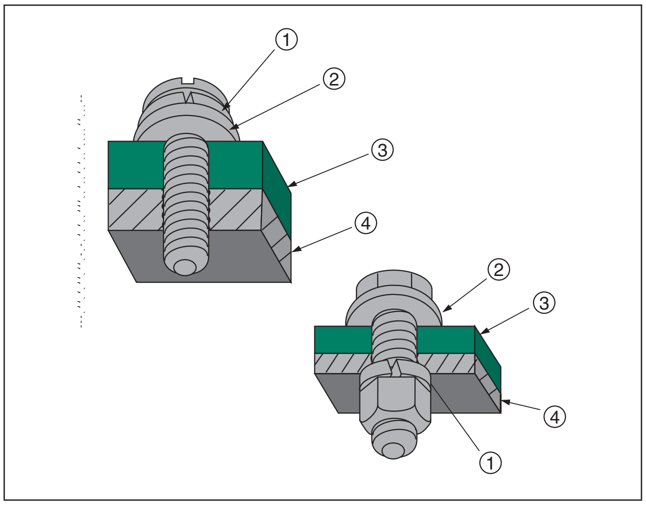

Figure 4-12
1. Lock washer, sharp edge showing towards flat washer
2. Flat washer
3. Nonconductive material (laminate, etc.)
4. Metal (not conductive pattern or foil)

Acceptable – Class 1,2,3

- Proper hardware sequence and orientation, see Figures 4-12 and 4-13.
- Slot or hole are covered with flat washer, see Figure 4-14.

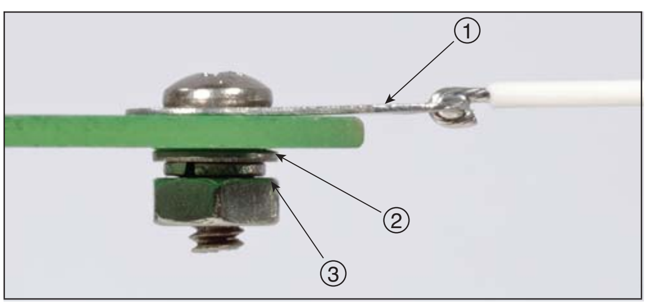

Figure 4-13
1. Solder lug
2. Flat washer
3. Lock washer, sharp edge towards flat washer

Acceptable – Class 1
Defect – Class 2,3

- Less than one and one-half threads extend beyond the threaded hardware, e.g., nut, unless otherwise specified by engineering drawing.

4.1.5 Hardware Installation – Threaded Fasteners and Other Threaded Hardware (cont.)

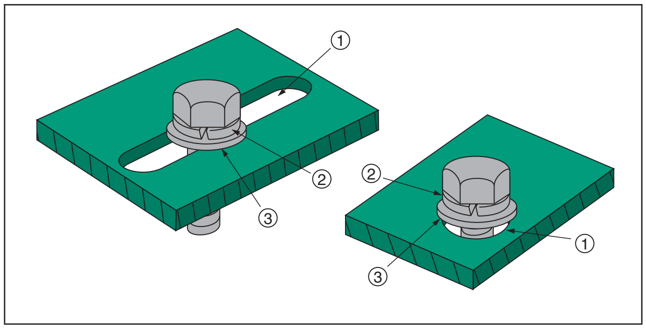

Figure 4-14
1. Slot or hole
2. Lock washer
3. Flat washer

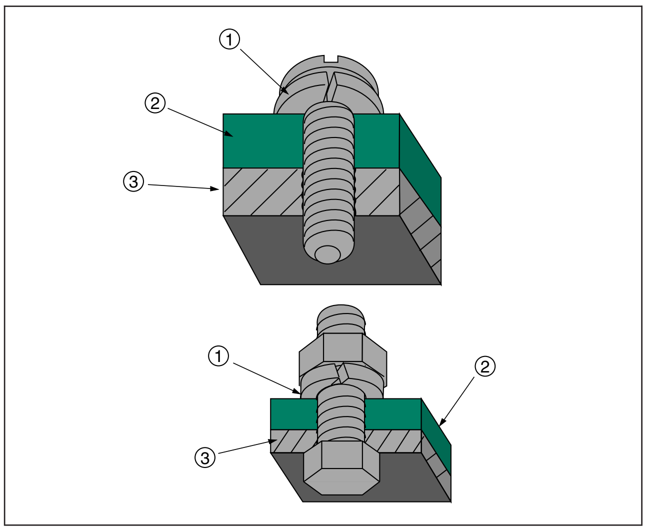

Figure 4-15
1. Lock washer
2. Nonmetal
3. Metal (not conductive pattern or foil)

Defect – Class 1,2,3

- Thread extension interferes with adjacent component.
- Hardware material or sequence not in conformance with drawing.
- Lock washer against nonmetal/laminate.
- Flat washer missing, see Figures 4-15 and 4-16.
- Hardware missing or improperly installed, see Figure 4-17.
- Hardware is not seated, see Figure 4-20.

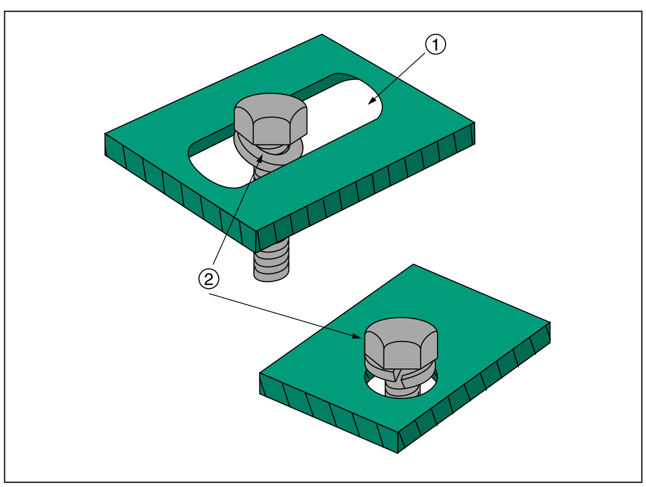

Figure 4-16
1. Slot or hole
2. Lock washer

Figure 4-17

4.1.5.1 Hardware Installation – Threaded Fasteners and Other Threaded Hardware – Torque

In addition to threaded fasteners used for installation of an item onto an assembly, there are other types of threaded items that may be used on individual parts within an assembly. These may require tightening to a specified torque value, or standard industry practice, to preclude loosening or part damage. Such items include, but are not limited to, connector coupling nuts, connector strain relief clamps/potting/molding boots, etc., fuse holder mounting nuts, and any other similar threaded items.

Where torque requirements are not specified, follow standard industry practices. However, some of these threaded items may be made of plastic or other material that can be damaged if excessive torque is applied during assembly, and for these items, it may be necessary to tighten the item to a specified torque value.

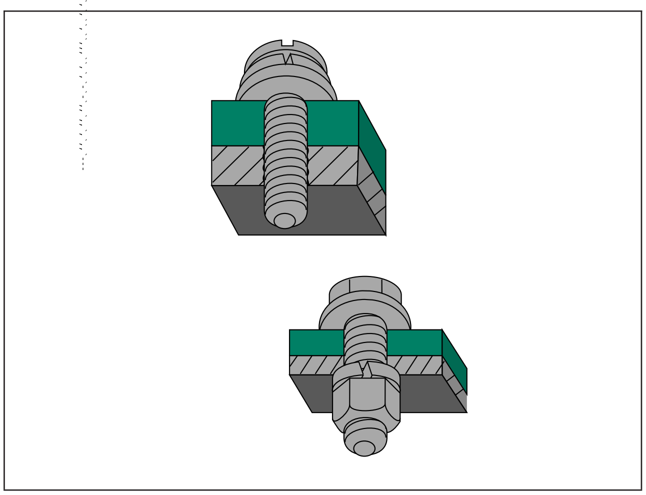

Figure 4-18

Figure 4-19

Acceptable – Class 1,2,3

- Fasteners are tight and split-ring lock washers, when used, are fully compressed.
- No evidence of damage resulting from over-tightening of the threaded item.
- Torque stripe on fasteners (witness/anti-tampering stripe), when required, see Figure 4-19:
  - Is continuous between the fastener and the substrate.
  - Extends from the top of the fastener onto the adjacent substrate (at minimum).
  - Is aligned with the center line of the fastener.
  - Is undisturbed (indicating no movement of the fastener and stripe after torquing).

4.1.5.1 Hardware Installation – Threaded Fasteners and Other Threaded Hardware – Torque (cont.)

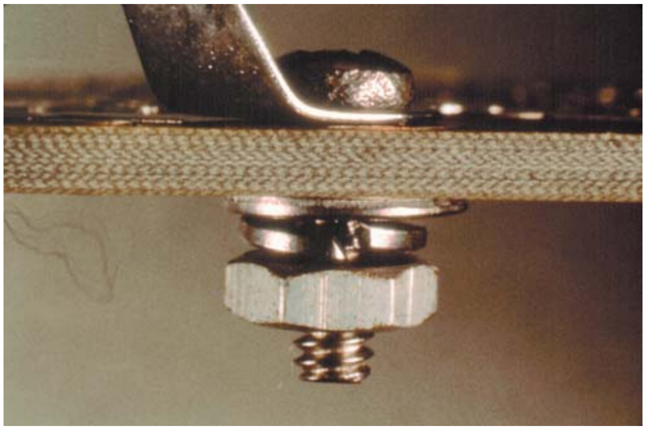

Figure 4-20

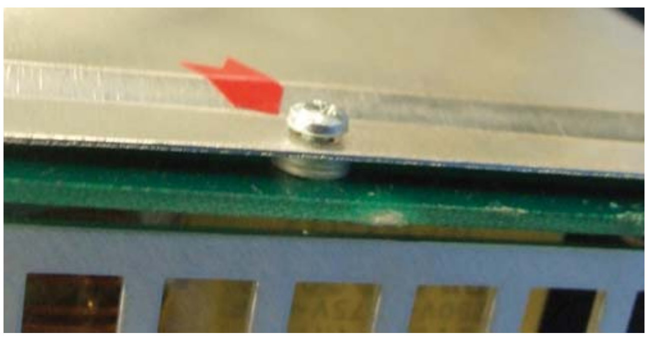

Figure 4-21

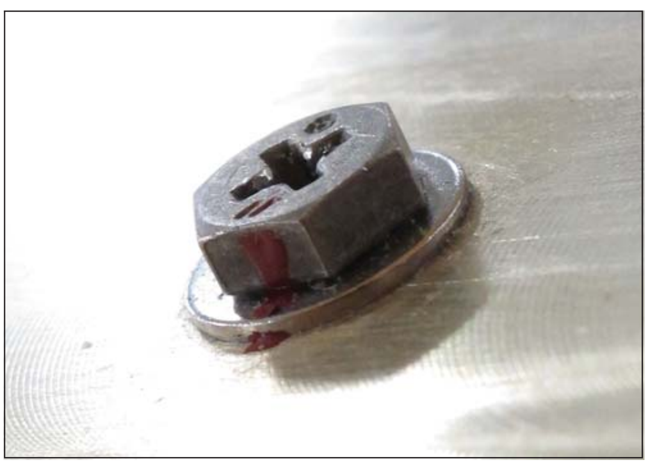

Figure 4-22

Defect – Class 1,2,3

- Split ring lock washer, if used, is not compressed, see Figure 4-20.
- Hardware is loose, see Figure 4-20.
- Evidence of damage to the parts being secured.
- Required torque stripe is not continuous between the fastener and the substrate.
- Required torque stripe does not extend from the top of the fastener onto the adjacent substrate (at minimum).
- Required torque stripe is not aligned with the center line of the fastener.
- Required torque stripe is disturbed (indicating movement of the fastener and stripe after torquing).

4.1.5.2 Hardware Installation – Threaded Fasteners and Other Threaded Hardware – Solid Wires

Figure 4-23

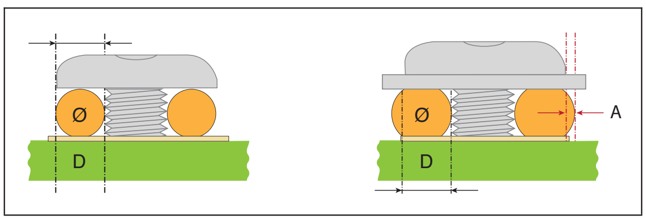

Figure 4-24
A. Less than or equal to 1/3 D

Acceptable – Class 1,2,3

- 1/3 or less of the conductor diameter protrudes from under the screw head.
- Mechanical attachment of the conductor is in contact between the screw head and the contact surface for a minimum of 180° around the screw head.
- Conductor is not wrapped more than 360°.
- Conductor extending outside the screw head does not violate minimum electrical clearance.
- Wire wrapped in the correct direction.
- No insulation in the contact area.

4.1.5.2 Hardware Installation – Threaded Fasteners and Other Threaded Hardware – Solid Wires (cont.)

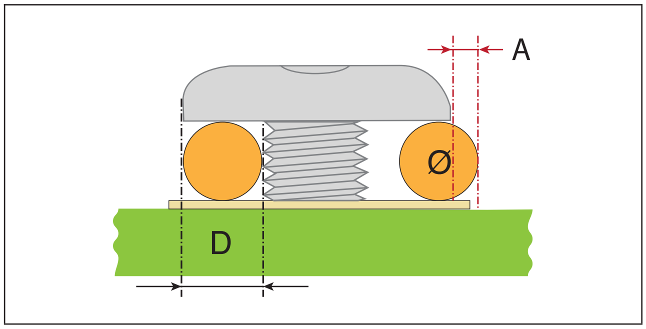

Figure 4-25
A. Overhang greater than 1/3 D

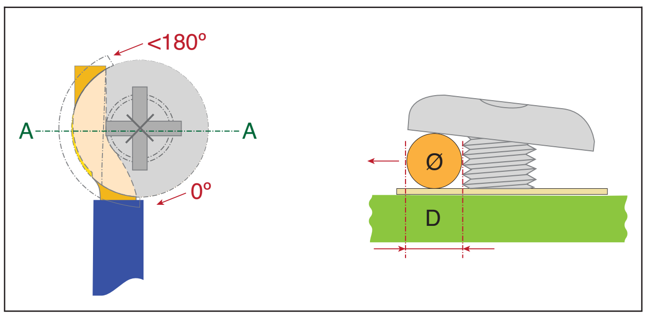

Figure 4-26

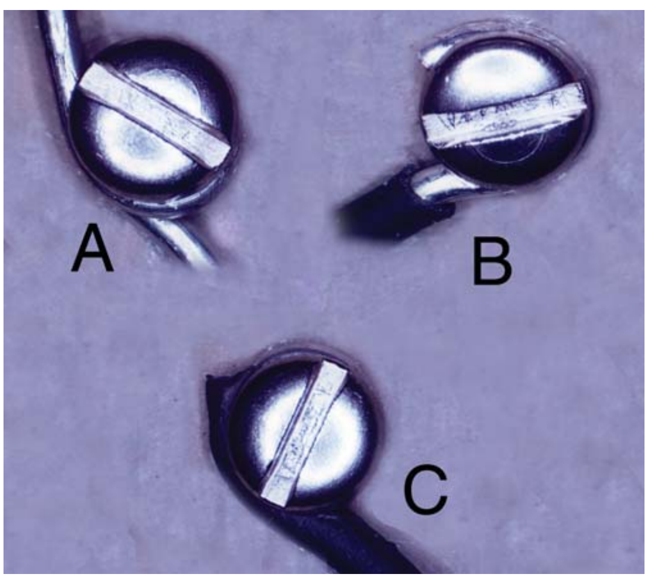

Figure 4-27

Defect – Class 1,2,3

- More than 1/3 of the conductor diameter protrudes from under the screw head (see Figure 4-25).
- Conductor not wrapped around screw body for at least 180° (see Figure 4-26-A).
- Conductor is wrapped more than 360° (see Figure 4-27-A).
- Conductor wrapped in wrong direction (see Figure 4-27-B).
- Insulation in the contact area (see Figure 4-27-C).

4.1.5.3 Hardware Installation – Threaded Fasteners and Other Threaded Hardware – Stranded Wires

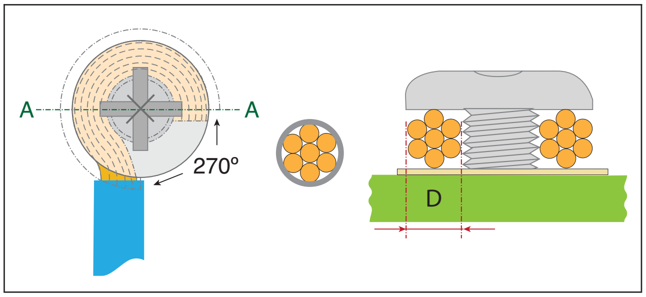

Figure 4-28

Acceptable – Class 1,2,3

- Less than 1/3 of the conductor diameter protrudes from under the screw head.
- Conductor extending outside the screw head does not violate minimum electrical clearance.
- Mechanical attachment of the conductor is in contact between the screw head and the contact surface for a minimum of 180° around the screw head.
- No insulation in the contact area.
- Conductor is not wrapped more than 360°.

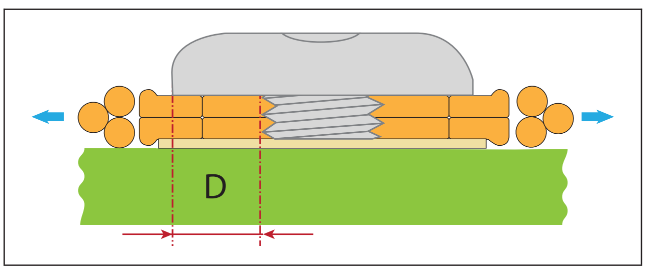

Figure 4-29

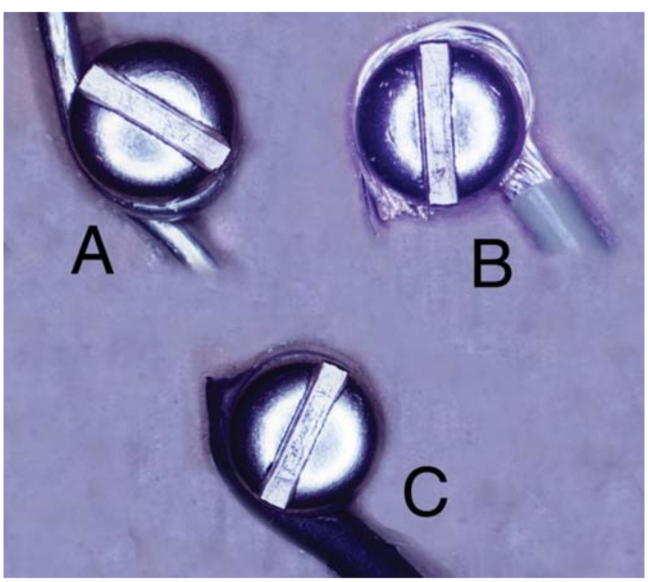

Figure 4-30

Defect – Class 1,2,3

- Conductor not wrapped around screw body for at least 180° (not shown).
- Stranded conductor was tinned (not shown).
- More than 1/3 of the conductor diameter protrudes from under the screw head (see Figure 4-29).
- Stranded conductor wrapped in wrong direction (tightening the screw unwinds the twisted conductor) (see Figure 4-30-B).
- Insulation in the contact area (see Figure 4-30-C).

4.2 Jackpost Mounting

This section covers the height relationship of the face of the jackpost to the associated connector face. This is critical to obtain maximum connector pin contact.

Note: ''C'' style retaining clips will add the thickness of the clip to the jackpost height.

Note: A trial mating may be required for final acceptance.

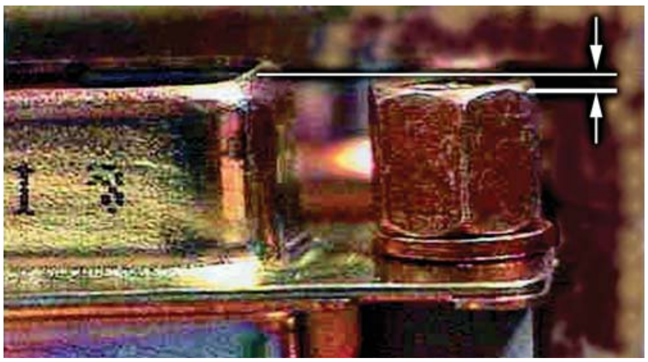

Figure 4-31

Acceptable – Class 1,2,3

- The jackposts can be above or below the face of the connector, depending on the design, providing the connector and jackposts mate correctly.
- Height is obtained by adding or removing washers in accordance with the connector manufacturer's instructions.

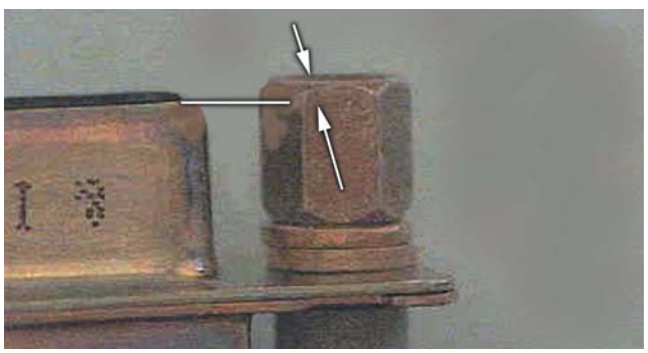

Figure 4-32

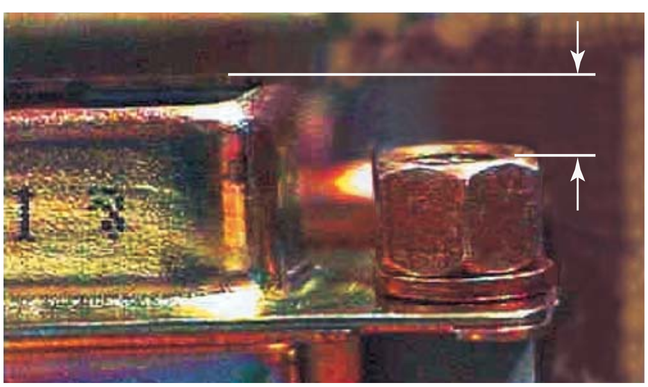

Figure 4-33

Defect – Class 1,2,3

- The jackposts are above or below the face of the connector, depending on the design, and the connector and jackposts do not mate correctly. (No figure showing the defect condition.)

4.3 Connector Pins

This section covers two types of pin installations; edge connector pins and press fit connector pins. Installation of these devices is usually done with automated equipment. Visual inspection of this mechanical operation includes: correct pins, damaged pins, bent and broken pins, damaged spring contacts and damage to the substrate or conductive pattern. For connector mounting criteria, see 7.1.8 Component Mounting – Connectors. For connector damage criteria, see 9.5 Connectors.

IPC-T-50 defines annular ring (annular width) as that portion of conductive material completely surrounding a hole.

4.3.1 Connector Pins – Edge Connector Pins

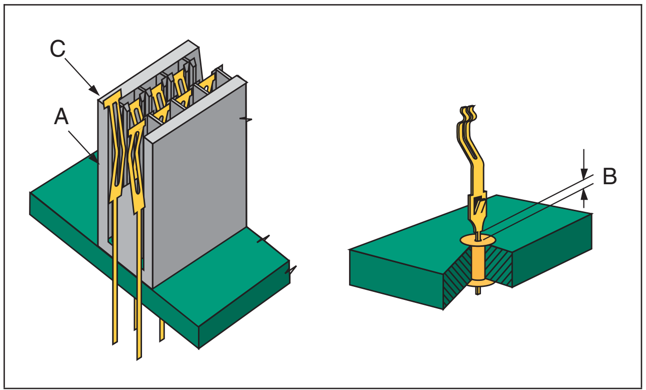

Figure 4-34

Acceptable – Class 1,2,3

- Contact is contained within the insulator, see Figure 4-34-A.
- Gap is within specified tolerance, see Figure 4-34-B.

Note: To provide allowance for an extraction tool, the gap between the contact shoulder and the land needs to be adequate for each manufacturer's repair tooling.

Defect – Class 1,2,3

- Contact is above insulator, see Figure 4-34-C.
- Gap between contact shoulder and land is greater than specified, see Figure 4-34-B.

4.3.2 Connector Pins – Press Fit Pins

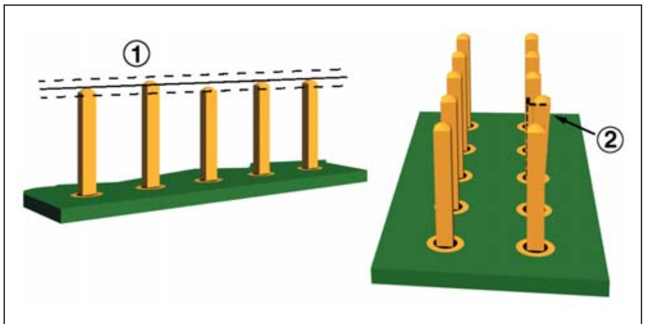

Figure 4-35
1. Pin height tolerance
2. Less than 50% pin thickness

Acceptable – Class 1,2,3

- Pins are bent off center by 50% pin thickness or less.
- Pin height is within tolerance.

Note: Nominal height tolerance is per pin connector or master drawing specification. The connector pins and mating connector must have a good electrical contact.

4.3.2 Connector Pins – Press Fit Pins (cont.)

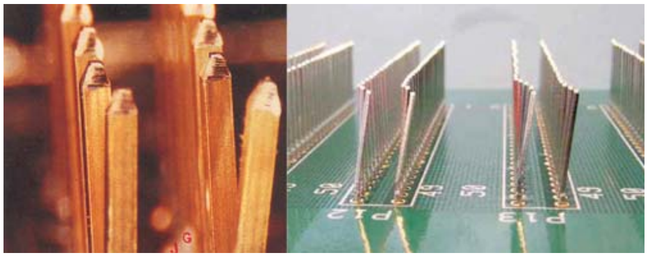

Figure 4-36

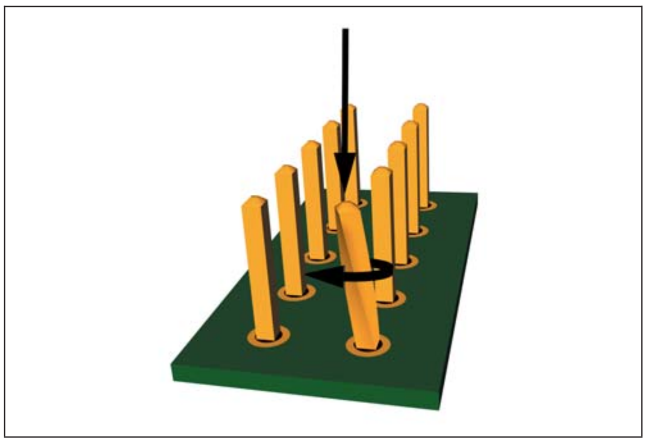

Figure 4-37

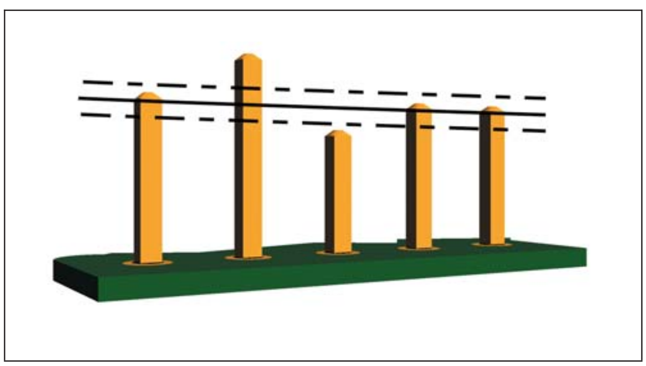

Figure 4-38

Defect – Class 1,2,3

- Pin is bent out of alignment – bent off center greater than 50% pin thickness, see Figure 4-36.
- Pin visibly twisted, see Figure 4-37.
- Pin height is out of tolerance as to specification, see Figure 4-38.

4.3.2.1 Connector Pins – Press Fit Pins – Land/Annular Ring

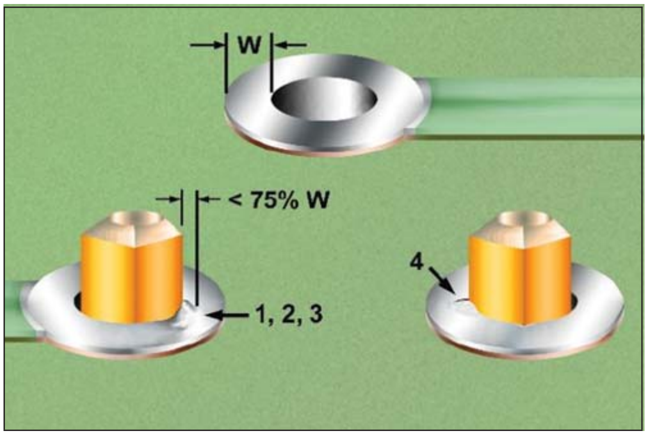

Figure 4-39
1. Annular ring lifted 75% of the width (W) or less
2. Annular ring with conductor
3. Annular ring not fractured
4. Annular ring lifted, fractured but firmly attached annular ring without conductor (nonfunctional)

Acceptable – Class 1,2

- Protrusion side annular ring lifted less than or equal to 75% of the width (W) of the annular ring, Figure 4-39.

Acceptable – Class 2

- No visual evidence of lifted annular land on insertion side.

Acceptable – Class 3

- No lifted or fractured annular rings.

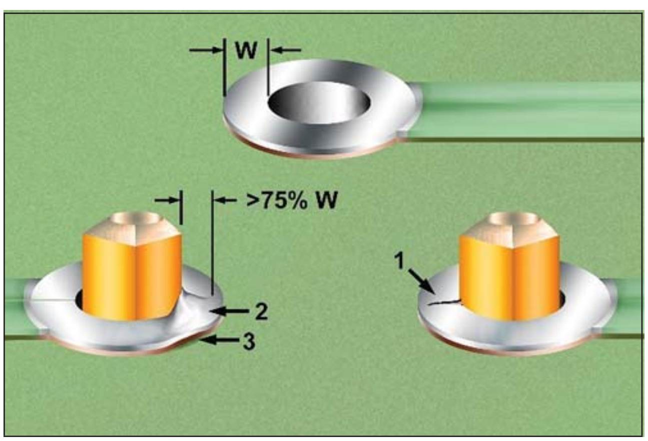

Figure 4-40
1. Annular ring fractured
2. Functional annular ring lifted greater than 75% of annular ring width (W)
3. Annular ring lifted

Defect – Class 1,2

- Any protrusion side functional annular ring lifted more than 75% of the width (W).

Defect – Class 2

- Any evidence of lifted annular ring on the insertion side.

Defect – Class 3

- Any lifted or fractured annular rings with press fit pins.

4.3.2.2 Connector Pins – Press Fit Pins – Soldering

The term ‘‘press fit pins’’ is generic in nature and many types of pressure inserted pins, e.g., connector, staked, etc., are not intended to be soldered. If soldering is required the following criteria are applicable.

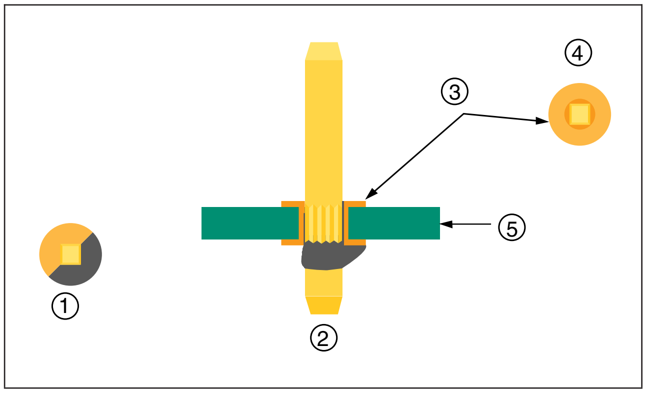

Figure 4-41
1. **Bottom view**
2. **Side view**
3. **Land**
4. **Top view**
5. **Printed board**

Acceptable – Class 1,2

- Solder fillet or coverage (protrusion side) is present on two adjacent sides of the pin.

Acceptable – Class 3

- A 330° solder fillet is evident on the protrusion side of the assembly.

Note: Solder fillet or fill on insertion side is not required.

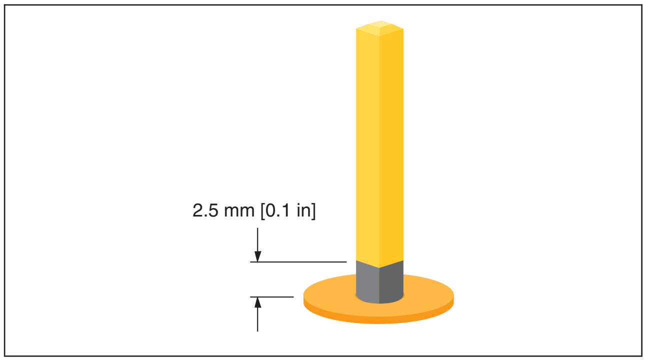

Figure 4-42

Acceptable – Class 1

- Solder wicking is permitted above 2.5 mm [0.1 in] on sides of pins provided there is no solder buildup that interferes with subsequent attachments to the pin.

Acceptable – Class 2,3

- Solder wicking on sides of pins is less than 2.5 mm [0.1 in], provided the solder does not interfere with subsequent attachments to the pin.

4.3.2.2 Connector Pins – Press Fit Pins – Soldering (cont.)

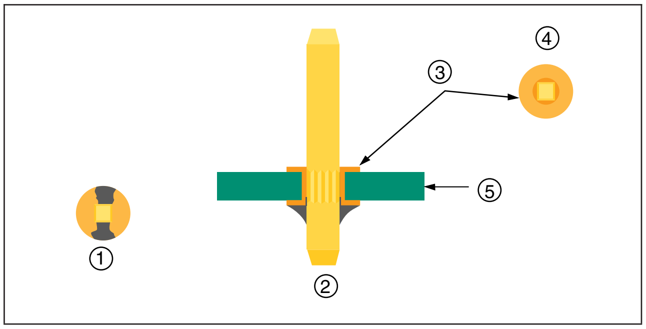

Figure 4-43
1. **Bottom view**
2. **Side view**
3. **Land**
4. **Top view**
5. **Printed board**

Defect – Class 1,2

- Solder fillet or coverage is evident on less than two adjacent sides of the pin on the protrusion side.

Defect – Class 3

- Less than 330° solder fillet on the protrusion side of the assembly.

Defect – Class 1,2,3

- Solder build up interferes with subsequent attachments to the pin.

Defect – Class 2,3

- Solder wicking exceeds 2.5 mm [0.1 in].

4.4 Wire Bundle Securing

Criteria can be found in IPC/WHMA-A-620.

4.5 Routing – Wires and Wire Bundles

Criteria can be found in IPC/WHMA-A-620.

5 Soldering

This section establishes the acceptability requirements for soldered connections of all types, e.g., SMT, terminals, through-hole, etc. Although Class 1, 2 and 3 applications and environments have been considered, the nature of the soldering process may dictate that an acceptable connection will have the same characteristics for all three classes, and an unacceptable connection would be rejected for all three classes.

Where appropriate, the type of soldering process used has been addressed specifically in the criteria description. In any case, the connection criteria apply regardless of which methods of soldering have been utilized, for example:

- Soldering irons.
- Resistance soldering apparatus.
- Induction, wave, or drag soldering.
- Reflow soldering.
- Intrusive soldering.

As an exception to the above, there are specialized soldering finishes, e.g., immersion tin, palladium, gold, etc., that require the creation of special acceptance criteria other than as stated in this document. The criteria should be based on design, process capability, and performance requirements.

Wetting cannot always be judged by surface appearance. The wide range of solder alloys in use may exhibit from low or near zero degree contact angles to nearly 90° contact angles as typical. The acceptable solder connection **shall** indicate evidence of wetting and adherence where the solder blends to the soldered surface.

The solder connection wetting angle (solder to component and solder to printed board termination) **shall not** exceed 90°, see Figure 5-1 A, B. As an exception, the solder connection to a termination may exhibit a wetting angle exceeding 90° (convex), see Figure 5-1 C, D, when it is created by the solder contour extending over the edge of the solderable termination area or solder mask.

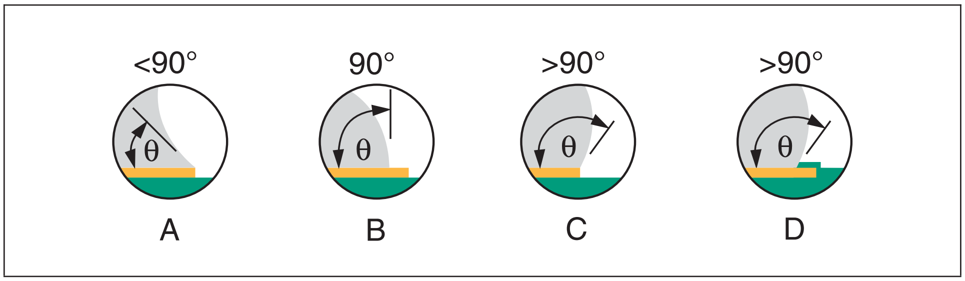

Figure 5-1

5 Soldering (cont.)

The following topics are addressed in this section.

5.1 Soldering Acceptability Requirements

See 5.2 Soldering – Soldering Anomalies for examples of soldering anomalies.

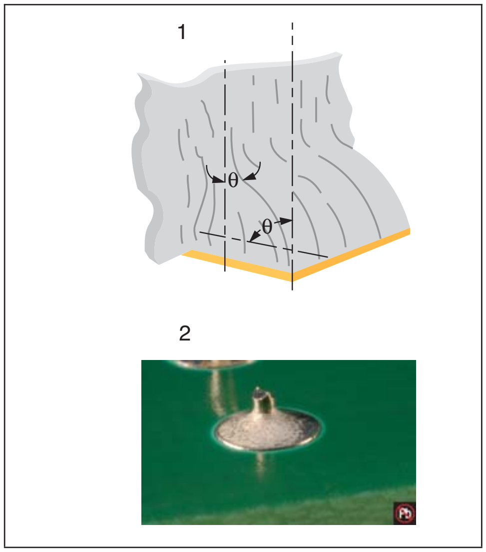

Figure 5-2

Figure 5-3

Acceptable – Class 1,2,3

- Solder fillet appears generally smooth and exhibits good wetting of the solder to the parts being joined.
- There are materials and processes, e.g., Pb-free alloys and slow cooling with large mass printed boards, that may produce dull matte, gray, or grainy appearing solders that are normal for the material or process involved. These solder connections are acceptable.
- The solder connection wetting angle (solder to component and solder to printed board termination, see Figure 5-2) do not exceed 90°, see Figure 5-1 A, B.
  - As an exception, the solder connection to a termination may exhibit a wetting angle exceeding 90°, see Figure 5-1 C, D when it is created by the solder contour extending over the edge of the solderable termination area or solder mask.

The primary difference between the solder connections created with processes using SnPb alloys and processes using Pb-free alloys is related to the visual appearance of the solder. This standard provides visual criteria for inspections of both SnPb and Pb-free connections. In this standard, figures specific to Pb-free connections will be identified with the symbol shown in Figure 5-3.

Acceptable Pb-free and SnPb connections may exhibit similar appearances but Pb-free alloys are more likely to have surface roughness (grainy or dull) or greater wetting contact angles.

Solder fillet criteria for SnPb and Pb-free alloys are the same.

Typical SnPb connections have from a shiny to a satin luster, generally smooth appearance and exhibit wetting as exemplified by a concave fillet between the objects being soldered. High-temperature solders may have a dull appearance. Touch-up (rework) of soldered connections is performed with discretion to avoid causing additional problems, and to produce results that exhibit the acceptability criteria of the applicable class.

5.2 Soldering Anomalies

5.2.1 Soldering Anomalies – Exposed Basis Metal

Some printed board and conductor finishes have different wetting characteristics and may exhibit solder wetting only to specific areas. Exposed basis metal or surface finishes should be considered normal under these circumstances, provided the achieved wetting characteristics of the solder connection areas are acceptable.

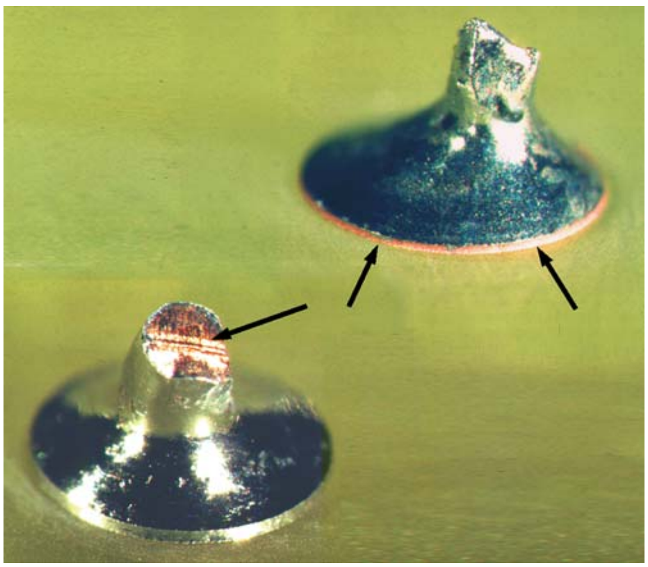

Figure 5-4

Acceptable – Class 1,2,3

- Exposed basis metal on:
  - Vertical conductor edges.
  - Cut ends of component leads or wires.
  - Organic Solderability Preservative (OSP) coated lands.
- Exposed surface finishes that are not part of the required solder fillet area.

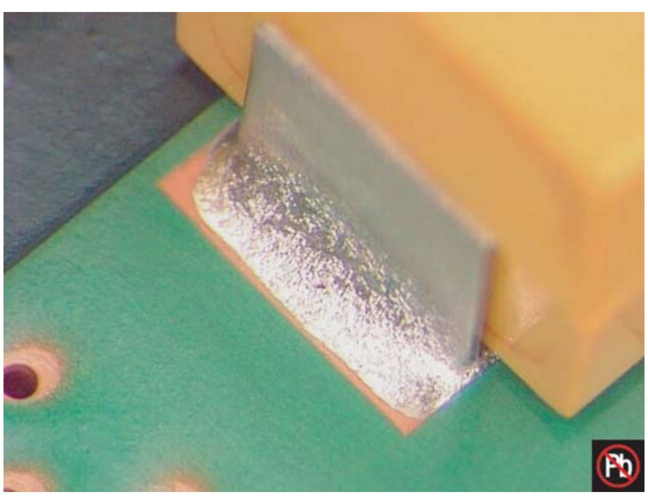

Figure 5-5

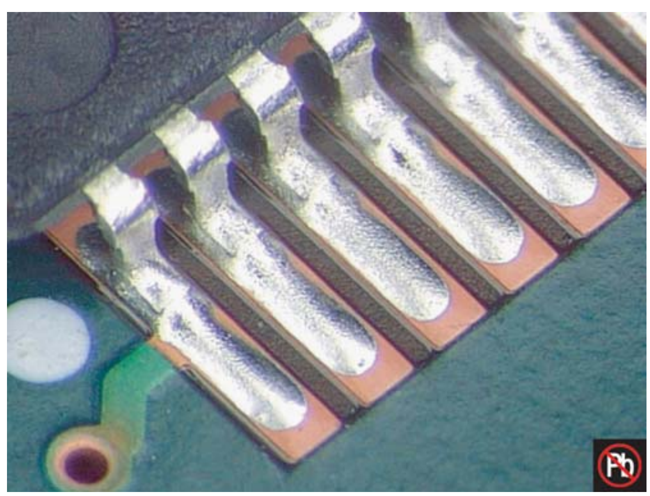

Figure 5-6

5.2.1 Soldering Anomalies – Exposed Basis Metal (cont.)

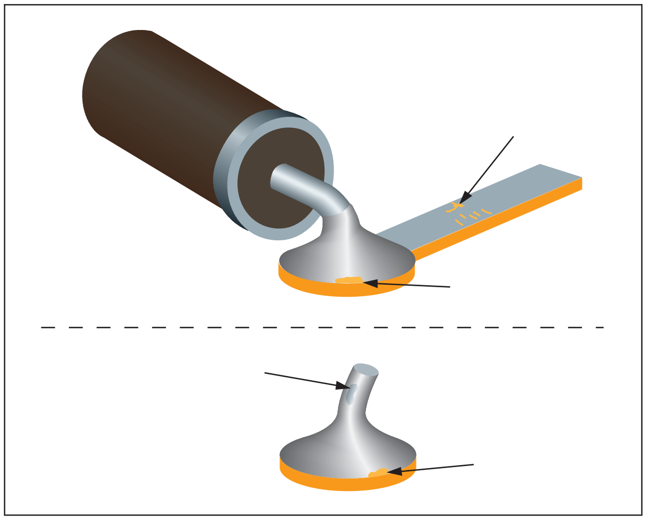

Figure 5-7

Acceptable – Class 1
Process Indicator – Class 2,3

- Exposed basis metal on component leads, conductors or land surfaces from nicks or scratches provided conditions do not exceed the requirements of 7.1.2.4 Through-Hole Technologies – Component Mounting – Leading Forming – Damage and 8.2.2 Surface Mount Assemblies – SMT Leads – Damage for leads and 10.3.1 Printed Boards and Assemblies – Conductor/Lands – Reduction for conductors and lands.

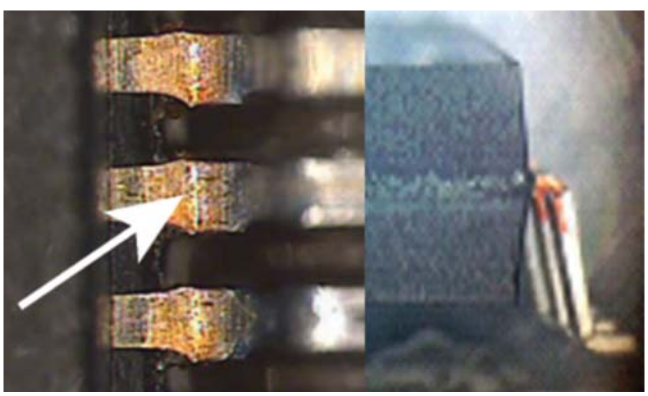

Figure 5-8

Defect – Class 1,2,3

- Exposed basis metal on component leads (see Figure 5-8 arrow), conductors or land surfaces from nicks, scratches or other conditions exceed the requirements of 7.1.2.4 Through-Hole Technologies – Component Mounting – Leading Forming – Damage and 8.2.2 Surface Mount Assemblies – SMT Leads – Damage for leads and 10.3.1 Printed Boards and Assemblies – Conductor/Lands – Reduction for conductors and lands.

5.2.2 Soldering Anomalies – Pin Holes/Blow Holes/Voids

Figure 5-9

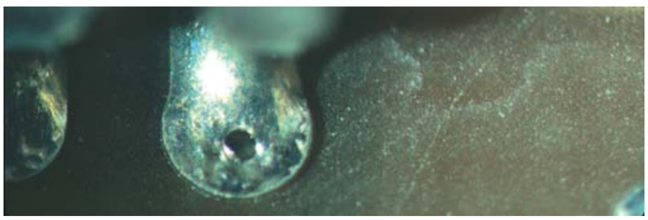

Figure 5-10

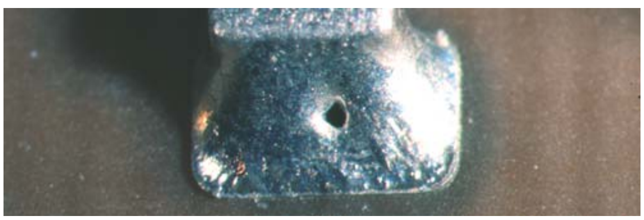

Figure 5-11

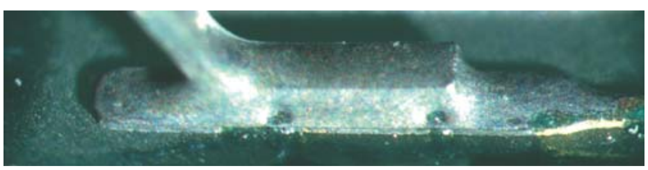

Figure 5-12

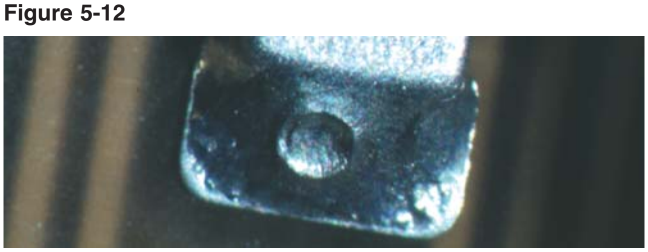

Figure 5-13

Acceptable – Class 1
Process Indicator – Class 2,3

- Blow holes (see Figures 5-9 and 5-10), pin holes (see Figure 5-11), and voids (see Figures 5-12 and 5-13) providing the solder connection meets all other requirements.

Defect – Class 1,2,3

- Solder connections where pin holes, blow holes, voids, etc., reduce the connections below minimum requirements (not shown).

5.2.3 Soldering Anomalies – Reflow of Solder Paste

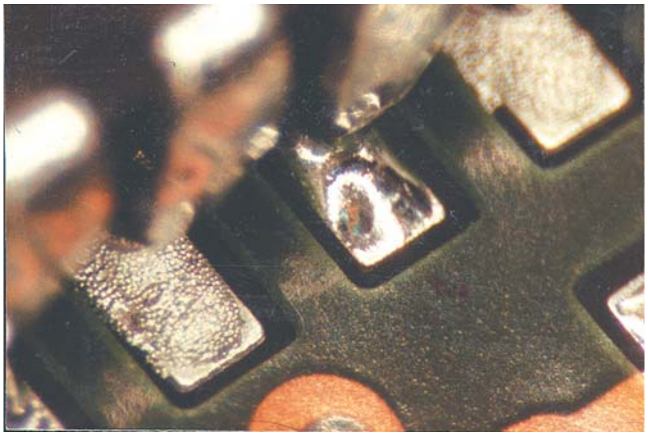

Figure 5-14

Defect – Class 1,2,3

• Incomplete reflow of solder paste.

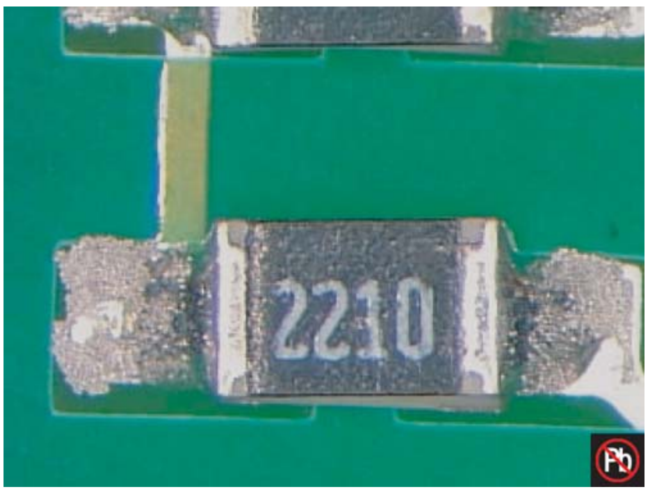

Figure 5-15

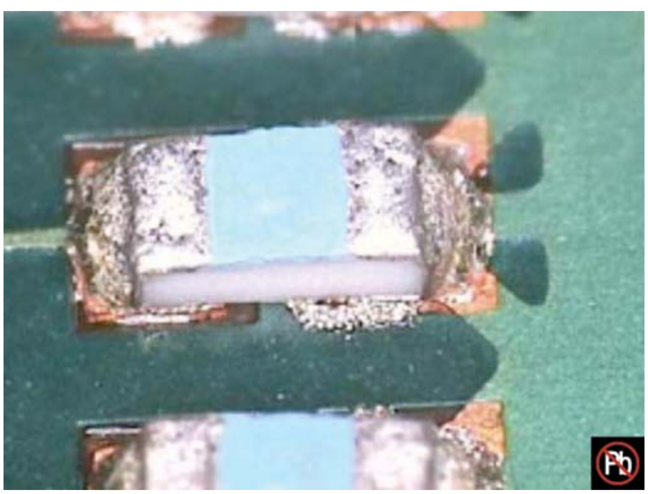

Figure 5-16

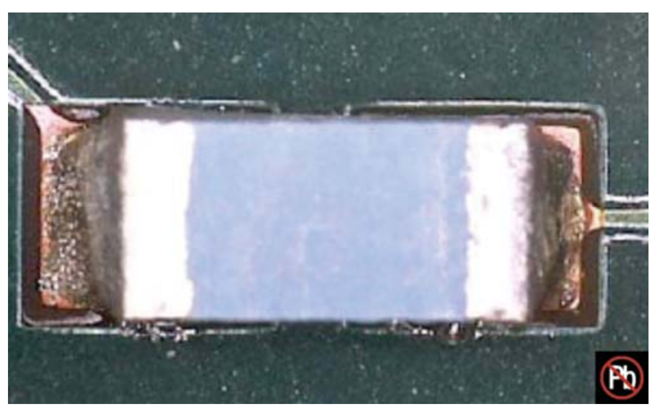

Figure 5-17

5.2.4 Soldering Anomalies – Nonwetting

IPC-T-50 defines nonwetting as the inability of molten solder to form a metallic bond with the basis metal. In this standard, that includes surface finishes, see 5.2.1 Soldering – Soldering Anomalies – Exposed Basis Metal.

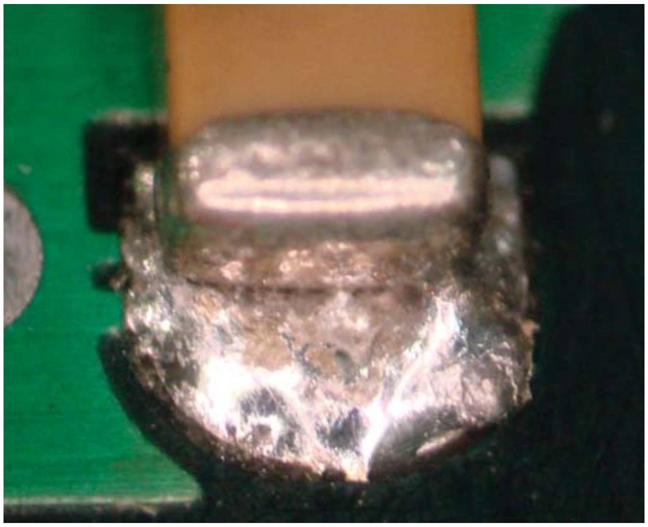

Figure 5-18

Defect – Class 1,2,3

- Solder has not wetted to the land or termination where solder is required, see Figures 5-18, 5-19, and 5-20 component terminations, Figure 5-21 shield termination, and Figure 5-22 wire termination.
- Solder coverage does not meet requirements for the termination type.

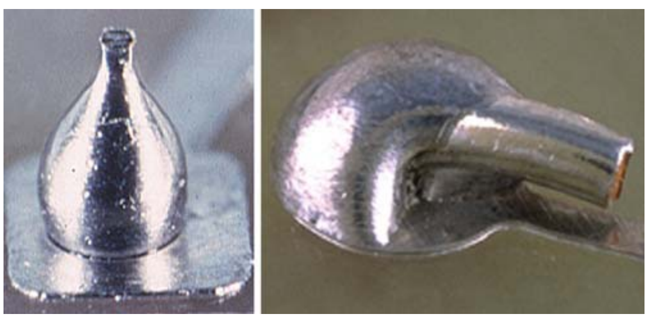

Figure 5-19

Figure 5-20

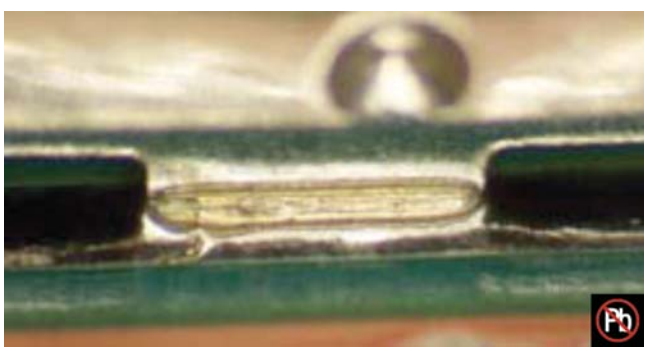

Figure 5-21

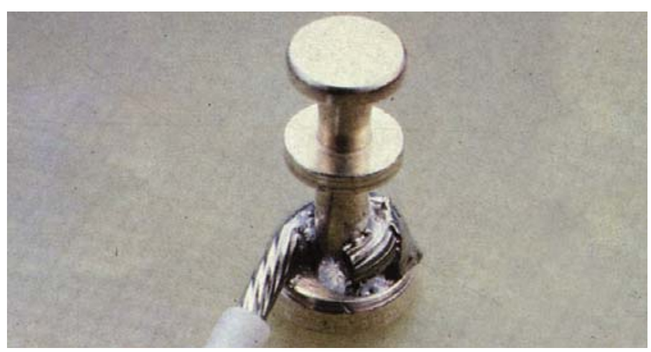

Figure 5-22

5.2.5 Soldering Anomalies – Cold/Rosin Connection

IPC-T-50 defines cold solder connection as ''A solder connection that exhibits poor wetting, and that is characterized by a grayish, porous appearance. (This is due to excessive impurities in the solder, inadequate cleaning prior to soldering, and/or the insufficient application of heat during the soldering process.)'' A rosin solder connection is defined in IPC-T-50 as ''A solder connection that has practically the same appearance as does a cold solder connection, but that also shows evidence of entrapped rosin separating the surfaces to be joined.''

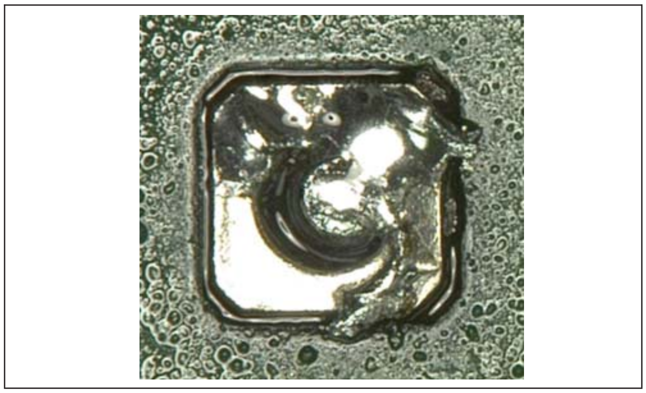

Figure 5-23

Defect – Class 1,2,3

- Nonwetting or incomplete wetting as a result of a cold, see Figure 5-23, or rosin (not shown) connection.

5.2.6 Soldering Anomalies – Dewetting

IPC-T-50 defines dewetting as a condition that results when molten solder coats a surface and then recedes to leave irregularly-shaped mounds of solder that are separated by areas that are covered with a thin film of solder and with the basis metal or surface finish not exposed.

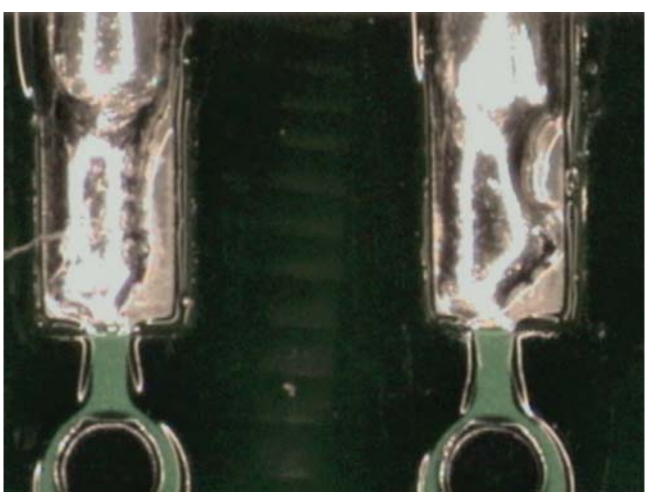

Figure 5-24

Defect – Class 1,2,3

- Evidence of dewetting that causes the solder connection to not meet the fillet requirements.

5.2.6 Soldering Anomalies – Dewetting (cont.)

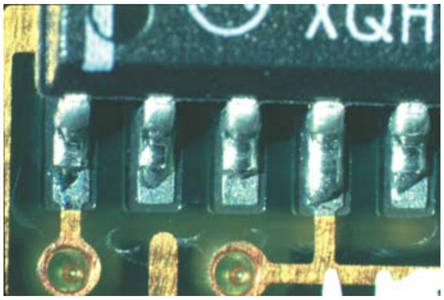

Figure 5-25

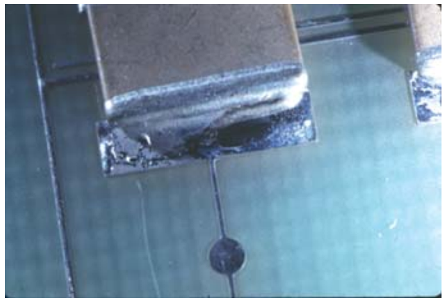

Figure 5-26

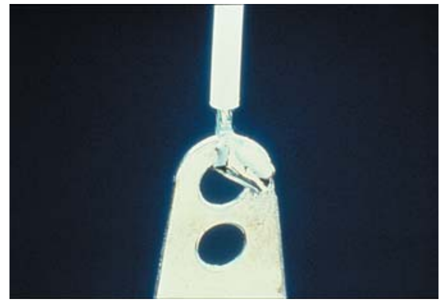

Figure 5-27

5.2.7 Soldering Anomalies – Excess Solder

Figure 5-28

Metal Lidded Components

Solder splashes or tinning on a metalized package body, see Figure 5-28, should be evaluated for impact upon hermetic and radiation hardening performance of the component considering the intended performance environment. Solder splashes on the metalized surfaces may be acceptable if the extended electrical performance is not required or compromised.

In the following criteria, the words ''entrapped,'' ''encapsulated,'' and ''attached'' are intended to mean that the service environment of the product will not cause particulate matter to become dislodged. The method to determine if the FOD could break loose in the service environment should be agreed between the Manufacturer and User.

5.2.7.1 Soldering Anomalies – Excess Solder – Solder Balls

Solder balls are spheres of solder that remain after the soldering process. This includes small balls of the original solder paste metal screen size that have splattered around the connection during the reflow process.

The method used to determine if conductive particulate matter (solder balls, fines, or splash) will become dislodged should be as agreed between User and Supplier.

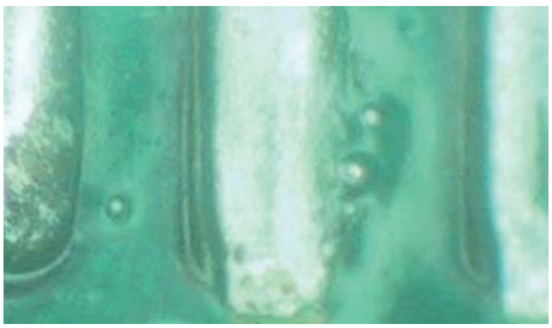

Figure 5-29

Acceptable – Class 1,2,3

- Solder balls are entrapped, encapsulated or attached, e.g., in no-clean residue, with conformal coating, soldered to a metal surface, embedded in the solder mask or under a component.
- Solder balls do not violate minimum electrical clearance.

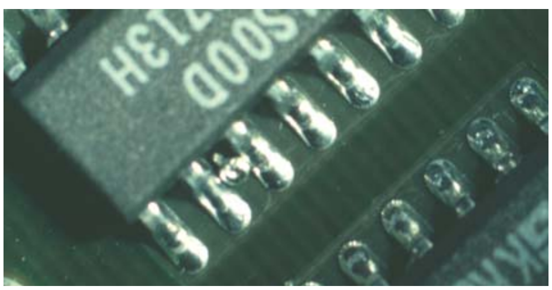

Figure 5-30

Defect – Class 1,2,3

- Solder balls are not entrapped, encapsulated or attached or can become dislodged in the service environment.
- Solder balls violate minimum electrical clearance.

Figure 5-31

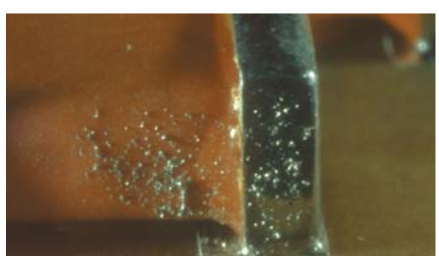

Figure 5-32

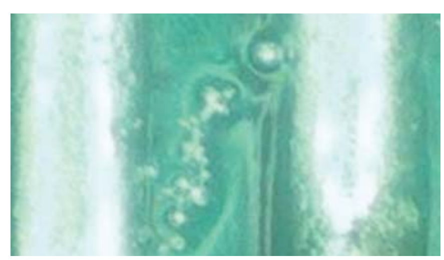

Figure 5-33

5.2.7.2 Soldering Anomalies – Excess Solder – Bridging

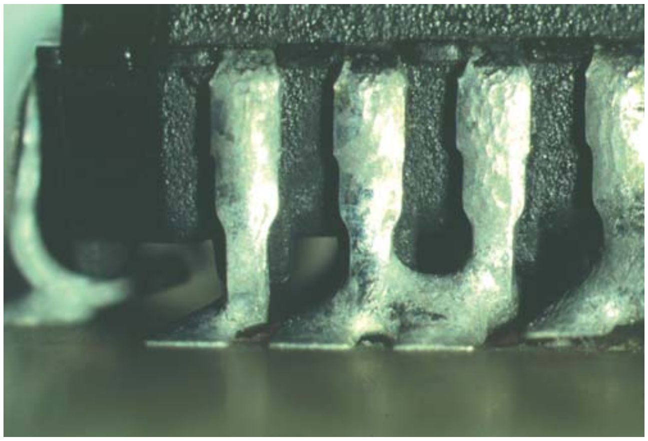

Figure 5-34

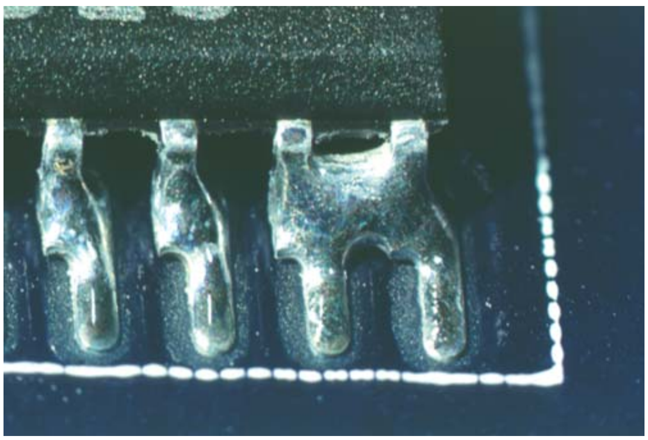

Figure 5-35

Defect – Class 1,2,3

- A solder connection across conductors that should not be joined.
- Solder has bridged to adjacent noncommon conductor or component.

Figure 5-36

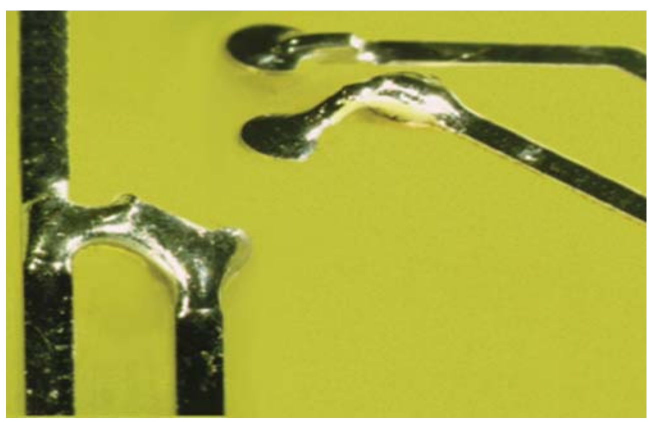

Figure 5-37

5.2.7.3 Soldering Anomalies – Excess Solder – Solder Webbing/Splashes

Acceptable – Class 1,2,3

- Solder splashes or metallic particles meet the following criteria:
  - Attached/entrapped/encapsulated on the assembly surface or solder mask, or soldered to metallic surface.
  - Do not violate minimum electrical clearance.

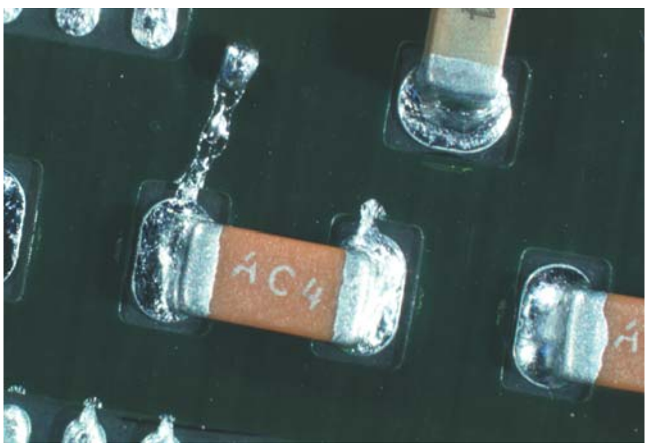

Figure 5-38

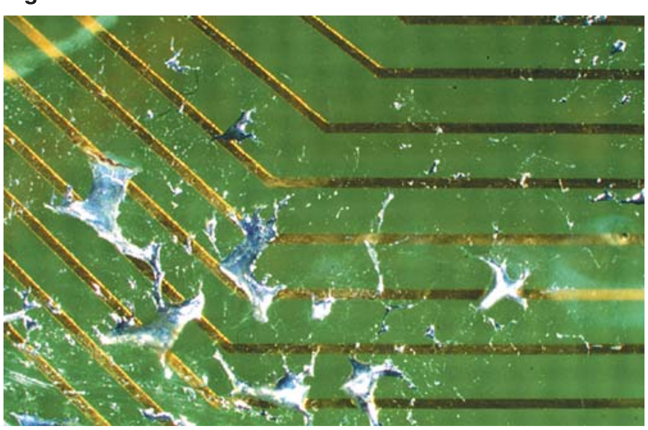

Figure 5-39

Defect – Class 1,2,3

- Solder webbing.
- Solder splashes that are not attached, entrapped, encapsulated.
- Solder splashes on metal component surfaces impact form, fit or function, e.g., damages lid seal on hermetic components.
- Violate minimum electrical clearance.

5.2.8 Soldering Anomalies – Disturbed Solder

Disturbed solder is not to be confused with cooling lines and secondary reflow.

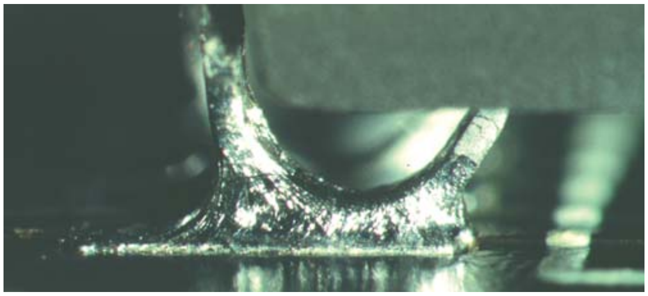

Figure 5-40

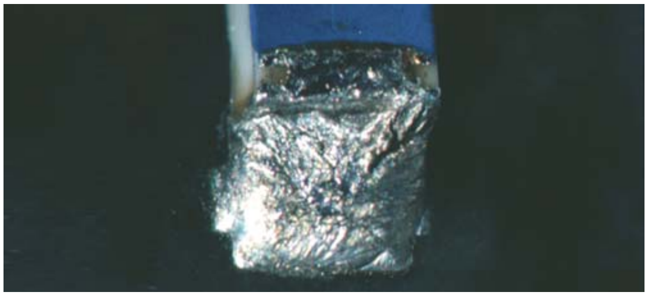

Figure 5-41

Defect – Class 1,2,3

- Disturbed solder joint characterized by uneven surface from movement in the solder connection during cooling.

5.2.9 Soldering Anomalies – Cooling Lines and Secondary Reflow

Surface appearance with cooling lines as shown in Acceptable Figures 5-42 (Pb-free) and 5-43 (SnPb) are more likely to occur in Pb-free alloys and are not a disturbed solder condition. Cooling lines and secondary reflow lines are the result of solder solidification mechanisms (not movement) which cause visual surface roughness.

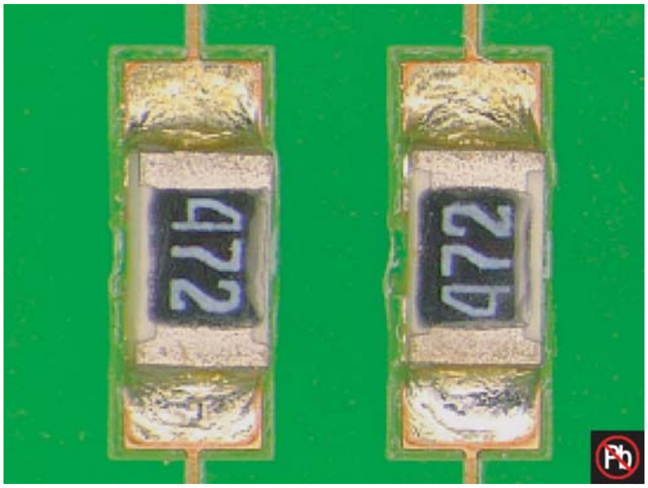

Figure 5-42

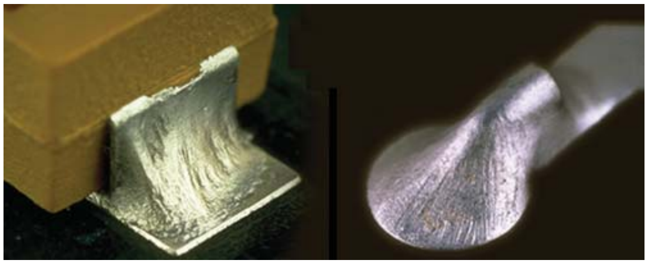

Figure 5-43

Acceptable – Class 1,2,3

- Pb-free and SnPb solder connections exhibit:
  - Cooling lines, see Figure 5-42.
  - Secondary reflow, see Figure 5-43.

5.2.10 Soldering Anomalies – Fractured Solder

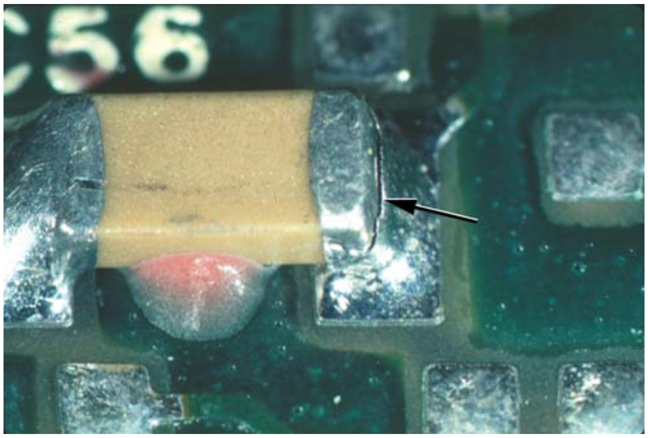

Figure 5-44

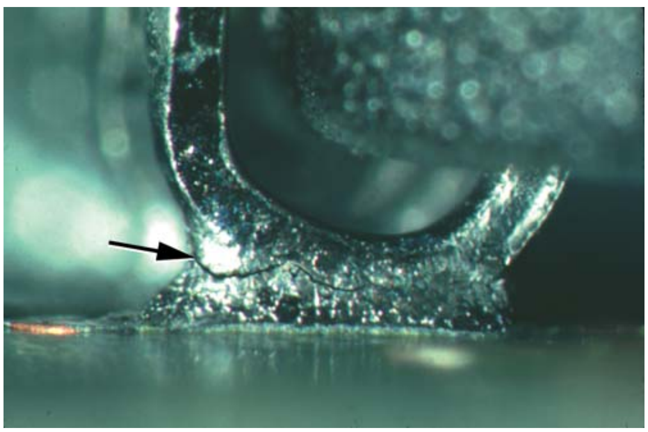

Figure 5-45

Defect – Class 1,2,3

- Fractured or cracked solder.

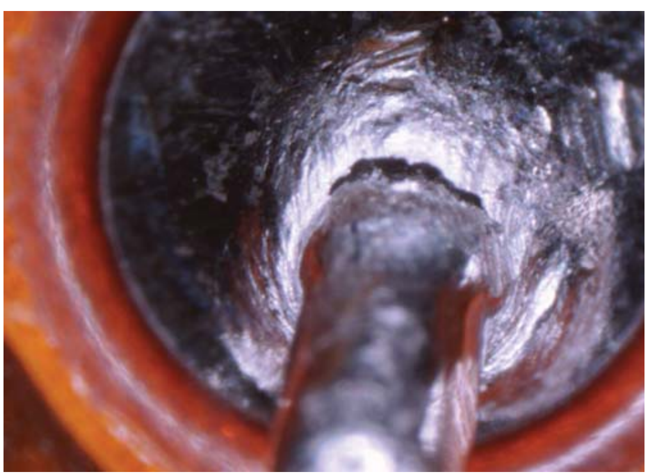

Figure 5-46

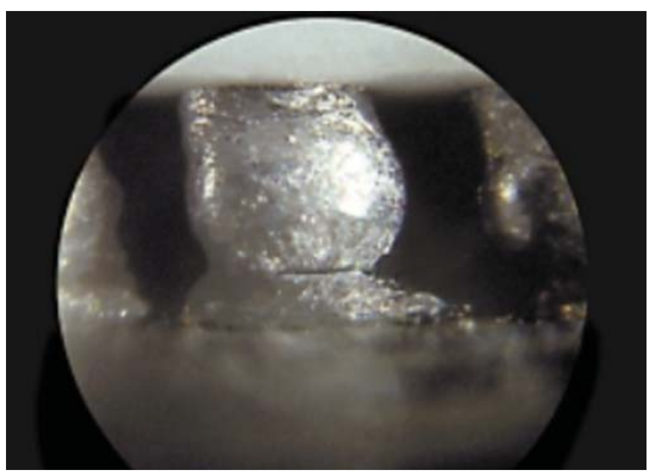

Figure 5-47

5.2.11 Soldering Anomalies – Solder Projections

Figure 5-48

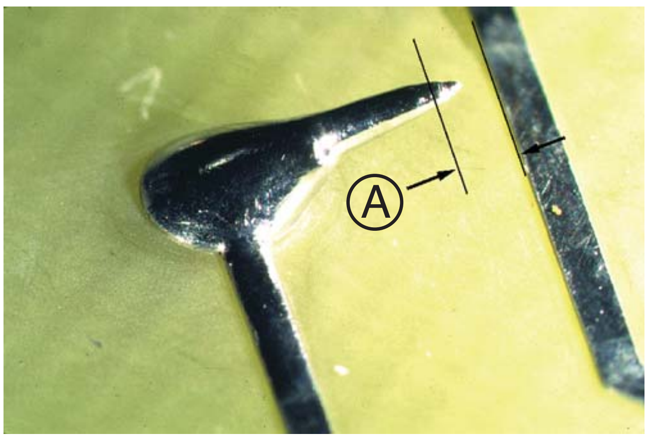

Figure 5-49

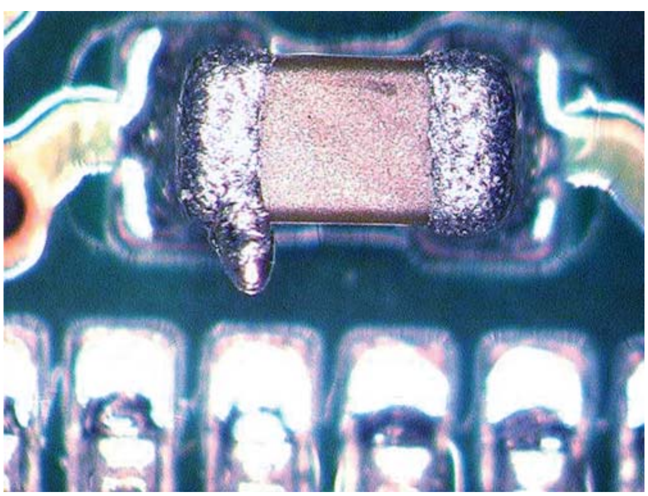

Figure 5-50

Defect – Class 1,2,3

- Solder projection violates assembly maximum height requirements or lead protrusion requirements, see Figure 5-48.
- Projection violates minimum electrical clearance, see Figures 5-49-A and 5-50.

5.2.12 Soldering Anomalies – Pb-Free Fillet Lift

These criteria are applicable to plated through-hole connections.

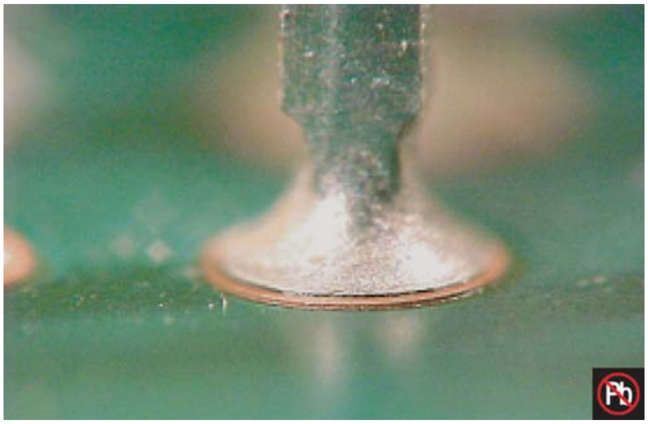

Figure 5-51

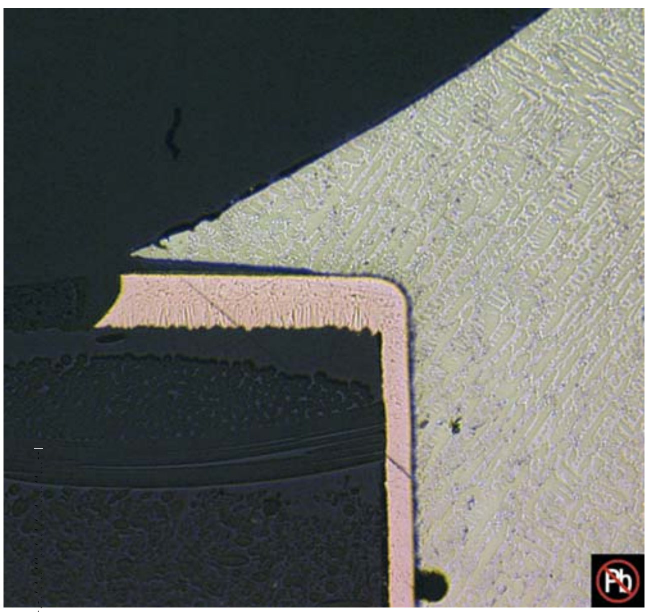

Figure 5-52

Acceptable – Class 1,2.3

- Fillet Lifting – separation of the bottom of the solder and the top of the land. The connection with the lifted fillet must meet all other acceptance criteria.

Note: Fillet lifting is the phenomenon in which the solder fillet is lifted off from the land on a board mainly during the flow solder process. The phenomenon is more likely to occur on the primary (solder destination) side rather than on the secondary (solder source) side which is exposed to flow soldering. Figure 5-52 is a microsection view of fillet lifting.

There is no defect associated with this anomaly.

Note: See 10.3.2 Printed Boards and Assemblies – Conductors/Lands – Lifted for criteria related to land damage that may be caused by fillet lifting.

5.2.13 Soldering Anomalies – Pb-Free Hot Tear/Shrink Hole

There is no defect associated with the anomaly provided the connection meets all other acceptance criteria. Figures 5-53 and 5-54 are examples of hot tear. Hot tear/shrinkage voids are generally found on the surface of the solder joint. The connection with the hot tear/shrinkage void **shall** meet all other acceptance criteria.

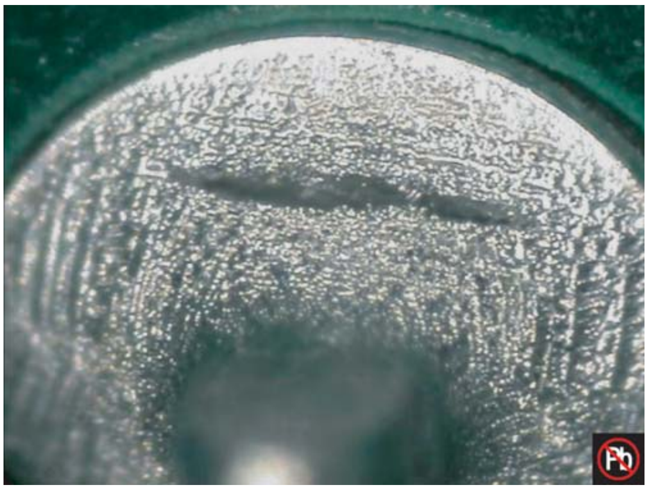

Figure 5-53

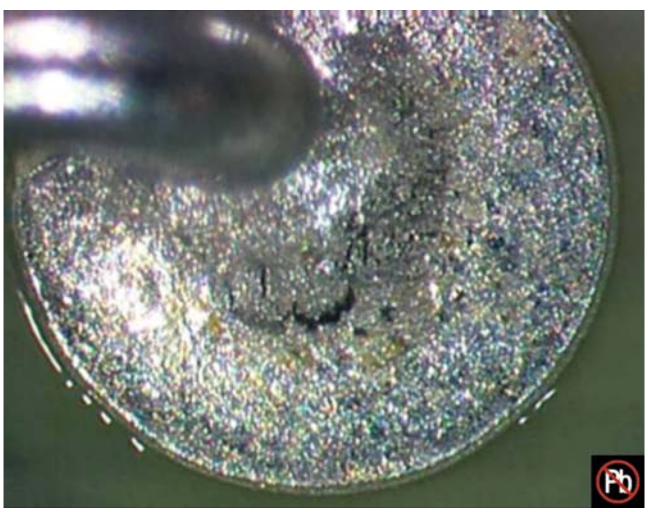

Figure 5-54

Acceptable – Class 1,2,3

- Hot Tear/Shrinkage Void – a crevice or void in the solder joint due to the solidification of the Pb-free solder alloy during assembly process.

5.2.14 Probe Marks and Other Similar Surface Conditions in Solder Joints

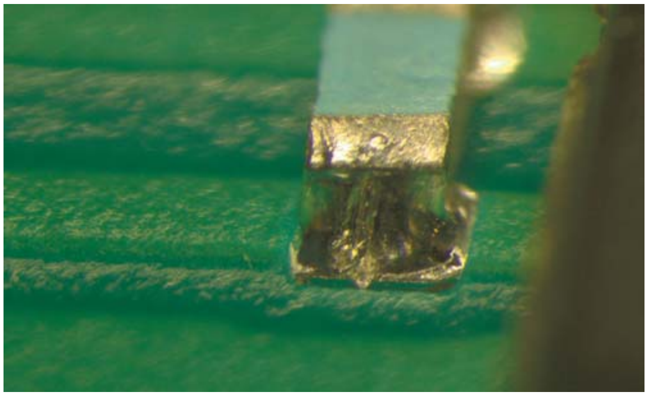

Figure 5-55

Acceptable – Class 1,2,3

- Probe marks and other similar surface conditions that do not violate other requirements.

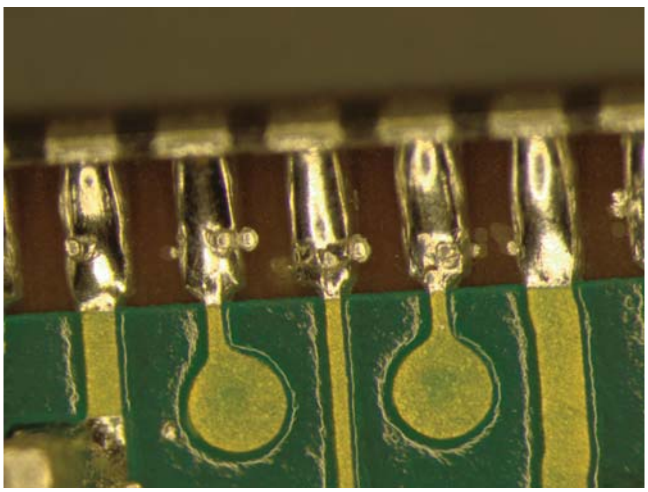

Figure 5-56

Defect – Class 1,2,3

- Probe marks and other similar surface conditions cause damage in excess of requirements.

5.2.15 Partially Visible or Hidden Solder Connections

A partially visible solder connection **shall** be inspected on the visible portion, and **shall** be compliant with the criteria stated herein for that type of connection. The non-visible portion of the connection should be maintained in accordance with 1.6 Process Control Methodologies.

Note: Nondestructive evaluation (NDE) may be used or as agreed between User and Supplier to verify the specified dimensions that are not visible through normal visual means.

5.2.16 Heat Shrinkable Soldering Devices

When heat shrinkable soldering devices are used, the solder preform (ring) and pickoff wire should be centered in the wire insulation opening (window) then shrunk in place. Self-sealing heat shrinkable solder devices are exempt from cleaning requirements.

A thermal indicator (if provided) is an aid for deciding when to stop heating. Its presence or absence in the installed part is not reason for rejection of the installation.

Acceptable – Class 1,2,3

- Wires overlap for at least three conductor diameters and are approximately parallel.
- The solder preform (ring) is centered over the connection.
- Solder preform has fully melted and forms a fillet joining the connection.
- Conductor contour is discernible.
- Sleeving covers insulation on all wires by a minimum of one wire diameter.
- No conductor strands piercing the sleeving.
- Sleeve is discolored but not charred.
- Meltable sealing ring does not interfere with formation of required solder connection.
- Meltable sealing ring provides 360° of seal at both ends.

Figure 5-57

Figure 5-58

Figure 5-59

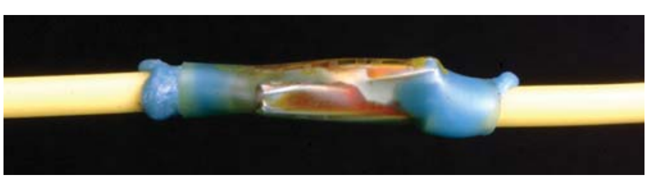

Figure 5-60

Defect – Class 1,2,3

- Solder fillet not wetted to all elements in the solder connection.
- The solder preform ring is not fully melted (see Figures 5-57 and 5-58).
- Conductor strands pierce the sleeving.
- Wires do not overlap at least three conductor diameters.
- Sleeving does not cover wire insulation on both ends at least one wire diameter (see Figure 5-59).
- Meltable sealing ring interferes with formation of required solder connection.
- Meltable sealing ring does not provide 360° of seal at either end.
- Sleeve is discolored such that internal attributes cannot be verified (not shown).
- Sleeving or wire insulation is charred (not shown).
- Conductor overlaps insulation of a wire (see Figure 5-60).
- Conductor contour is not discernible (not shown).
- Wire strands are exposed (not shown).
- Solder has flowed beyond the meltable sealing rings or has extruded beyond the end of the heat shrinkable sleeving (not shown).

5.2.17 Inclusions

Acceptable – Class 1,2,3

• No inclusions.

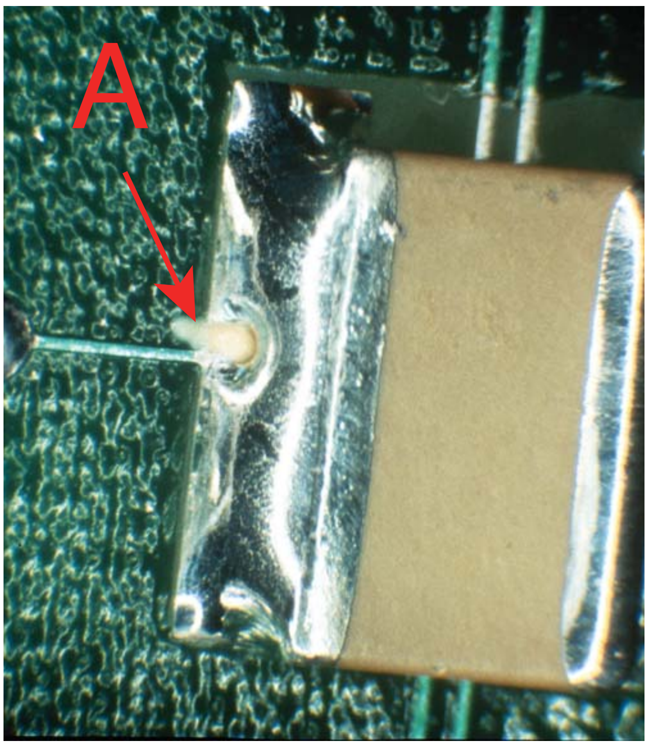

Figure 5-61
A. Brush hair

Defect – Class 1,2,3

• Inclusions that penetrate or project from the solder fillet.

6 Terminal Connections

These criteria apply to both wires and component leads. The wrap conditions should achieve a mechanical connection between the lead/wire and the terminal sufficient to assure that the lead/wire does not move during the soldering operation. Typically the mechanical connection includes a 180° mechanical wrap to affect mechanical connection.

As an exception to the wrap conditions described above, it is acceptable when attaching leads/wires to bifurcated, slotted, pierced, punched or perforated terminals for the lead/wire to extend straight through the opening of the terminal with no wrap. Except for slotted terminals (6.11 Terminal Connections – Slotted) leads/wires with no wrap need to be staked, bonded, or constrained to a degree that the attachment is mechanically supported, see 6.10.1 Terminal Connections – Bifurcated – Lead/Wire Placement – Side Route Attachments and 6.10.2 Terminal Connections – Bifurcated – Lead/Wire Placement – Staked Wires. The purpose is to prevent transmission of shock, vibration, and movement of the attached wires that could degrade the solder connection.

The criteria in this section are grouped together in seventeen main subsections. Not all combinations of wire/lead types and terminal types can possibly be covered explicitly, so criteria are typically stated in general terms to apply to all similar combinations. For example, a resistor lead and a multistranded jumper wire connected to turret terminals have the same wrap and placement requirements, but only the multistranded wire could be subject to birdcaging.

In addition to the criteria in this section the criteria of 5 Soldering are applicable.

The following topics are addressed in this section.

6 Terminal Connections (cont.)

6.1 Swaged Hardware

This section contains criteria for the basic types of swaged hardware.

Terminals

Swaged hardware that overhangs the land is acceptable if it does not violate minimum electrical clearance, see 1.8.5 Electrical Clearance.

6.1.1 Swaged Hardware – Terminals

This section shows mechanical assembly of turret and bifurcated terminals. Terminals that are to be soldered to a land may be mounted so that they can be turned by hand, but are vertically stable.

6.1.1.1 Swaged Hardware – Terminals – Terminal Base to Land Separation

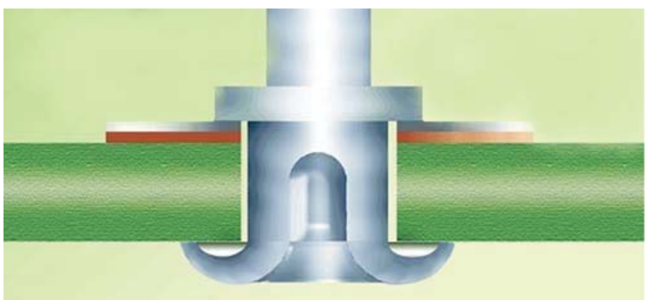

Figure 6-1

Acceptable – Class 1,2,3

- Terminal may be rotated by finger force once swaged.
- Terminal is vertically stable (no vertical movement).

Acceptable – Class 1,2

- Terminal base circumference has 180° or more contact with the land, with separation not exceeding two land thicknesses.

Acceptable – Class 3

- Terminal base circumference has 270° or more contact with the land, with separation not exceeding one land thickness.

6.1.1.1 Swaged Hardware – Terminals Terminal Base to Land Separation (cont.)

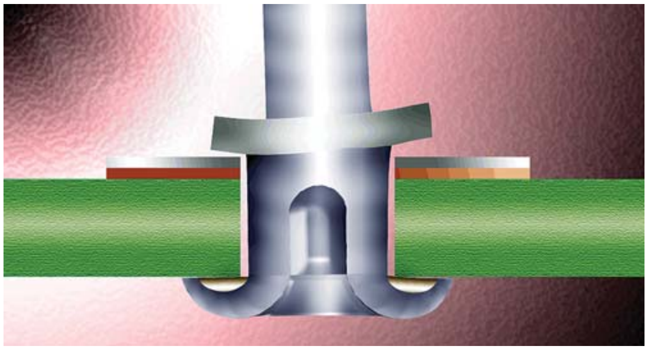

Figure 6-2

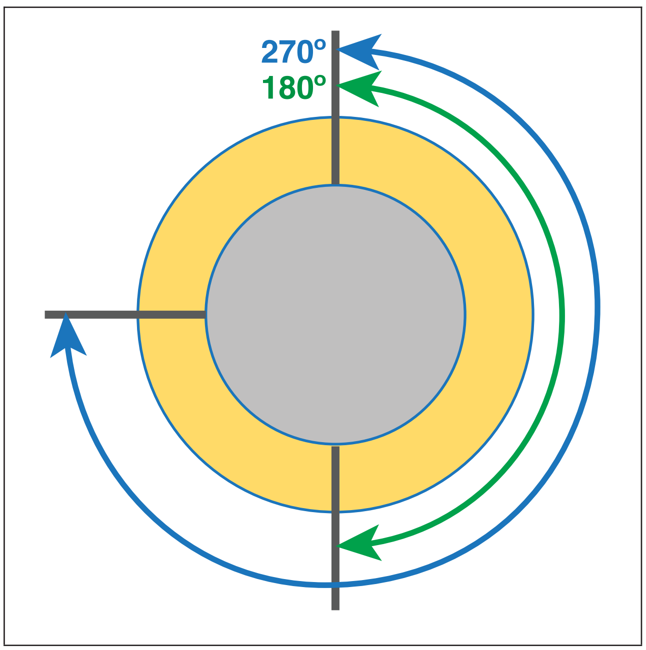

Figure 6-3

Defect – Class 1,2

- Terminal base circumference has less than 180° contact with the land.
- Terminal base has separation exceeding two land thicknesses.

Defect – Class 3

- Terminal base circumference has less than 270° contact with the land.
- Terminal base has separation exceeding one land thickness.

Defect – Class 1,2,3

- Terminal is not vertically stable.

6.1.1.2 Swaged Hardware – Terminals – Turret

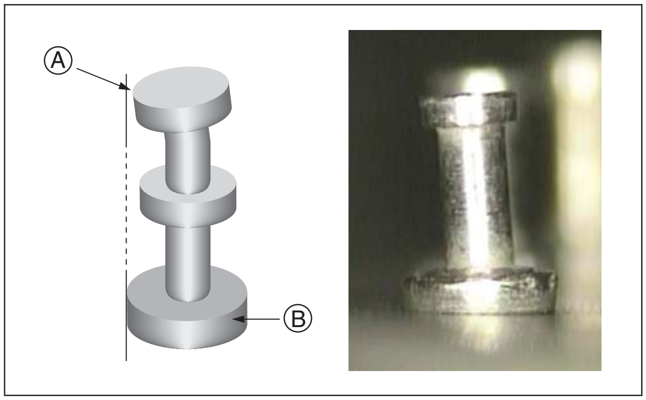

Figure 6-4

Acceptable – Class 1,2,3

- Terminal is bent, but the top edge, see Figure 6-4-A, does not extend beyond the base, see Figure 6-4-B.

Figure 6-5

Acceptable – Class 1
Defect – Class 2,3

- The top edge of the terminal is bent beyond the edge of the base.

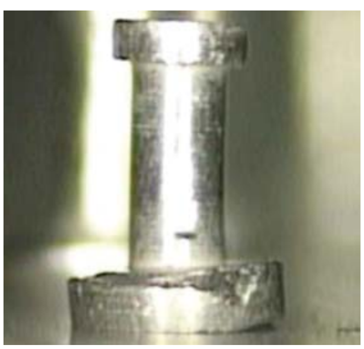

Figure 6-6

Defect – Class 1,2,3

- The center post is fractured.

6.1.1.3 Swaged Hardware – Terminals – Bifurcated

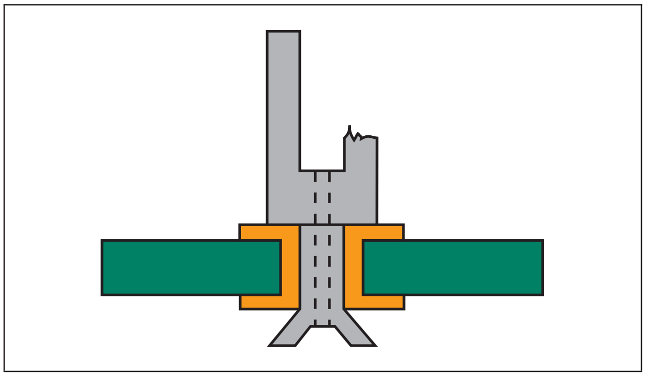

Figure 6-7

Acceptable – Class 1
Defect – Class 2,3

- A post is broken, but sufficient mounting area remains to attach the specified wires/leads.

Defect – Class 1,2,3

- Both posts are broken.

6.1.2 Swaged Hardware – Rolled Flange

The rolled flange terminal is used for mechanical attachments where electrical attachment to a land is not required. Rolled flange attachments are not to be soldered to a printed board land pattern nor installed on active circuitry. They may be installed on inactive and isolated circuitry.

Figure 6-8 identifies the three key features of a rolled flange swaged terminal.

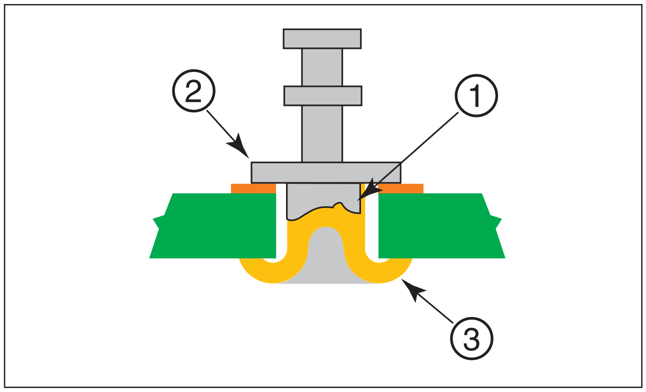

Figure 6-8
1. Shank
2. Terminal base
3. Rolled flange

Acceptable – Class 1,2,3

- Burnishing and deformation required to form the terminal swage.
- No more than three radial cracks.
- Any two radial splits or cracks are separated by 90° or more.
- Damage of the substrate is less than limits of 10.2 Printed Boards and Assemblies – Laminate Conditions.
- No circumferential splits or cracks.
- Splits or cracks do not enter the terminal shank.

Defect – Class 1,2,3

- Any circumferential splits or cracks.
- Any splits or cracks that enter the terminal shank.
- More than three radial splits or cracks.
- Radial splits or cracks are separated by less than 90°.
- Missing rolled flange pieces.
- Terminals installed on active circuitry or PTHs.
- Soldering of the rolled flange.
- Any mechanical damage of the substrate beyond requirements, see 10.2 Printed Boards and Assemblies – Laminate Conditions.

6.1.3 Swaged Hardware – Flared Flange

The shank extending beyond the land surface is swaged to create an inverted cone, uniform in spread, and concentric to the hole, see Figure 6-9.

Flared flange solder criteria are provided in 6.1.5 Terminal Connections – Swaged Hardware – Solder.

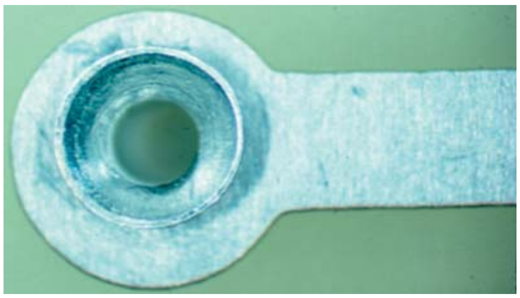

Figure 6-9

Acceptable – Class 1,2,3

- Split in flared flange does not enter into the barrel.
- Not more than three radial splits.
- Radial splits or cracks are separated by at least 90°.

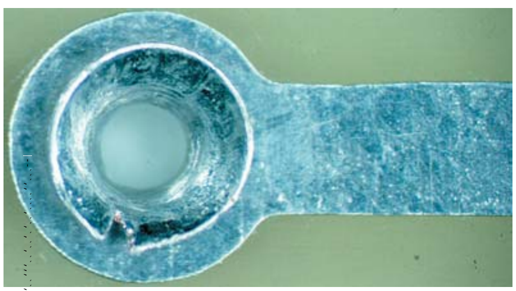

Figure 6-10

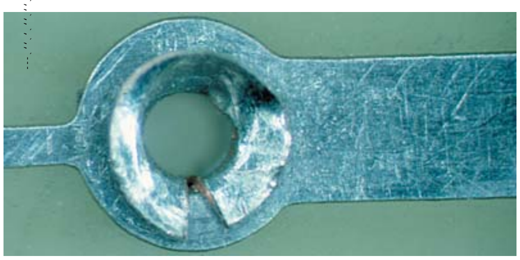

Figure 6-11

Defect – Class 1,2,3

- Flared flange periphery uneven or jagged.
- Split enters into barrel.
- Any circumferential splits/cracks, see Figure 6-12.
- More than three radial splits.
- Radial splits or cracks are separated by less than 90°.
- Missing flared flange pieces.

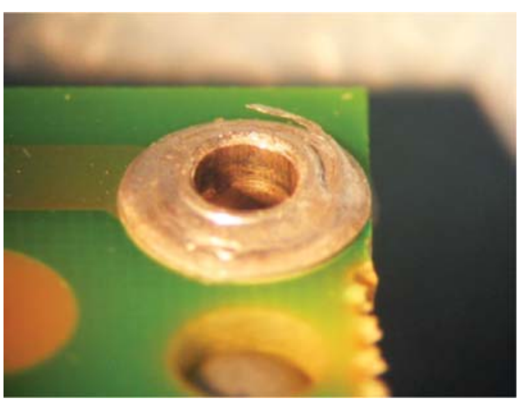

Figure 6-12

6.1.4 Swaged Hardware – Controlled Split

This form of swaged hardware is obtained by using scored hardware with a number of uniform segments. When swaged, each segment should conform to a particular angle, be uniform in spread, and concentric to the hole, see Figure 6-13.

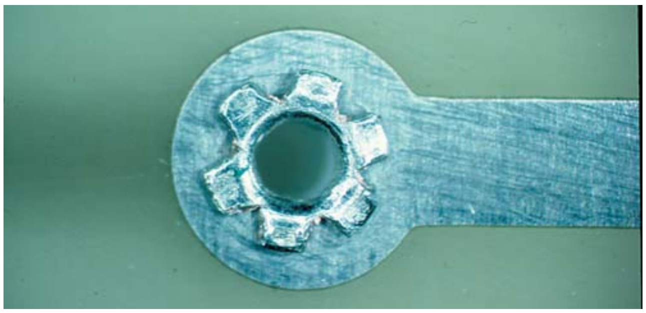

Figure 6-13

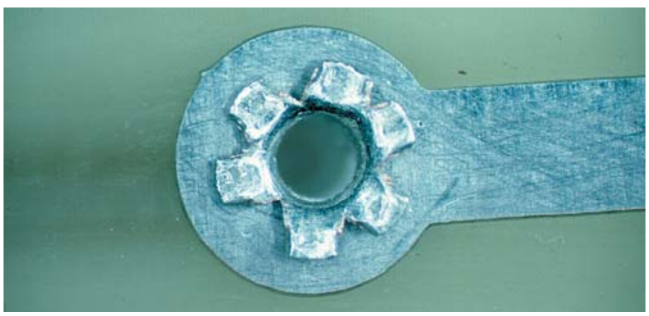

Figure 6-14

Acceptable – Class 1,2,3

- Flange splits down to the board but not into the barrel.

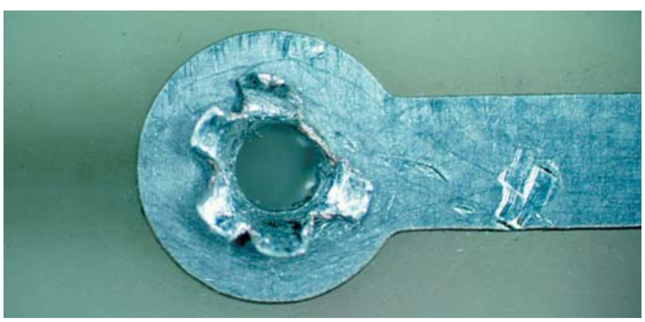

Figure 6-15

Figure 6-16

Defect – Class 1,2,3

- Flange damaged.
- Segments excessively deformed.
- Segment missing.
- Split enters into barrel.
- Circumferential splits/cracks.

6.1.5 Swaged Hardware – Solder

These solder acceptance criteria, summarized in Table 6-1, are applicable to flared flange and flat set swaged hardware.

Table 6-1 Swaged Hardware Minimum Soldering Requirements

Criteria	Class 1	Class 2	Class 3
A. Circumferential fillet and wetting – solder source side.	270°		330°
B. Percentage of solder source side land area covered with wetted solder.	75%		
C. Height of solder in flared flange.	75%		
D. Height of solder on flat set flange.	100%		

Acceptable – Class 1,2,3

- 75% or more of the land area is covered with wetted solder.
- Solder fillet is at least 75% of flare flange height.
- Solder fillet is 100% of flat set flange height.
- Solder flow is discernible between swaged flange and land of the printed board or other substrate.

6.1.5 Swaged Hardware – Solder (cont.)

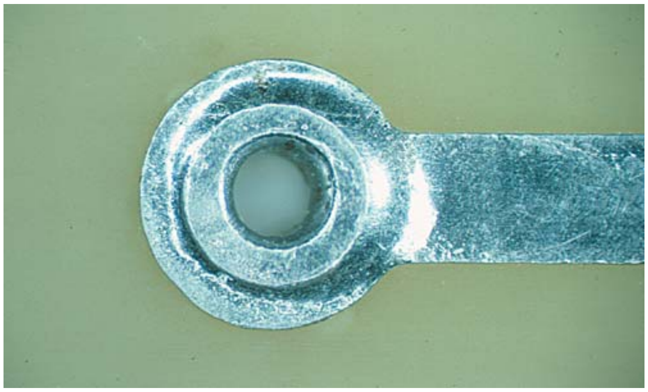

Figure 6-17

Acceptable – Class 1,2

- Minimum of 270° fillet and wetting flange to land.
- Any radial split is filled with solder.

Acceptable – Class 3

- Minimum of 330° fillet and wetting flange to land.

Figure 6-18

Defect – Class 1,2

- Less than 270° fillet and wetting flange or eyelet to land.
- Any radial split not filled with solder.

Defect – Class 1,2,3

- Improperly swaged, flange not seated on terminal area.
- Solder fillet is not 75% of flared flange height.
- Solder fillet is not 100% of flat set flange height.
- Less than 75% of the land area is covered with wetted solder.

Defect – Class 3

- Solder is less than 330° around flange.

6.2 Insulation

6.2.1 Insulation – Damage

6.2.1.1 Insulation – Damage – Presolder

Coatings added over insulation base material such as resin coatings over polyimide are not considered to be part of the insulation and these criteria are not intended to be applicable to those coatings.

The cut ends of some insulation materials, particularly those with a fiberglass barrier, may show fraying. Acceptability of this fraying should be agreed upon between Manufacturer and User.

These criteria are also applicable to post-assembly acceptance. Additional criteria for insulation damage as a result of soldering operations are provided in 6.2.1.2 Terminal Connections – Insulation – Damage – Post Solder.

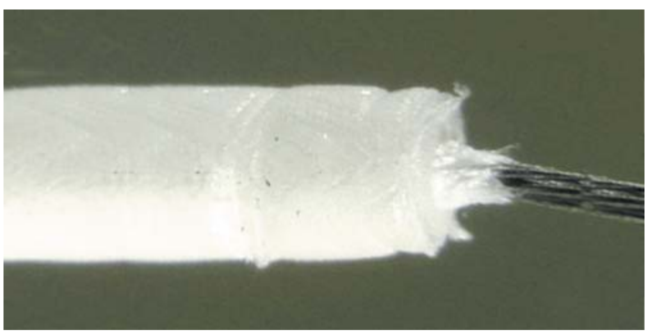

Figure 6-19

Acceptable – Class 1,2,3

- Insulation thickness is reduced by 20% or less.
- Chemical solutions, paste, and creams used to strip solid wires do not cause degradation to the wire.
- Discoloration of insulation resulting from thermal processing provided it is not charred, cracked or split.

6.2.1.1 Insulation – Damage – Presolder (cont.)

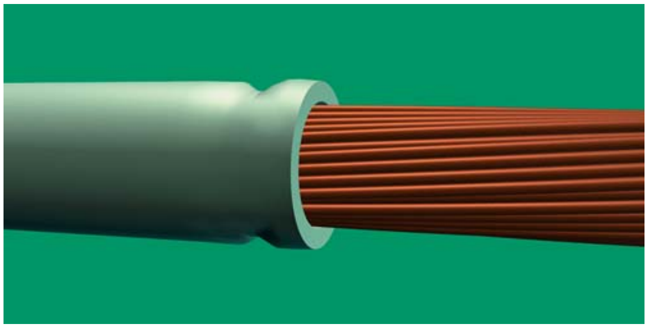

Figure 6-20

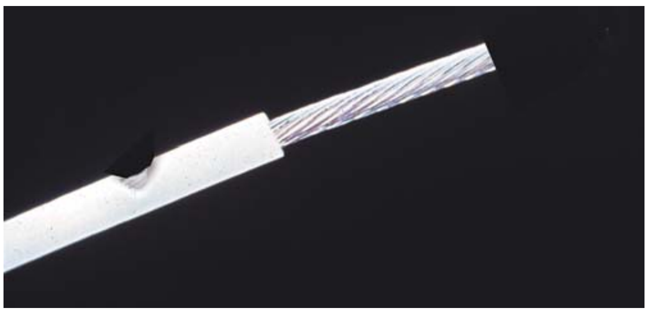

Figure 6-21

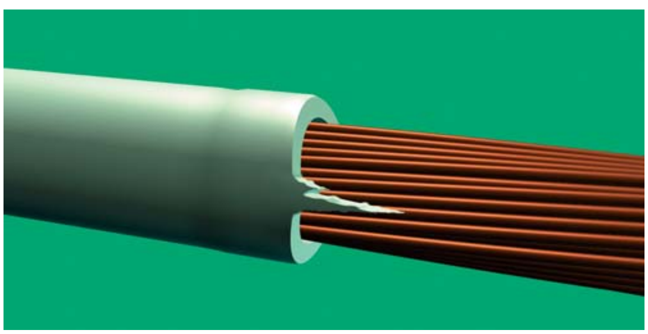

Figure 6-22

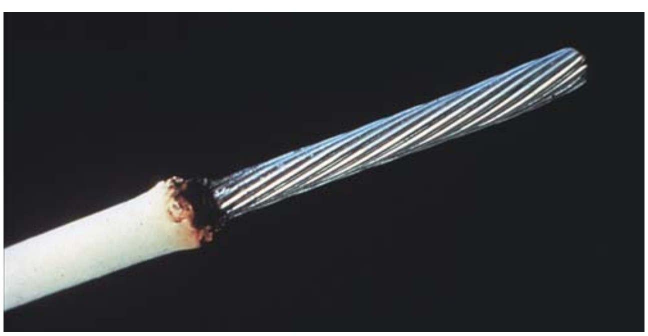

Figure 6-23

Defect – Class 1,2,3

- Any cuts, breaks, cracks or splits in insulation (not shown).
- Insulation is melted into the wire strands (not shown).
- Insulation thickness is reduced by more than 20%, see Figures 6-20 and 6-21.
- Uneven or ragged pieces of insulation (frays, tails, and tags) are greater than 50% of the wire diameter or 1 mm [0.04 in] whichever is more, see Figure 6-22.
- Insulation is charred, see Figure 6-23.

6.2.1.2 Insulation – Damage – Post-Solder

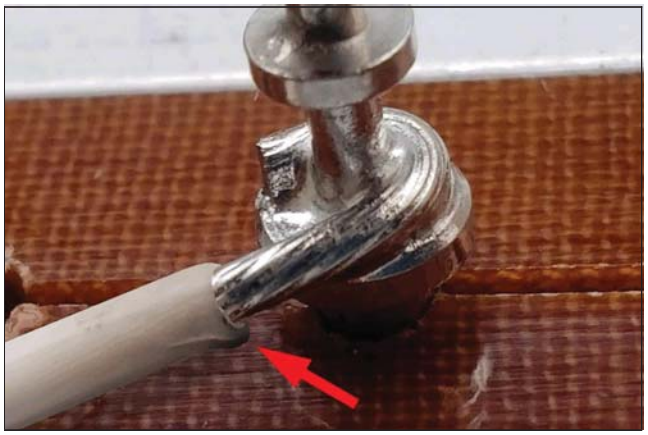

Figure 6-24

Acceptable – Class 1,2,3

- Melting of the insulation that does not violate any of the wire installation requirements.

Figure 6-25

Defect – Class 1,2,3

- Insulation charred.

6.2.2 Insulation – Clearance

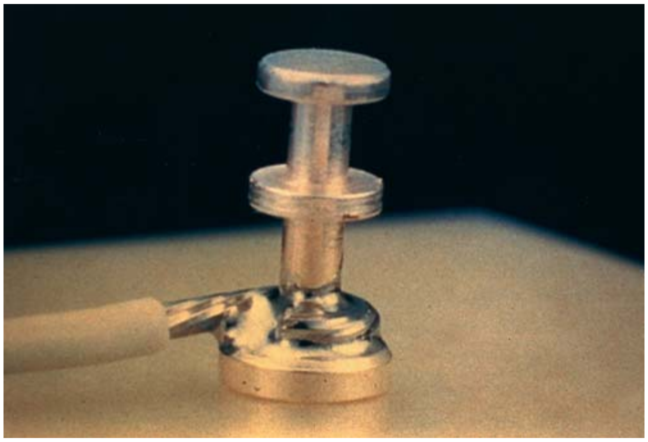

Figure 6-26

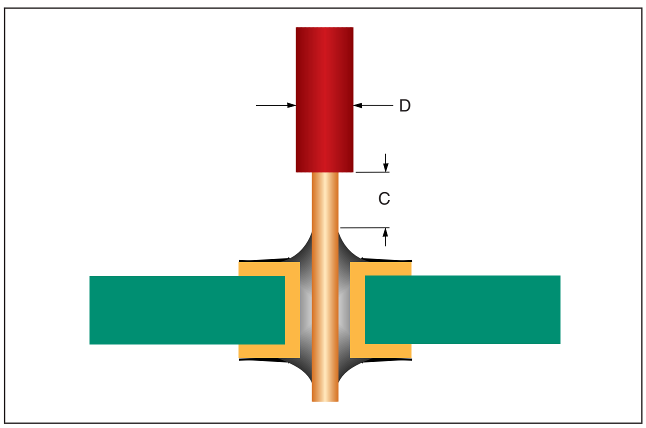

Figure 6-27

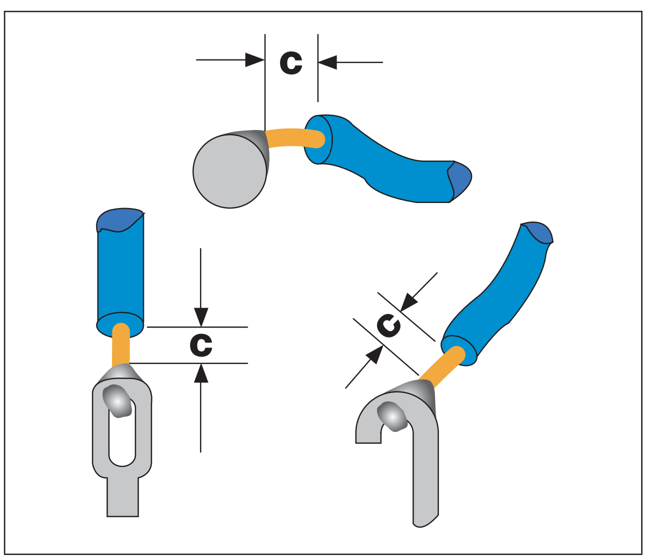

Figure 6-28

Acceptable – Class 1,2,3

- The insulation clearance (C) between the end of the insulation and the solder is two wire diameters or less including insulation or 1.5 mm [0.06 in], whichever is greater.
- Insulation clearance (C) does not permit violation of minimum electrical clearance to adjacent noncommon conductors.
- The insulation is in contact with the solder but does not interfere with formation of an acceptable connection.

6.2.2 Insulation – Clearance (cont.)

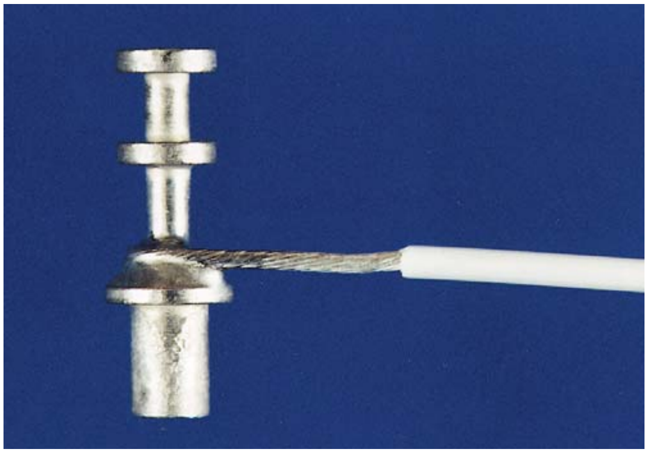

Figure 6-29

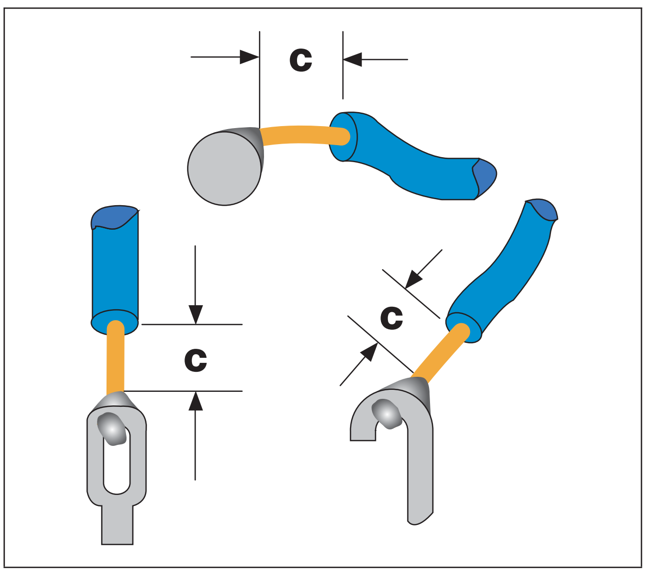

Figure 6-30

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- The insulation clearance (C) is greater than two wire diameters including insulation or 1.5 mm [0.06 in], whichever is greater.

Defect – Class 1,2,3

- Insulation clearance (C) permits violation of minimum electrical clearance to adjacent noncommon conductors.
- Insulation interferes with formation of an acceptable solder connection.

Defect – Class 2,3

- Insulation is embedded in or covered with solder (not shown).

6.2.3 Insulation – Insulation Sleeving

These criteria are intended for use with shrink sleeving. Criteria for other types of sleeving should be agreed upon between Manufacturer and User.

6.2.3.1 Insulation – Insulation Sleeving – Placement

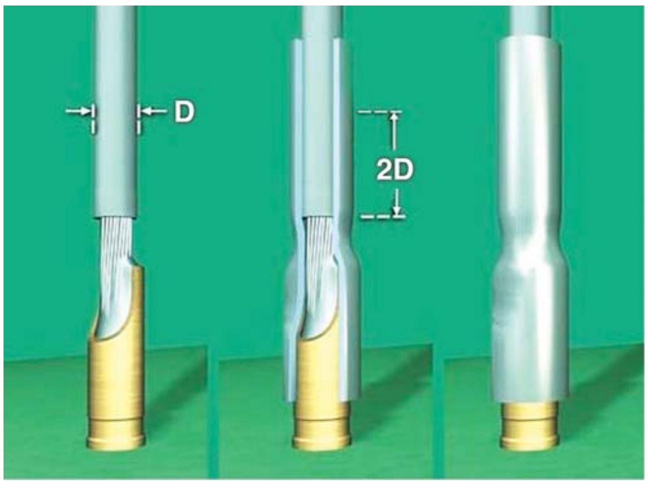

Figure 6-31

Acceptable – Class 1,2,3

- Insulation sleeving overlaps the connector terminal and the wire insulation by a minimum of two wire diameters.
- Insulation sleeving is more than 50% wire diameter and not more than two wire diameters from the point where the connector terminal enters the connector insert.

Acceptable – Class 1

- Sleeving/tubing is tight on terminal, but not tight on wire/cable.

Acceptable – Class 2,3

- Sleeving/tubing is tight on terminal and wire/cable.
- Multiple pieces of sleeving overlap each other by at least three wire/cable diameters.

6.2.3.1 Insulation – Insulation Sleeving – Placement (cont.)

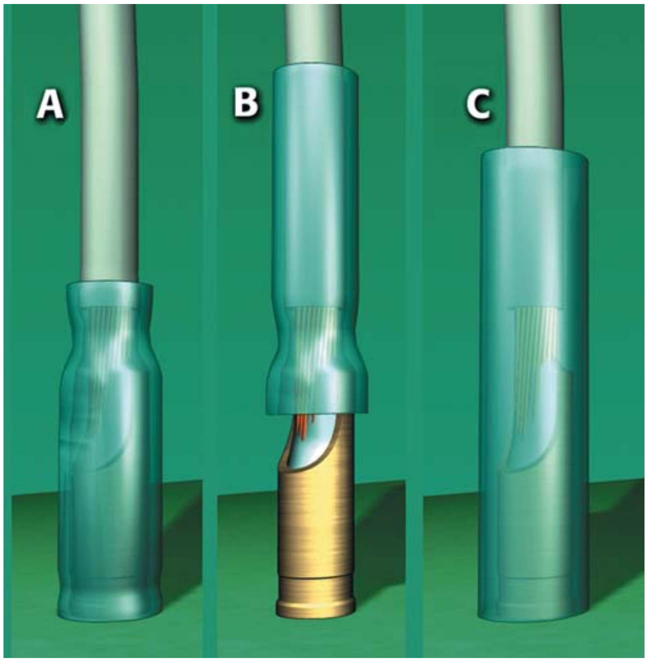

Figure 6-32

Defect – Class 1

- Sleeving/tubing is not tight on terminal.

Defect – Class 2,3

- Sleeving/tubing is not tight on terminal and wire/cable.
- Multiple pieces of sleeving overlap is less than three wire/cable diameters.

Defect – Class 1,2,3

- Insulation sleeving overlaps the wire insulation by less than two wire diameters, see Figure 6-32-A.
- Insulation sleeving is more than two wire diameters from the point where the connector terminal enters the connector insert, see Figure 6-32-B.
- Insulation sleeve is loose on the terminal (could slide or vibrate off, exposing more than the allowed amount of conductor or terminal), see Figure 6-32-C.
- Insulation sleeving prevents movement of floating contact in the insert, when movement is required.
- Sleeving does not extend over the soldered connection.

6.2.3.2 Insulation – Insulation Sleeving – Damage

Acceptable – Class 1,2,3

- No damage to insulation sleeving, i.e., splits, char, cracks, tears or pinholes.
- Connectors, wires, sleeving, and components are not damaged.
- Solder is not disturbed.

Figure 6-33

Figure 6-34

Defect – Class 1,2,3

- Insulation sleeving is damaged, i.e., splits, char, cracks, tears or pinholes.
- Connectors, wires, sleeving or components are damaged.
- If visible, through the sleeving, solder connection is disturbed.

6.3 Conductor

6.3.1 Conductor – Deformation

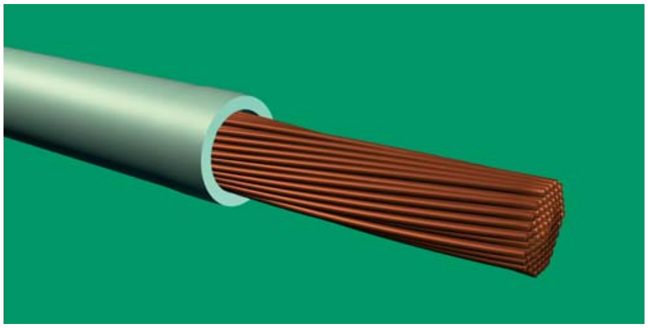

Figure 6-35

Acceptable – Class 1,2,3

- Where strands were straightened during the insulation removal, they have been restored to approximate the original spiral lay of the strands.
- Wire strands are not kinked.

Acceptable – Class 1
Defect – Class 2,3

- The general spiral lay of the strands has not been maintained.

Defect – Class 3

- Wire strand is kinked.

6.3.2 Conductor – Damage

6.3.2.1 Conductor – Damage – Stranded Wire

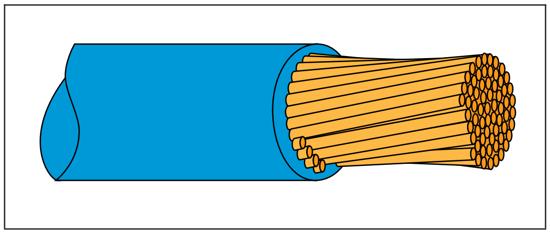

Figure 6-36

Acceptable – Class 1
Process Indicator – Class 2,3

- Strands cut, broken, scraped or severed if the number of damaged or broken strands in a single wire does not exceed the limits in Table 6-2.

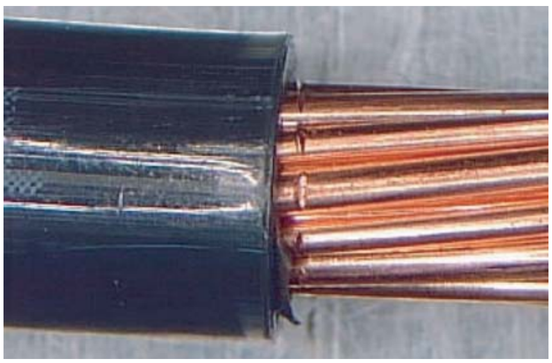

Figure 6-37

Defect – Class 1,2,3

- Damaged strands exceed the limits in Table 6-2.

Table 6-2 Strand Damage[1,2,3]

Number of Strands	Maximum allowable strands scraped, nicked or severed for Class 1,2	Maximum allowable strands scraped, nicked or severed for Class 3 for wires that will not be tinned before installation	Maximum allowable strands scraped, nicked or severed for Class 3 for wires that will be tinned prior to installation
1 (solid conductor)	No damage in excess of 10% of conductor diameter.		
2-6	0	0	0
7-15	1	0	1
16-25	3	0	2
26-40	4	3	3
41-60	5	4	4
61-120	6	5	5
121 or more	6% of strands	5% of strands	5% of strands

Note 1. No damaged strands for wires used at a potential of 6 kV or greater.
Note 2. For plated wires, a visual anomaly that does not expose basis metal is not considered to be strand damage.
Note 3. A strand is considered damaged if nicks or scrapes exceed 10% of strand diameter.

6.3.2.2 Conductor – Damage – Solid Wire

Acceptable – Class 1,2,3

- No nicks or deformation exceeding 10% of the diameter, width or thickness of the conductor. See 5.2.1 Soldering – Soldering Anomalies – Exposed Basis Metal for exposed basis metal criteria.

Defect – Class 1,2,3

- Wire is damaged more than 10% of the wire diameter or thickness.
- Wire deformed from repeated bending.

6.3.3 Conductor – Strand Separation (Birdcaging) – Presolder

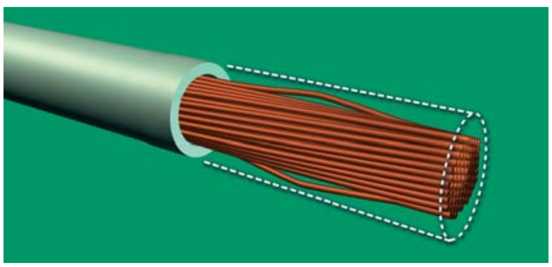

Figure 6-38

Acceptable – Class 1,2,3

- Wire strands have separation (birdcaging) but do not:
  - Exceed one strand diameter.
  - Extend beyond wire insulation outside diameter.

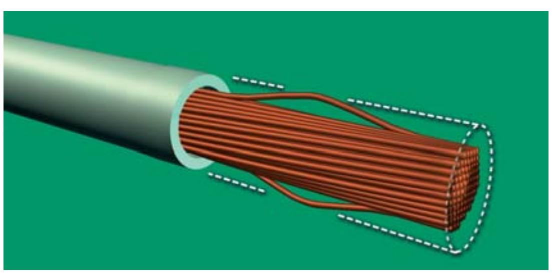

Figure 6-39

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Wire strands have separation exceeding one strand diameter but do not extend beyond wire insulation outside diameter.

6.3.3 Conductor – Strand Separation (Birdcaging) – Presolder (cont.)

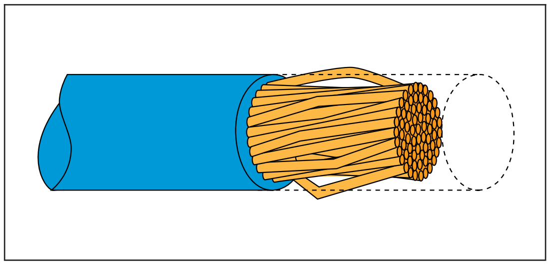

Figure 6-40

Acceptable – Class 1
Defect – Class 2,3

- Wire strands extend beyond wire insulation outside diameter.

6.3.4 Conductor – Strand Separation (Birdcaging) – Post-Solder

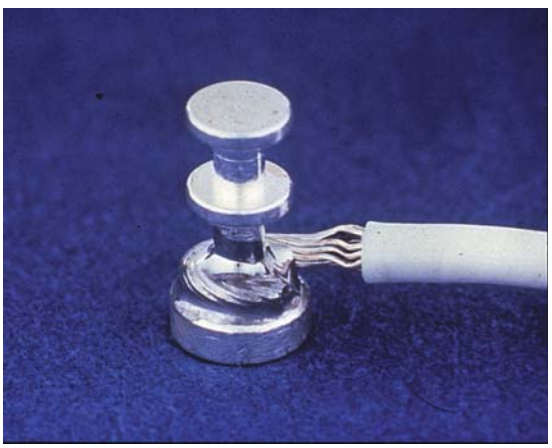

Figure 6-41

Acceptable – Class 1,2,3

- Wire strands have separation (birdcaging), but do not:
  - Exceed one strand diameter.
  - Extend beyond wire insulation outside diameter.

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Wire strands have separation exceeding one strand diameter but do not extend beyond wire insulation outside diameter.

6.3.4 Conductor – Strand Separation (Birdcaging) – Post-Solder (cont.)

Figure 6-42

Acceptable – Class 1
Defect – Class 2,3

- Wire strands are birdcaged beyond wire insulation outside diameter.

6.3.5 Conductor – Tinning

In this document, the terms pretinning and tinning have the same meaning, as defined in IPC-T-50: ''The application of molten solder to a basis metal or surface finish in order to increase its solderability.''

Tinning of stranded wire has the added benefit of bonding the individual wire strands together, thereby allowing the wire to be formed to terminals or attachment points without separation of the individual strands (birdcaging).

The following criteria are applicable if tinning is required.

Note: EIA/IPC/JEDEC J-STD-002 provides additional information for assessing these requirements.

Figure 6-43

Acceptable – Class 1,2,3

- The solder wets the tinned portion of the wire and penetrates the inner strands of the stranded wire.
- Solder wicks up the wire provided the solder does not extend to a portion of the wire that is required to remain flexible.
- The tinning leaves a smooth coating of solder and the outline of the strands are discernible.

Process Indicator – Class 2,3

- Strands are not discernible but excess solder does not affect form, fit or function.
- Solder does not penetrate to the inner strands of the wire.

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Length of untinned strands from end of insulation is greater than one wire diameter.

6.3.5 Conductor – Tinning (cont.)

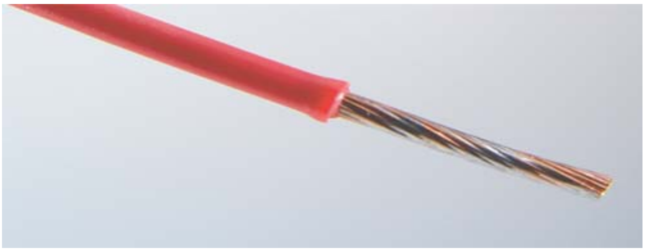

Figure 6-44

Defect – Class 2,3

- Pinholes, voids or dewetting/nonwetting exceeds 5% of the area required to be tinned, see Figure 6-44.
- Solder does not wet the tinned portion of the wire.
- Stranded wire is not tinned prior to attachment to terminals or forming splices (other than mesh).

Figure 6-45

Defect – Class 1,2,3

- Solder wicking extends into the portion of wire that is required to remain flexible after soldering.
- Solder build-up or icicles within the tinned wire area that affect subsequent assembly steps, see Figure 6-45.

6.4 Service Loops

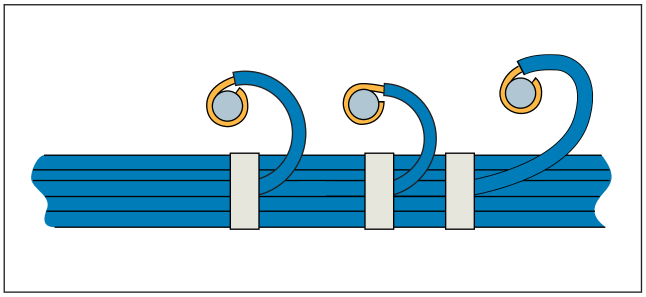

Figure 6-46

Acceptable – Class 1,2,3

- When a service loop is required, wire has sufficient length to allow one field re-termination to be made.

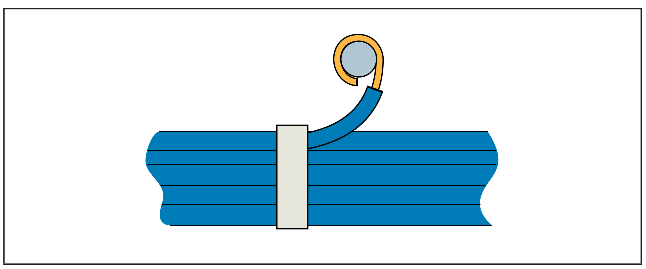

Figure 6-47

Defect – Class 1,2,3

- When a service loop is required, wire does not have sufficient length to allow at least one field re-termination to be made.

6.5 Routing – Wires and Wire Bundles – Bend Radius

Bend radius is measured along the inside curve of the wire or wire bundles.

The minimum bend radius of a harness assembly **shall not** be less than whichever wire/cable in the assembly has the largest bend radius defined in Table 6-3. See IPC-A-640 for information on fiber optic cables.

Table 6-3 Minimum Bend Radius Requirements

Wire/Cable Type	Multiple of Wire/Cable Outer Diameter		
	Class 1	Class 2	Class 3
Coaxial Flexible Cable[1]	10X		
Coaxial Fixed Cable[2]	5X		
Semi-rigid Coax	Not less than manufacturer's stated minimum bend radius		
Ethernet cable	4X		
Shielded Wires and Cables[3]	No Requirement Established		5X
Unshielded Cable[3]	No Requirement Established		3X for AWG 10 and smaller 5X for larger than AWG 10
Insulated Wire Flat Ribbon Cable	2X		
Bare Bus Wire Enamel Insulated Wire	2X		
Polyimide Insulated Wires (Shielded or Unshielded)	No Requirement Established		10X
Composite Insulation	No Requirement Established		6X[4]

Note 1. Coaxial Flexible Cable Coaxial cable that is or may be flexed during operation of the equipment.
Note 2. Coaxial Fixed Cable Coaxial cable that is secured to prevent movement; not expected to have the cable repeatedly flexed during operation of the equipment.
Note 3. As supplied by the wire/cable manufacturer.
Note 4. Applies to AS22759. See the appropriate specification if not covered by these.

Acceptable – Class 1,2,3

- Minimum bend radius meets requirements of Table 6-3.

Defect – Class 1,2,3

- Bend radius is less than the minimum bend radius requirements of Table 6-3.

6.6 Stress Relief

6.6.1 Stress Relief – Wire

If the wire/terminal connection is supported to prevent stress at the solder connection, then dress of the wire is not required to continue the curvature of the dress.

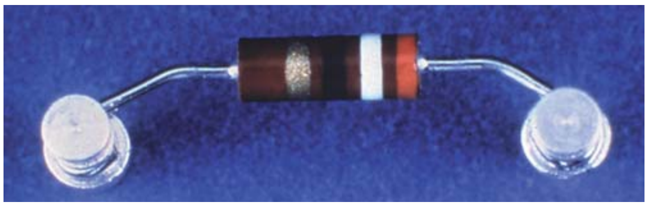

Figure 6-48

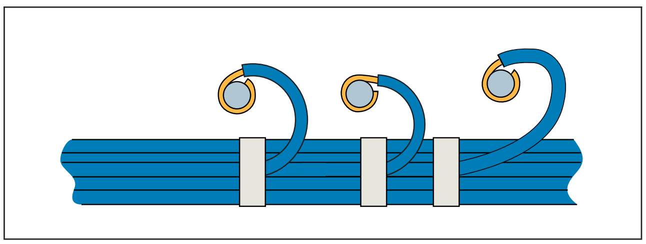

Figure 6-49

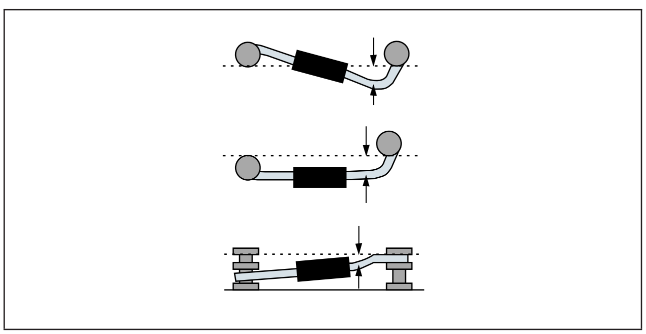

Figure 6-50

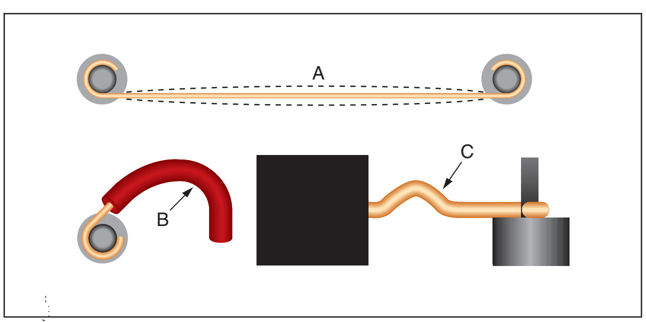

Figure 6-51

Acceptable – Class 1,2,3

- The wire approaches the terminal with a loop or bend sufficient to relieve any tension on the connection during thermal/vibration stress.
- The direction of the stress-relief bend places no strain on the mechanical wrap or the solder connection.
- Bend not touching terminal is in conformance with Table 6-3.
- Each lead has stress relief when the component is clipped or adhesive mounted or otherwise constrained.
- The wire is straight between the connections with no loop or bend, but wire is not taut, see Figure 6-51-A.
- At least one lead has stress relief, provided the component is not clipped or adhesive mounted or otherwise constrained, see Figure 6-50.
- Wire is not kinked.

6.6.1 Stress Relief – Wire (cont.)

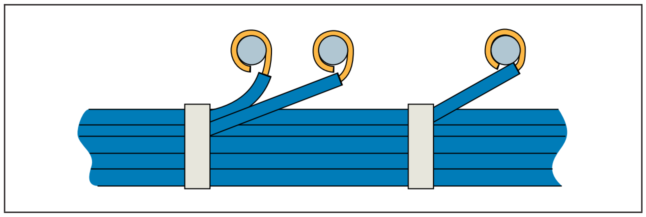

Figure 6-52

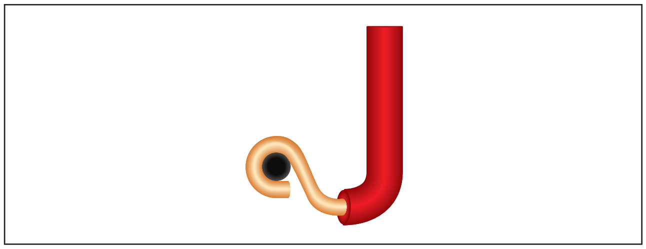

Figure 6-53

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- There is insufficient stress relief, see Figure 6-52.
- The wire is under stress at the wrap, see Figure 6-52.
- The wire is formed around the terminal opposite to the feed-in direction, see Figure 6-53.

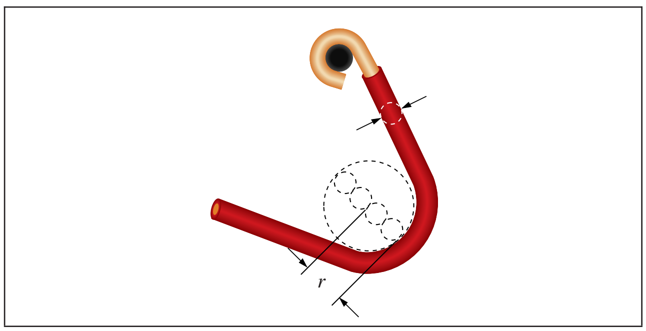

Figure 6-54

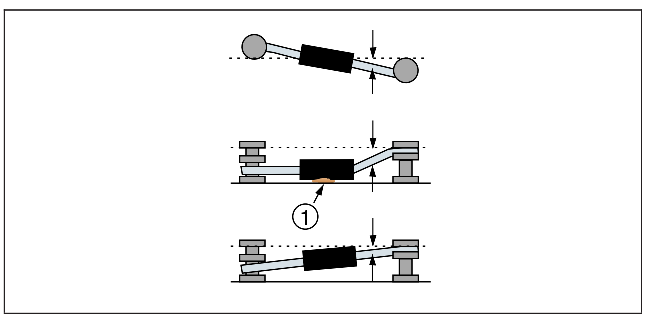

Figure 6-55
1. Adhesive

Defect – Class 1,2,3

- Does not meet bend radius requirements. See Table 6-3, see Figure 6-54.
- No stress relief.
- Stress relief not present in all leads of a constrained component, see Figure 6-55.
- Wire is stretched taut between the terminals.
- Lead/wire is kinked, see Figure 6-56.

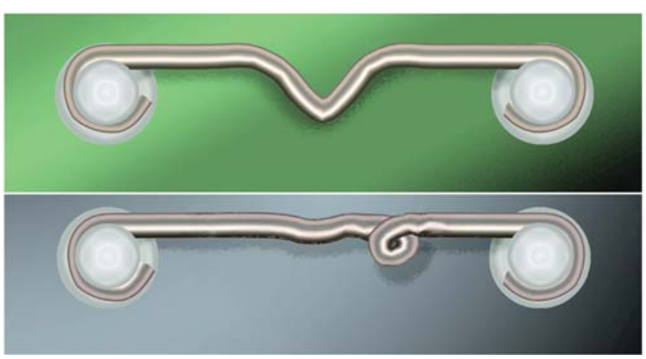

Figure 6-56

6.7 Lead/Wire Placement – General Requirements

The criteria associated with each terminal type or connection are in clauses 6.9 through 6.16.

Unless otherwise specified the wire or lead should be in contact with base of the terminal or a previously installed wire. The lead and wire ends should not extend beyond the terminal greater than one lead diameter.

Wires should be placed in ascending order with the largest on the bottom.

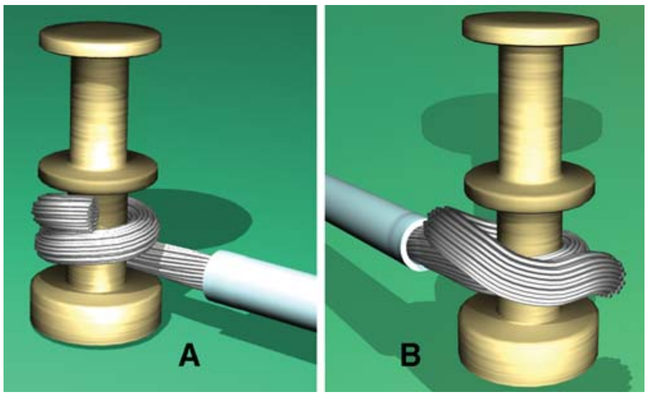

Figure 6-57

Wire Overwrap – When a wire/lead that is wrapped more than 360° and remains in contact with the terminal post, see Figure 6-57-A.

Wire Overlap – When a wire/lead that is wrapped more than 360° and crosses over itself, i.e., does not remain in contact with the terminal post, see Figure 6-57-B.

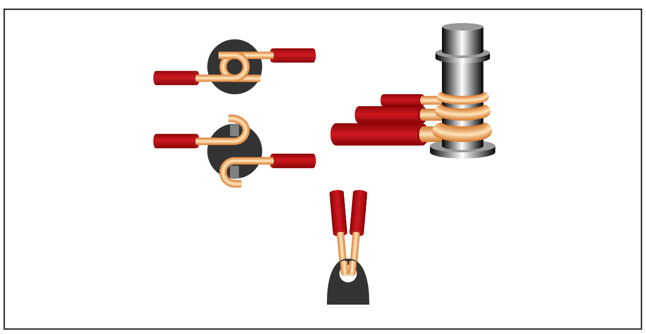

Figure 6-58

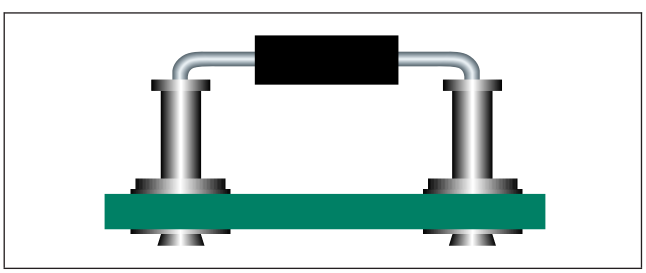

Figure 6-59

Acceptable – Class 1,2,3

- Wrapped conductors do not cross over or overlap each other on terminal.
- Strand separation (birdcaging) meets the requirements of 6.3.3 Terminal Connections – Conductor – Strand Separation (Birdcaging) – Presolder and 6.3.4 Terminal Connections – Conductor – Strand Separation (Birdcaging) – Post Solder.
- Calibration parts mounted to the tops of hollow terminals, see Figure 6-59.

Acceptable – Class 1
Defect – Class 2,3

- Terminal altered to accept oversized wire or wire group.
- Wrapped conductors cross over or overlap each other on terminal, see Figure 6-57-B.
- Strand separation (birdcaging) does not meet the requirements of 6.3.3 Terminal Connections – Conductor – Strand Separation (Birdcaging) – Presolder and 6.3.4 Terminal Connections – Conductor – Strand Separation (Birdcaging) – Post Solder.
- The lead or wire interferes with the wrapping of other leads or wires on the terminal.

6.8 Solder – General Requirements

Unless otherwise stated for a specific terminal type, the following are general requirements for all terminals.

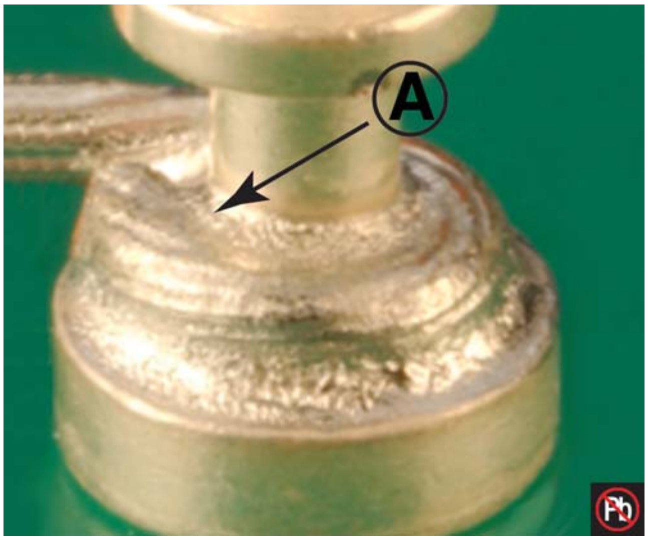

Figure 6-60

Figure 6-61

Acceptable – Class 1,2

- Depression of solder between the terminal and the wrap of the wire is less than or equal to 50% of the wire/lead radius (R), see Figures 6-60-A and 6-62-2.

Acceptable – Class 3

- Depression of solder between the terminal and the wrap of the wire is less than or equal to 25% of the wire/lead radius (R), see Figures 6-60-A and 6-62-2.

Acceptable – Class 1,2,3

- Solder fillet at least 75% of the circumference of the wire/lead and terminal interface.
- For leads/wires with a wrap greater than or equal to 180°, solder fillet is at least 75% of the wire/lead and terminal interface in the minimum required wrap area.
- When acceptable wire wrap is less than 180°, solder fillet is 100% of the circumference of the wire/lead and terminal interface.

Acceptable – Class 1
Process Indicator – Class 2,3

- Wire/lead not discernible in solder connection.

6.8 Solder – General Requirements (cont.)

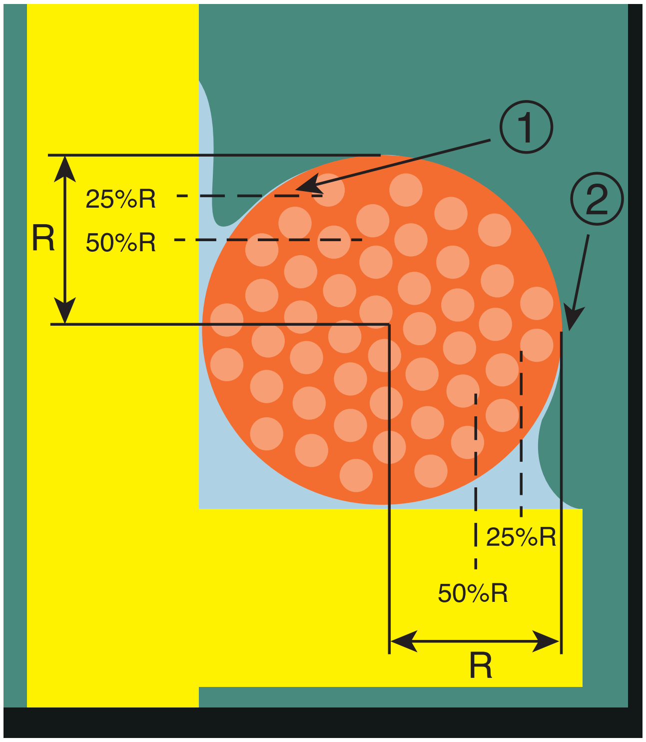

Figure 6-62 Solder Depression

1. As shown, solder depression is a defect for Class 3.
2. As shown, solder depression is acceptable for all three Classes.

Defect – Class 1,2

- Depression of solder between the terminal and the wrap of the wire is greater than 50% of wire/lead radius (R).

Defect – Class 3

- Depression of solder between the terminal and the wrap of the wire is greater than 25% of wire/lead radius (R), see Figure 6-62-1.

Defect – Class 1,2,3

- For terminals with a required minimum wrap of less than 180°, solder is wetted less than 100% of the required minimum wrap area.
- For terminals with a required minimum wrap of equal to or greater than 180°, solder is wetted less than 75% of the required minimum wrap area.

6.9 Turrets and Straight Pins

6.9.1 Turrets and Straight Pins – Lead/Wire Placement

Table 6-4 is applicable to leads and wires attached to turret and straight pin terminals.

Table 6-4 Turret or Straight Pin Terminal Lead/Wire Placement[2]

Criteria	Class 1	Class 2	Class 3
< 90° contact between the lead/wire and terminal post	Defect		
90° to < 180° contact between the lead/wire and terminal post	Acceptable	Process Indicator	Defect
≥ 180° contact between lead/wire and post	Acceptable		
Wire overlaps itself, Note 1	Acceptable	Defect	
Wire violates minimum electrical clearance	Defect		

Note 1. See 6.7 Terminal Connections – Lead/Wire Placement – General Requirements.
Note 2. See 6.15 Terminal Connections – AWG 30 and Smaller Diameter Wires – Lead/Wire Placement for criteria AWG 30 and smaller wires.

6.9.1 Turrets and Straight Pins – Lead/Wire Placement (cont.)

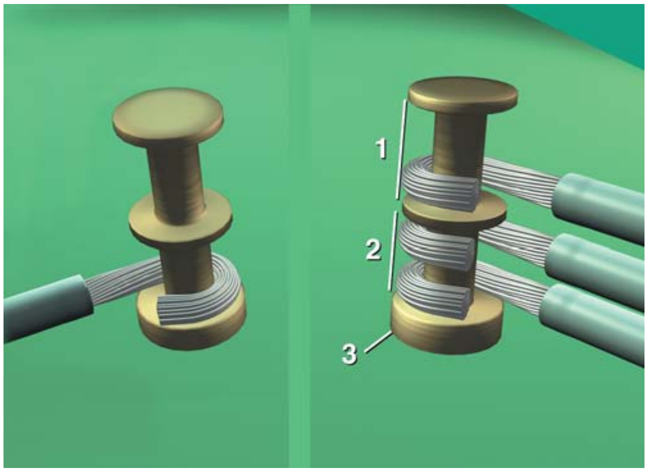

Figure 6-63
1. Upper guide slot
2. Lower guide slot
3. Base

Acceptable – Class 1,2,3

• Wires and leads wrapped a minimum of 180° and do not overlap.

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

• On straight pins, the top wire on terminal is less than one wire diameter below the top of the terminal.

Acceptable – Class 1
Defect – Class 2,3

• Wire overlaps itself.

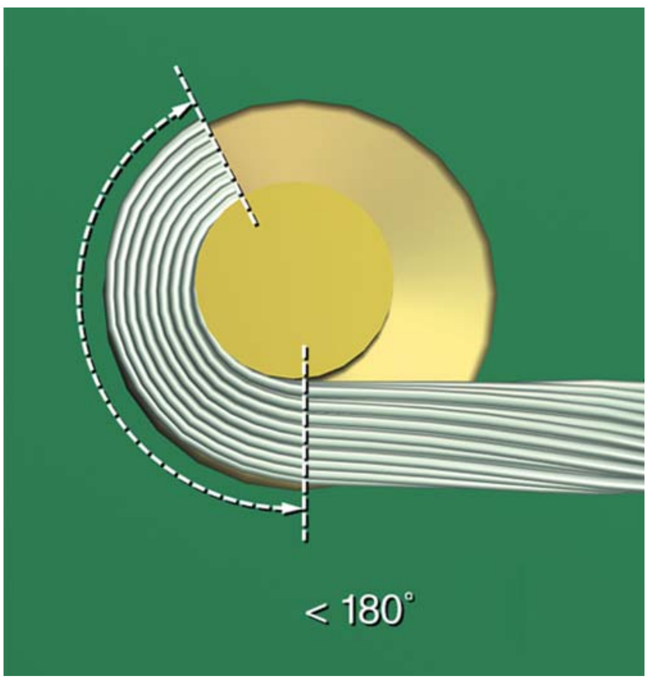

Figure 6-64

Process Indicator – Class 2

• Wrap for round posts has 90° to less than 180° of contact between the wires and the terminal.

Defect – Class 1,2

• Wrap for round posts has less than 90° of contact between the wires and the terminal.

Defect – Class 1,2,3

• Long wire end violates minimum electrical clearance.

Defect – Class 3

• Wrap for round posts has less than 180° of contact between the wires and the terminal.

6.9.2 Turrets and Straight Pins – Solder

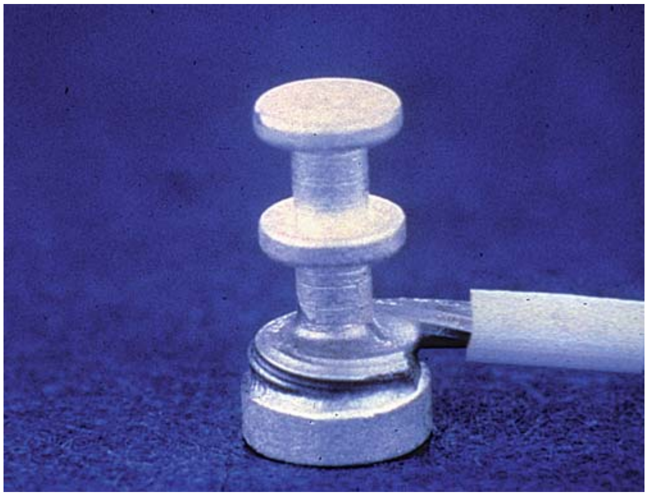

Figure 6-65

Figure 6-66

Acceptable – Class 1,2,3

- Solder is wetted to at least 75% of the contact area between the wire/lead and terminal interface for leads wrapped equal to or more than 180°.

Acceptable – Class 1,2

- Solder is wetted to 100% of contact areas between the wire/lead and terminal interface for leads wrapped between 90° and 180°.

Acceptable – Class 1
Process Indicator – Class 2,3

- Wire/lead not discernible in solder connection.

Figure 6-67

Defect – Class 1,2

- Solder is wetted less than 100% of the lead to terminal contact area when the wrap is more than 90° and less than 180°.

Defect – Class 1,2,3

- Less than 75% fillet of the lead to terminal contact when the wrap is equal to or more than 180°.

6.10 Bifurcated

6.10.1 Bifurcated – Lead/Wire Placement – Side Route Attachments

Table 6-5 is applicable to leads and wires attached to side-route bifurcated terminals.

Table 6-5 Bifurcated Terminal Lead/Wire Placement – Side Route

Criteria	Class 1	Class 2	Class 3
< 90° wrap	Defect		
≥ 90° wrap	Acceptable		
Wire overlaps itself, Note 1	Acceptable	Defect	
Violates minimum electrical clearance	Defect		

Note 1. See 6.7 Terminal Connections – Lead/Wire Placement – General Requirements.

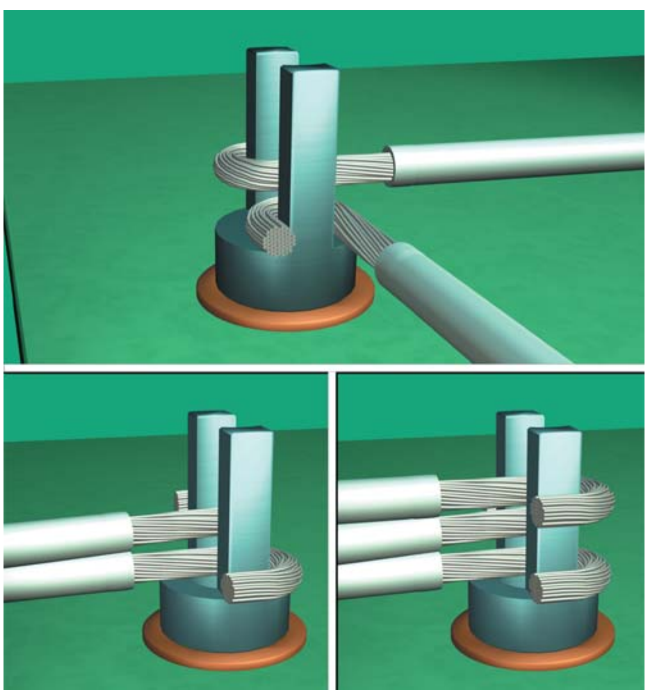

Figure 6-68

Acceptable – Class 1,2,3

- Wire end extends beyond the base of the terminal provided minimum electrical clearance is maintained.
- Wire passes through the slot and makes positive contact with at least one corner of the post.
- No portion of the wrap extends beyond the top of the terminal post.
- If required, wire wrap is at least 90°.

6.10.1 Bifurcated – Lead/Wire Placement – Side Route Attachments (cont.)

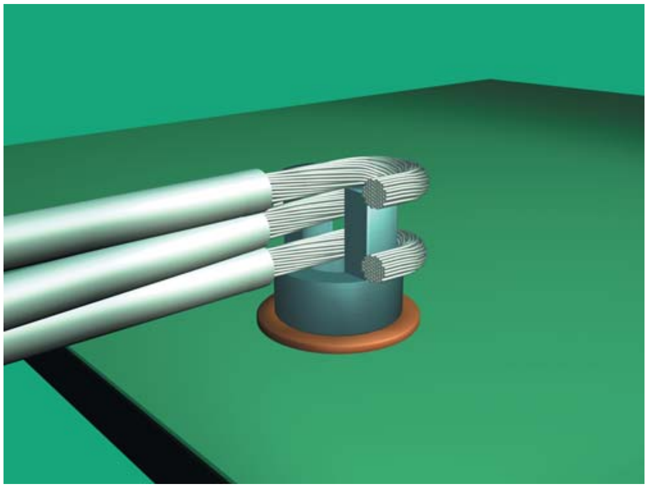

Figure 6-69

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Any portion of the wrap extends beyond the top of terminal post.
- Wire does not have positive contact with at least one corner of the post.

Acceptable – Class 1
Defect – Class 2,3

- Wire overlaps itself.

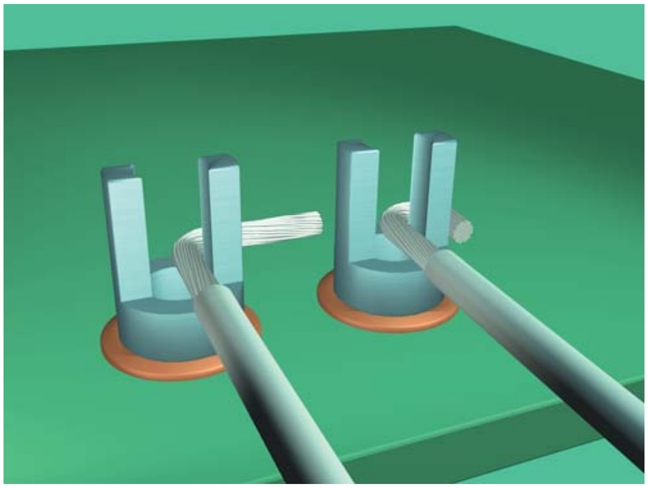

Figure 6-70

Defect – Class 3

- Wire/lead equal to or greater than 0.75 mm [0.03 in] in diameter is wrapped less than 90° and is not staked, see 6.10.2 Terminal Connections – Bifurcated – Lead/Wire Placement – Staked Wires.

Defect – Class 1,2,3

- Wire does not pass through slot.
- Wire end violates minimum electrical clearance, see Figure 6-70.
- Wire/lead less than 0.75 mm [0.03 in] in diameter is wrapped around a post less than 90° and is not staked, see 6.10.2 Terminal Connections – Bifurcated – Lead/Wire Placement – Staked Wires.

6.10.2 Bifurcated – Lead/Wire Placement – Staked Wires

As an alternative to wrap requirements of 6.10.1 Terminal Connections – Bifurcated – Lead/Wire Placement – Side Route Attachments, the following criteria (summarized in Table 6-6) apply to wires/leads/components that are staked, bonded or otherwise constrained to provide support for the solder connection.

Table 6-6 Staking Requirements of Side Route Straight Through Connections – Bifurcated Terminals

Conductor Diameter	Class 1	Class 2	Class 3
< 0.75 mm [0.03 in], Note 1	Defect if not staked		
≥ 0.75 mm [0.03 in], Note 2	Acceptable if not staked	Process Indicator if not staked	Defect if not staked

Note 1. AWG-22 and smaller
Note 2. AWG-20 and larger

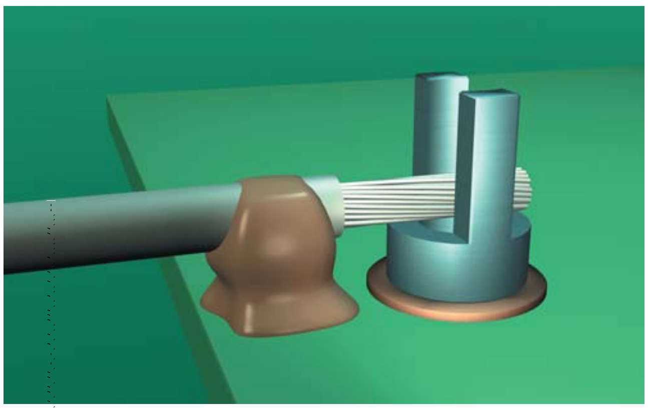

Figure 6-71

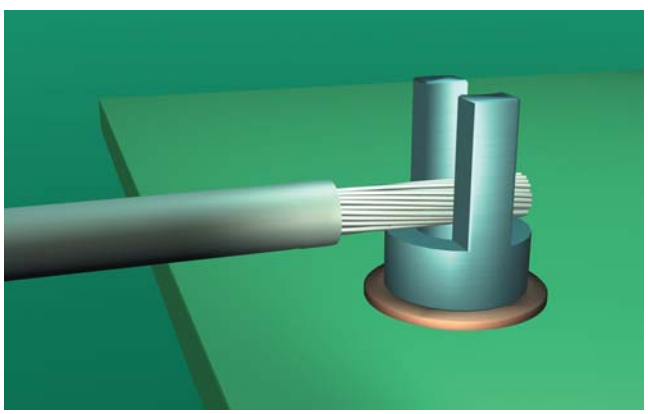

Figure 6-72

Acceptable – Class 1
Process Indicator – Class 2

- Wires or leads equal to or greater than 0.75 mm [0.03 in] and wrapped less than 90° are not staked.

Acceptable – Class 1
Process Indicator – 2
Defect – Class 3

- Straight through wire/lead is not in contact with the base of the terminal or the previously installed wire/lead.
- Wire/lead does not extend beyond the post of the terminal.

Defect – Class 1,2

- Wires or leads less than 0.75 mm [0.03 in] and wrapped less than 90° are not staked.

Defect – Class 3

- Any straight through wire is not staked.

6.10.3 Bifurcated – Lead/Wire Placement – Bottom and Top Route Attachments

Table 6-7 is applicable to leads and wires attached to bottom-route bifurcated terminals.

Table 6-7 Bifurcated Terminal Lead/Wire Placement – Bottom Route

Criteria	Class 1	Class 2	Class 3
< 90° wrap	Acceptable	Process Indicator	Defect
90° to 180° wrap	Acceptable		

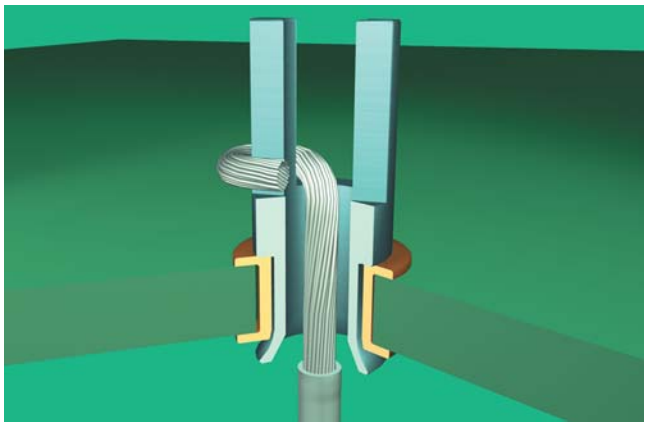

Figure 6-73

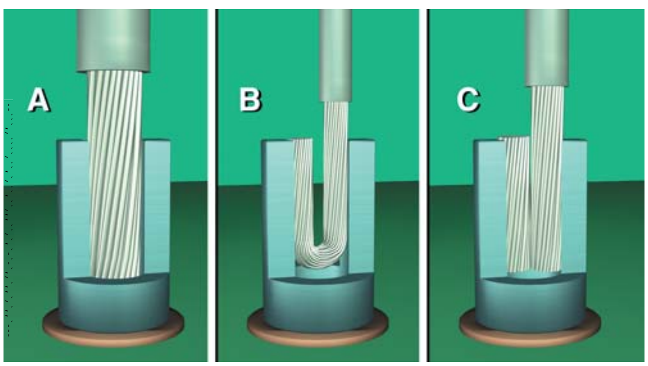

Figure 6-74

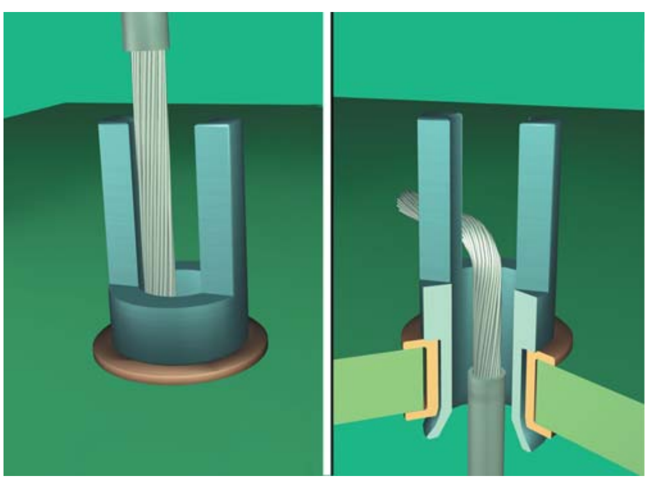

Figure 6-75

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Wire insulation enters base or posts of terminal.
- Top route wire is not supported with filler.
- Bottom route wire not wrapped to terminal base or post with a minimum 90° bend.

6.10.4 Bifurcated – Solder

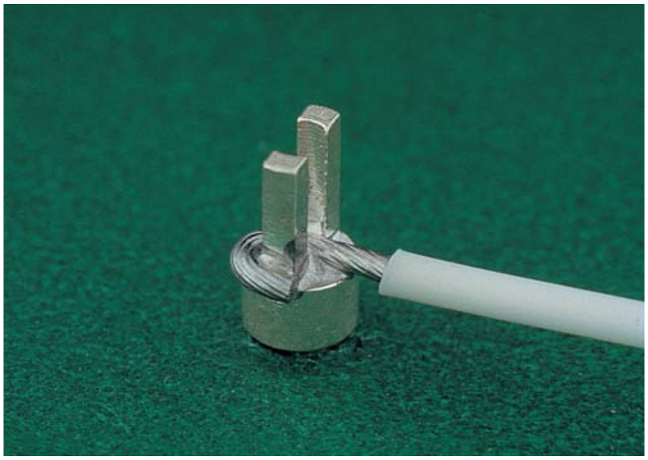

Figure 6-76

Figure 6-77

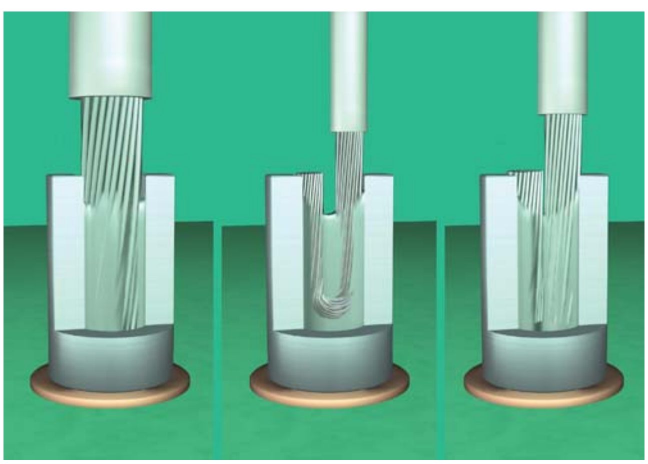

Figure 6-78

Acceptable – Class 1,2,3

- Solder is wetted to at least 75% of the contact area between the wire/lead and terminal interface for leads required to be wrapped at least 180°.
- Solder is wetted to 100% of the contact area between the wire/lead and terminal interface for leads wrapped less than 180°.
- Solder is 75% of the height of the terminal post for top-route wires.

6.10.4 Bifurcated – Solder (cont.)

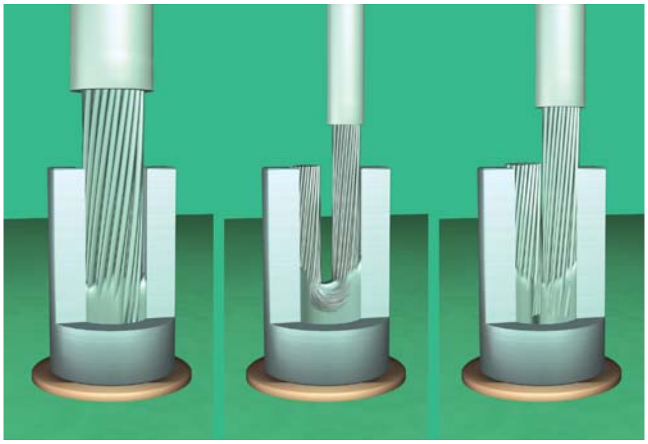

Figure 6-79

Defect – Class 1,2,3

- Solder is less than 75% of the height of the terminal post for top-route wires.
- Less than 100% fillet of the lead to terminal contact when the wrap is less than 180° (not shown).
- Less than 75% fillet of the lead to terminal contact when the required wrap is at least 180° (not shown).

6.11 Slotted

6.11.1 Slotted – Lead/Wire Placement

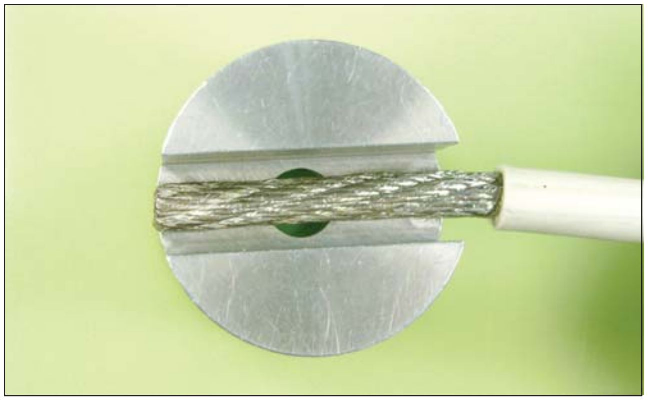

Figure 6-80

Acceptable – Class 1,2,3

- Lead or wire end is discernible on the exit side of terminal.
- No portion of the wire termination extends above the top of the terminal post.
- Wire is in contact with base of terminal area or previously installed wire.

Note: Wrap is not required on a slotted terminal.

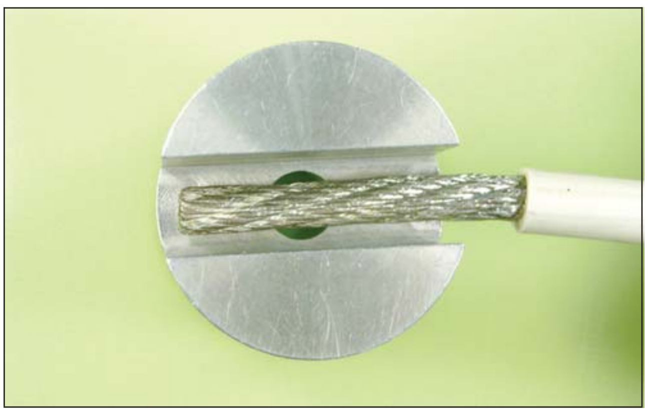

Figure 6-81

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Wire extends above the top of the terminal post.

Defect – Class 1,2,3

- Lead end is not flush or does not extend beyond the exit side of terminal.
- Wire end violates minimum electrical clearance.

6.11.2 Slotted – Solder

Solder should form a fillet with that portion of the lead or wire that is in contact with the terminal. Solder may completely fill the slot but should not be built up on top of the terminal. The lead or wire should be discernible in the terminal.

Figure 6-82

Acceptable – Class 1,2,3

- Solder fills terminal slot.
- Lead or wire end is discernible in the solder on the exit side of terminal.

Figure 6-83

Defect – Class 1,2,3

- Wire or lead end is not discernible on the exit side of the terminal.
- Fillet not formed with 100% of the portion of the wire that is in contact with the terminal (not shown).

6.12 Pierced/Perforated

6.12.1 Pierced/Perforated – Lead/Wire Placement

Table 6-8 is applicable to leads and wires attached to pierced or perforated terminals.

Table 6-8 Pierced or Perforated Terminal Lead/Wire Placement

Criteria	Class 1	Class 2	Class 3
Wire overlaps itself, Note 1.	Acceptable	Defect	
Wire does not pass through the eye.	Acceptable	Defect	
Wire does not contact at least two surfaces of the terminal.	Acceptable	Defect	
Wire end violates minimum electrical clearance.	Defect		

Note 1. See 6.7 Terminal Connections – Lead/Wire Placement – General Requirements.

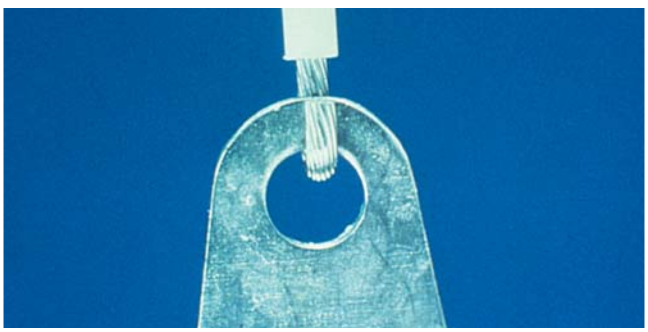

Figure 6-84

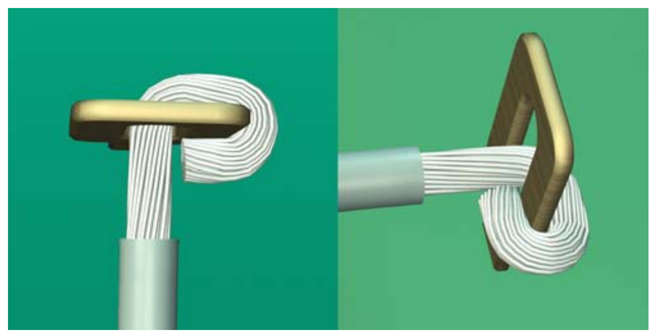

Figure 6-85

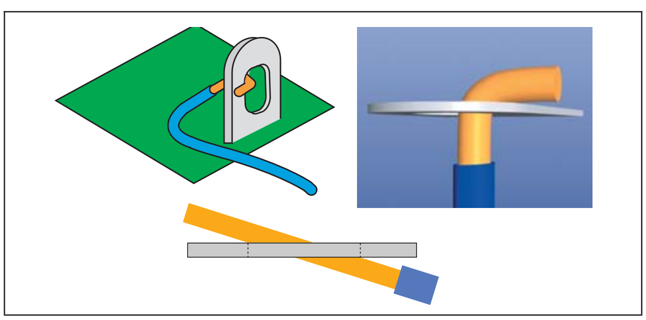

Figure 6-86

6.12.1 Pierced/Perforated – Lead/Wire Placement (cont.)

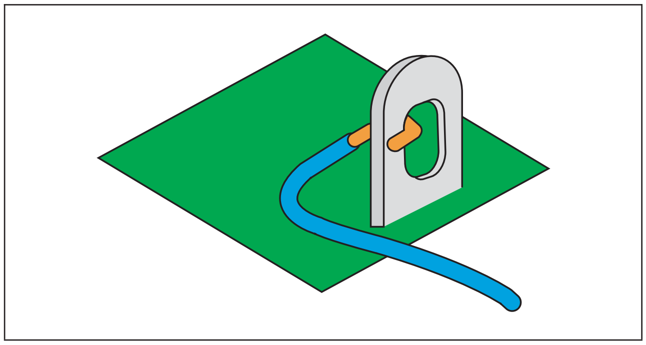

Figure 6-87

Acceptable – Class 2,3

- Wire contacts at least two surfaces of the terminal.

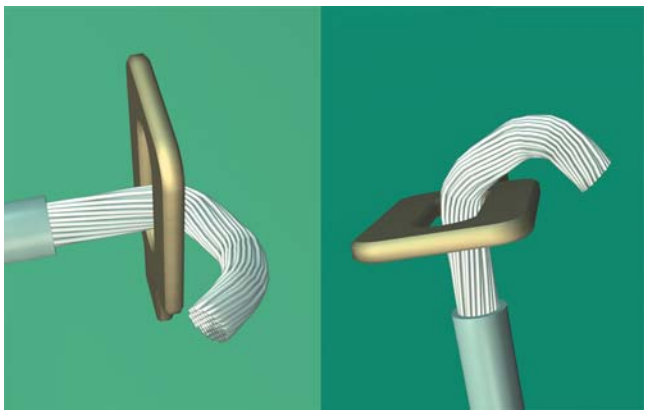

Figure 6-88

Acceptable – Class 1
Defect – Class 2,3

- Wire does not contact at least two surfaces of the terminal.
- Wire does not pass through the eye of the terminal.
- Wire overlaps itself.

Defect – Class 2,3

- Terminal altered to accept oversize wire or wire group.

Defect – Class 1,2,3

- Wire end violates minimum electrical clearance to noncommon conductor (not shown).

6.12.2 Pierced/Perforated – Solder

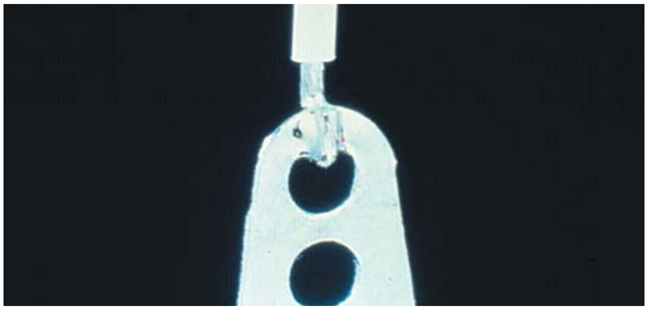

Figure 6-89

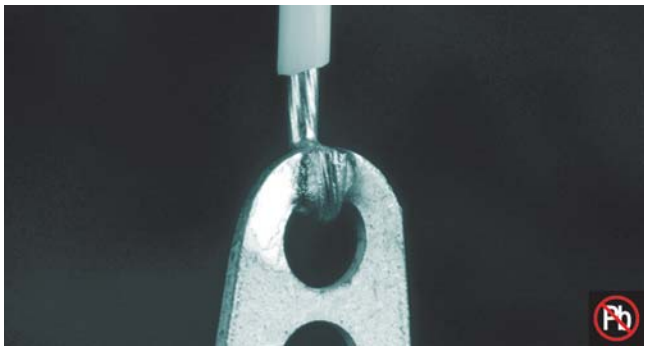

Figure 6-90

Acceptable – Class 1,2,3

- Solder fillet joins the wire to the terminal for at least 75% of the wire and terminal interface for wraps of equal to or more than 180°.
- Solder fillet joins the wire to the terminal for 100% of the wire and terminal interface for wraps less than 180°.

Acceptable – Class 1
Process Indicator – Class 2,3

- Wire/lead not discernible in solder connection.

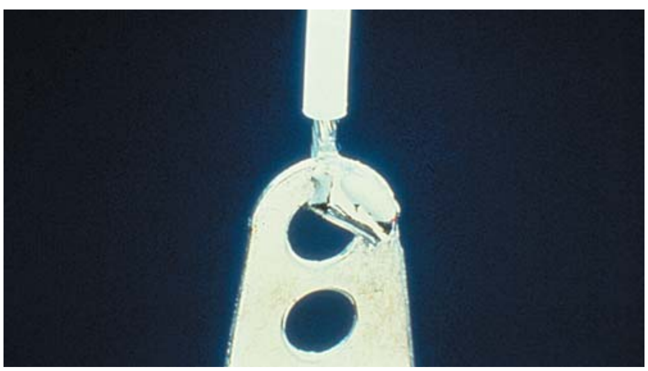

Figure 6-91

Defect – Class 1,2,3

- Less than 100% fillet of the lead to terminal contact when the wrap is less than 180°.
- Less than 75% fillet of the lead to terminal contact when the wrap is equal to or more than 180°.

6.13 Hook

6.13.1 Hook – Lead/Wire Placement

Table 6-9 is applicable to leads and wires attached to hook terminals.

Table 6-9 Hook Terminal Lead/Wire Placement

Criteria	Class 1	Class 2	Class 3
< 90° contact between the lead/wire and terminal post.	Defect		
90° to < 180° contact between the lead/wire and terminal post.	Acceptable	Process Indicator	Defect
≥ 180° contact between the lead/wire and terminal post.	Acceptable		
Wire overlaps itself, Note 1.	Acceptable	Defect	
Less than one lead/wire diameter space from end of hook to closest wire.	Acceptable	Process Indicator	Defect
Wire less than two lead/wire diameters or 1 mm [0.04 in], whichever is greater, from the terminal base.	Acceptable	Process Indicator	Defect
Wire violates minimum electrical clearance.	Defect		

Note 1. See 6.7 Terminal Connections – Lead/Wire Placement – General Requirements.

6.13.1 Hook – Lead/Wire Placement (cont.)

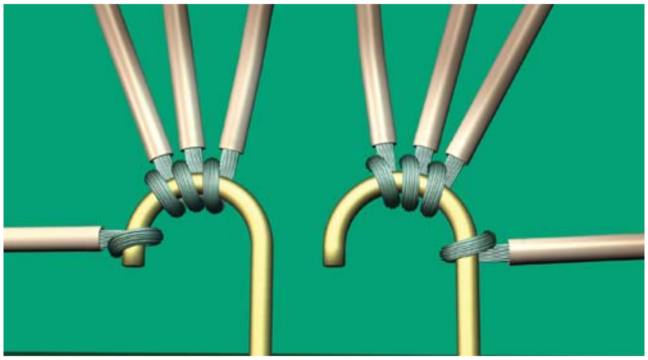

Figure 6-92

Acceptable – Class 1,2,3

- Wire contacts and wraps terminal at least 180°.
- Minimum of one wire diameter space from end of hook to the closest wire.
- Wires do not overlap.

Figure 6-93

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Wire is wrapped less than one wire diameter from end of hook.
- Wire is less than two wire diameters or 1 mm [0.04 in], whichever is greater, from the base of the terminal.
- Wire wrap is less than 180°.

Defect – Class 1,2

- Wire wrap is less than 90°.

Acceptable – Class 1
Defect – Class 2,3

- Wire overlaps itself.

Defect – Class 1,2,3

- Wire end violates minimum electrical clearance to noncommon conductor.

6.13.2 Hook – Solder

Figure 6-94

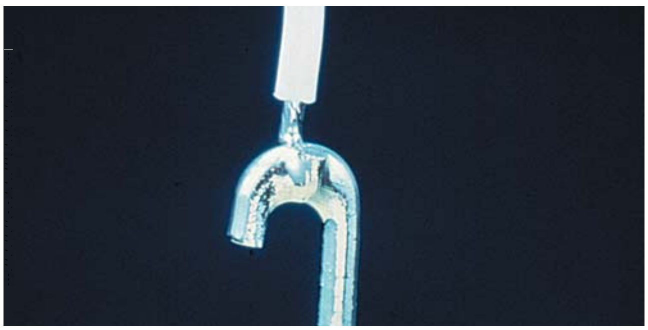

Figure 6-95

Acceptable – Class 1,2

- Solder is wetted to 100% of the contact area between the wire/lead and terminal interface for leads wrapped less than 180°.

Acceptable – Class 1,2,3

- Solder is wetted to at least 75% of the contact area between the wire/lead and terminal interface for leads wrapped equal to or more than 180°.

Acceptable – Class 1
Process Indicator – Class 2,3

- Wire/lead not discernible in solder connection.

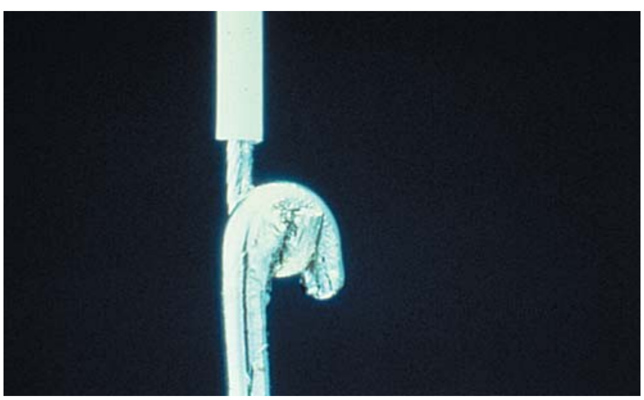

Figure 6-96

Defect – Class 1,2

- Less than 100% fillet of the lead to terminal contact when the wrap is less than 180°.

Defect – Class 1,2,3

- Less than 75% fillet of the lead to terminal contact when the wrap is equal to or more than 180°.

6.14 Solder Cups

6.14.1 Solder Cups – Lead/Wire Placement

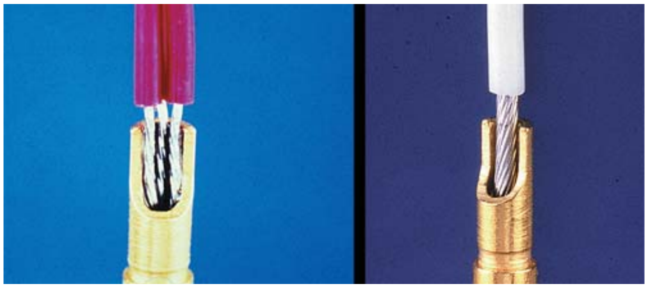

Figure 6-97

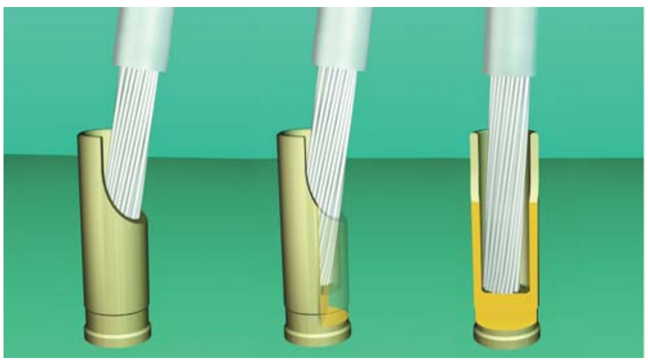

Figure 6-98

Acceptable – Class 1,2,3

- Wire does not interfere with subsequent assembly steps.
- Conductor strands not cut or modified to fit into the terminal.
- Multiple conductors are not twisted together.

Acceptable – Class 1
Process Indicator – Class 2,3

- Wire does not contact the back wall or other wires.

Not Established – Class 1
Process Indicator – Class 2
Defect – Class 3

- Wire(s) not inserted for the full depth of cup.

Acceptable – Class 1
Defect – Class 2,3

- Solder cup altered to accept oversized wire or wire group.

Defect – Class 1,2,3

- Strands not in conformance with 6.3.2 Terminal Connections – Conductor – Damage.
- Wire strands outside of the cup.
- Wire placement interferes with subsequent assembly steps.
- Multiple conductors are twisted together.

6.14.2 Solder Cups – Solder

These criteria are applicable to either solid or stranded wire, single or multiple wires.

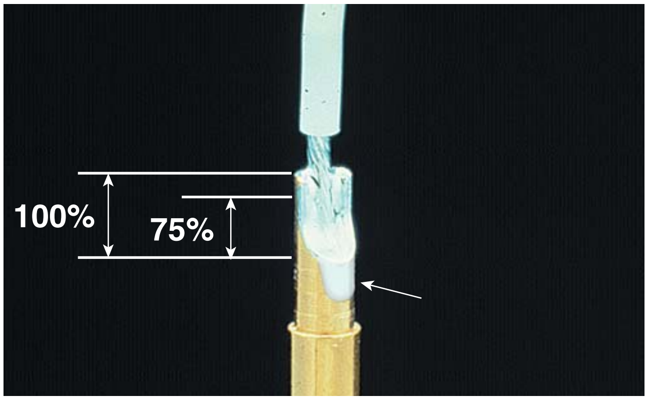

Figure 6-99

Figure 6-100

Acceptable – Class 1,2,3

- Thin film of solder on the outside of the cup.
- Vertical fill of solder from the lip of the cup to the top is at least 75%.
- Solder buildup on the outside of the cup, as long as it does not affect form, fit or function, see Figure 6-99.
- Solder visible in or slightly protrudes from the inspection hole (if one is provided).

6.14.2 Solder Cups – Solder (cont.)

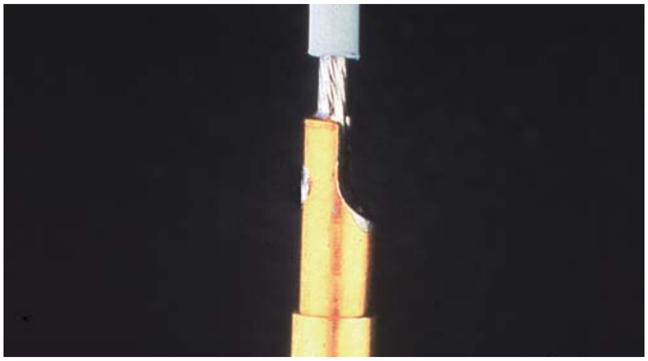

Figure 6-101

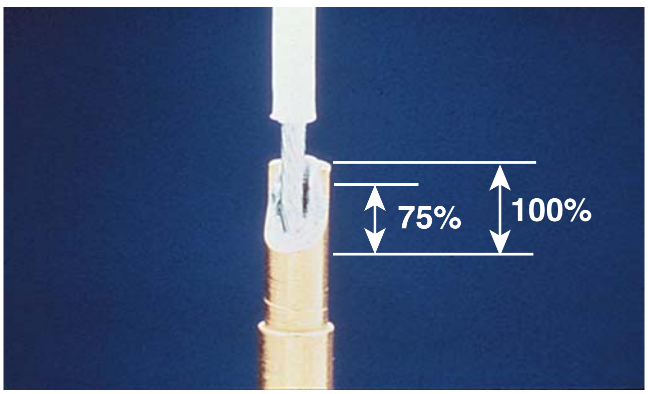

Figure 6-102

Defect – Class 1,2,3

- Solder does not fill the inside of the cup.
- Vertical fill of solder from the lip of the cup to the top is less than 75%.
- Solder buildup on outside of the cup negatively affects form, fit or function.
- Solder not visible in the inspection hole (if one is provided).

6.15 AWG 30 and Smaller Diameter Wires – Lead/Wire Placement

Table 6-10 is applicable to AWG 30 and smaller diameter wires. These criteria do not apply to jumper wires.

Table 6-10 AWG 30 and Smaller Wire Wrap Requirements

Criteria	Class 1	Class 2	Class 3
< 90°	Defect		
≥ 90° to < 180°	Acceptable	Defect	
180° to < 360°	Acceptable	Process Indicator	Defect
≥ 360°	Acceptable		

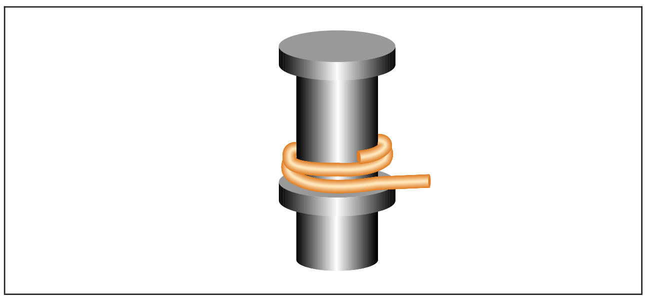

Figure 6-103

Acceptable – Class 1,2,3

- Wrap(s) complies with Table 6-10.
- Wire does not overlap or cross over itself or other wires terminated on the terminal.

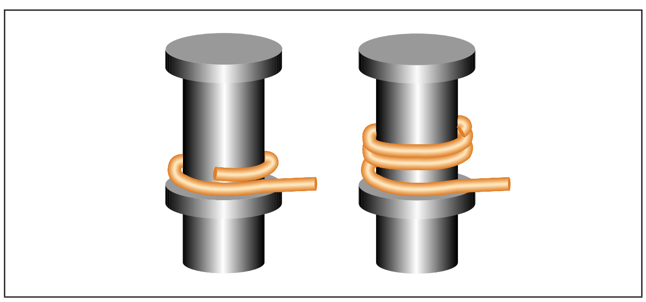

Figure 6-104

Acceptable – Class 1
Defect – Class 2,3

- Wire has equal to or more than 90° wrap but less than 180° wrap.

6.15 AWG 30 and Smaller Diameter Wires – Lead/Wire Placement (cont.)

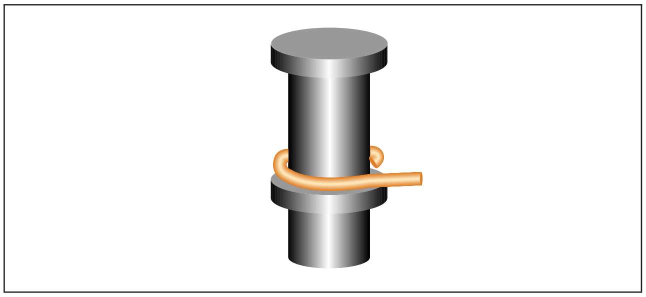

Figure 6-105

Acceptable – Class 1
Defect – Class 2

- Wire has less than 180° wrap.

Process Indicator – Class 2
Defect – Class 3

- Wire has less than one wrap (360°) around terminal.

Defect – Class 3

- Wire has less than one 90° wrap.

6.16 Series Connected

These criteria apply when three or more terminals are connected by a common bus wire.

Figure 6-106

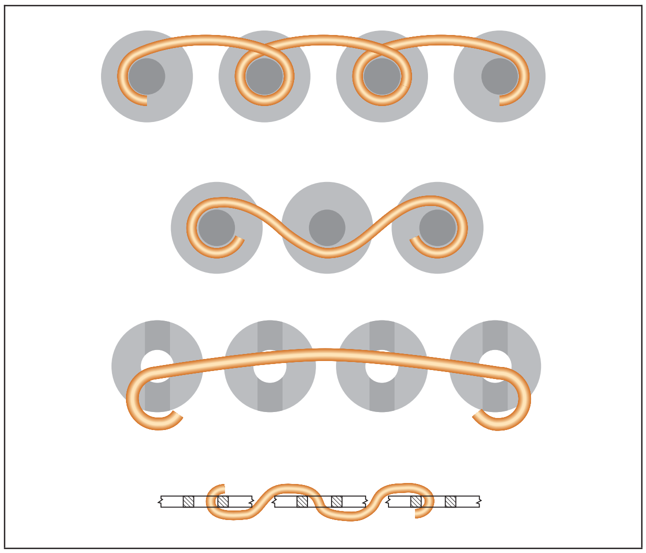

Figure 6-107

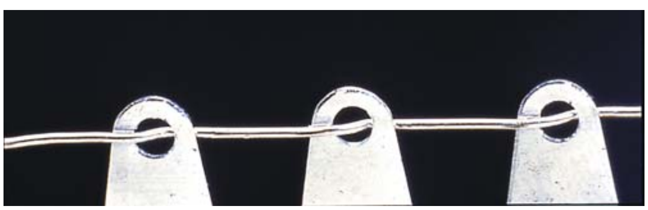

Figure 6-108

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Turrets – Wire does not wrap 360° around each intermediate terminal or is not interwoven between terminals.
- Hooks – Wire wraps less than 360° around intermediate terminal.
- Bifurcated – Wire does not pass between the posts or is not in contact with the terminal base or a previously installed wire.
- Pierced/Perforated – Wire does not contact two nonadjacent sides of each inner terminal.

Defect – Class 1,2,3

- No stress relief between any two terminals.
- The connection to the first and last terminals does not meet the required wrap for individual terminals.

6.17 Edge Clip – Position

Figure 6-109

Acceptable – Class 1,2,3

- Clip has 25% maximum overhang off land.
- Overhang does not reduce spacing below minimum electrical clearance.

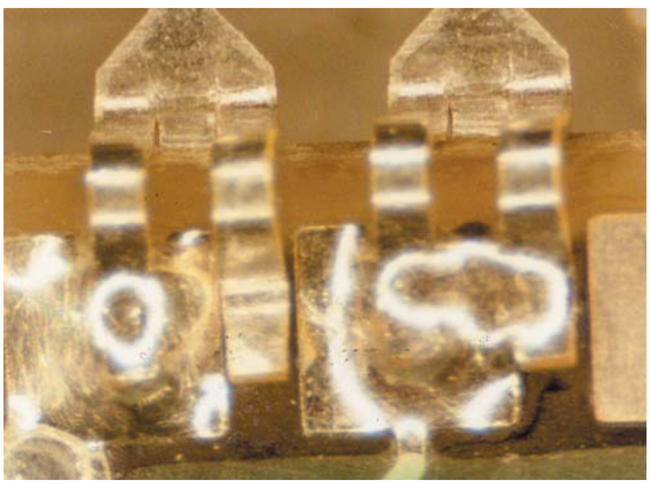

Figure 6-110

Defect – Class 1,2,3

- Clip exceeds 25% overhang off land.
- Clip overhangs land, reducing the spacing below minimum electrical clearance.

7 Through-Hole Technology

This section includes hardware, adhesive, forming, mounting, termination and soldering criteria for through-hole installation.

The placement of any component on the electronic assembly does not prevent the insertion or removal of any hardware (tool clearance included) used to mount the assembly.

Minimum spacing between installed hardware and the conducting land, component leads or uninsulated components depends on specified voltage and is not less than the specified minimum electrical clearance, see 1.8.5 Electrical Clearance.

Bonding material is sufficient to hold the part but does not encapsulate and cover component identification.

Visual inspection includes part identification and polarity, assembly sequence, and damage to hardware, component, or board.

In addition to the criteria in this section the criteria of 5 Soldering are applicable.

The following topics are addressed in this section.

7.1 Component Mounting

7.1.1 Component Mounting – Orientation

This section covers acceptability requirements for the installation, location, and orientation of components and wires mounted onto printed boards.

Criteria are given for only the actual mounting or placement of components or wires on electronic assemblies and to standoff spacers. Solder is mentioned where it is an integral part of the placement dimensions, but only as related to those dimensions.

Inspection usually starts with a general overall view of the electronic assembly, then follows each component/wire to its connection, concentrating on the lead into the connection, the connection and the tail end of the lead/wire leaving the connection. The wire/lead protrusion step for all lands should be saved for last so that the board can be flipped over and all connections checked together.

7.1.1.1 Component Mounting – Orientation – Horizontal

Additional criteria for horizontal mounting of axial leaded components are provided in clauses 7.3.1 (supported holes) and 7.4.1 (unsupported holes).

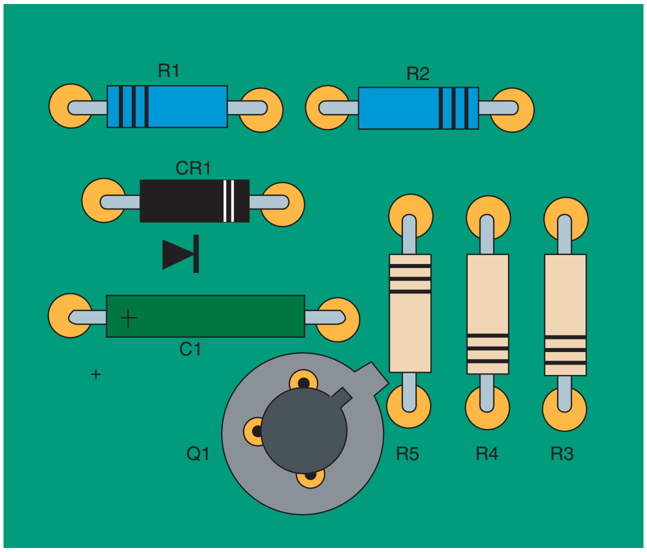

Figure 7-1

Acceptable – Class 1,2,3

- Polarized and multilead components are oriented correctly.
- When hand formed and hand-inserted, polarization markings are discernible.
- All components are as specified and terminate to correct lands.
- Nonpolarized components are not oriented so that markings all read the same way (left-to-right or top-to-bottom).

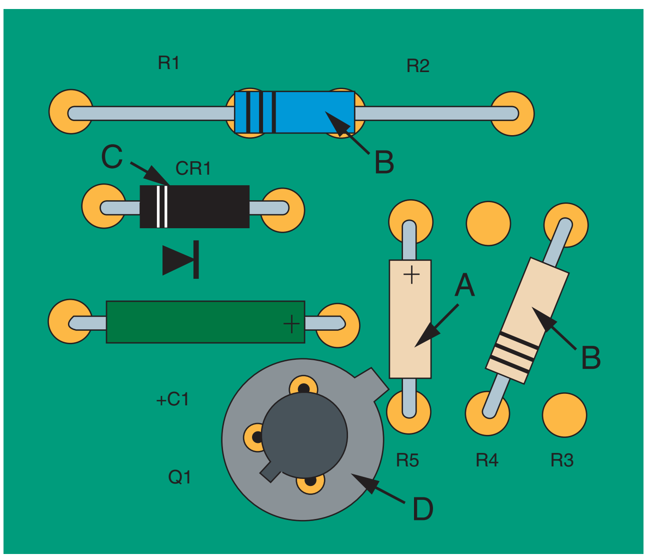

Figure 7-2

Defect – Class 1,2,3

- Component is not as specified (wrong part), see Figure 7-2-A.
- Component not mounted in correct holes, see Figure 7-2-B.
- Polarized component mounted backwards, see Figure 7-2-C.
- Multileaded components are not oriented correctly, see Figure 7-2-D.

7.1.1.2 Component Mounting – Orientation – Vertical

Additional criteria for vertical mounting of axial leaded components are provided in 7.3.2 Through-Hole Technology – Supported Holes – Axial Leaded – Vertical and 7.4.2 Through-Hole Technology – Unsupported Holes – Axial Leaded – Vertical.

In the examples in Figures 7-3 through 7-5, the arrows printed on the black capacitor casing are pointing to the negative end of the component.

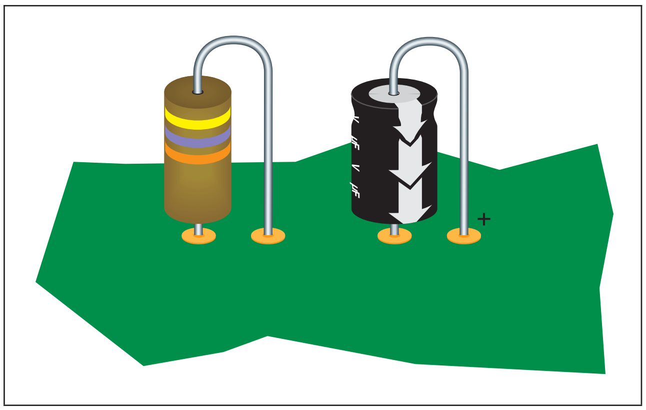

Figure 7-3

Acceptable – Class 1,2,3

- Polarized part is mounted with a long ground lead.
- Polarized marking hidden.
- Nonpolarized component markings read from bottom to top.

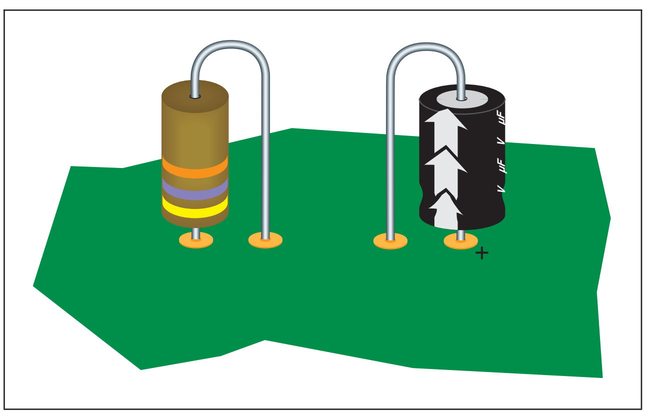

Figure 7-4

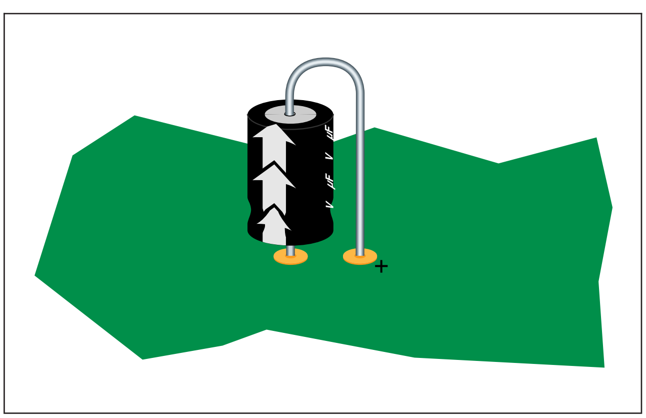

Figure 7-5

Defect – Class 1,2,3

- Polarized component is mounted backwards.

7.1.2 Component Mounting – Lead Forming

7.1.2.1 Component Mounting – Lead Forming – Bend Radius

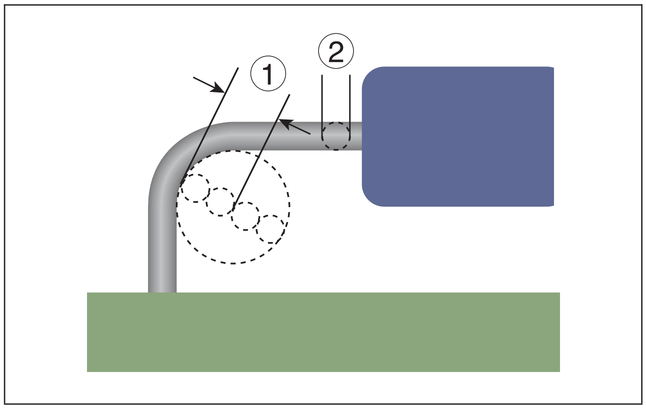

Figure 7-6
1. Radius (R)
2. Diameter (D)

Acceptable – Class 1,2,3

- The inside bend radius of component leads meets requirements of Table 7-1.

Table 7-1 Lead Bend Radius

Lead Diameter (D) or Thickness (T)	Minimum Inside Bend Radius (R)
< 0.8 mm [0.03 in]	1 (D) or (T)
0.8 mm [0.03 in] to 1.2 mm [0.05 in]	1.5 (D) or (T)
> 1.2 mm [0.05 in]	2 (D) or (T)

Note: Rectangular leads use thickness (T).

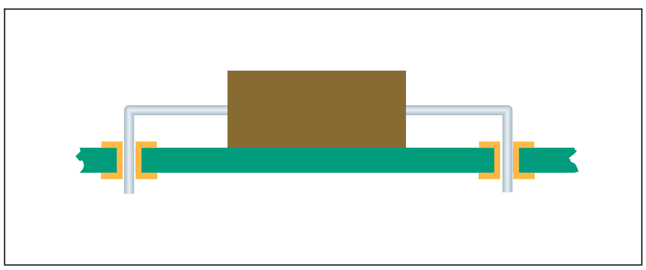

Figure 7-7

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Inside bend radius does not meet requirements of Table 7-1.

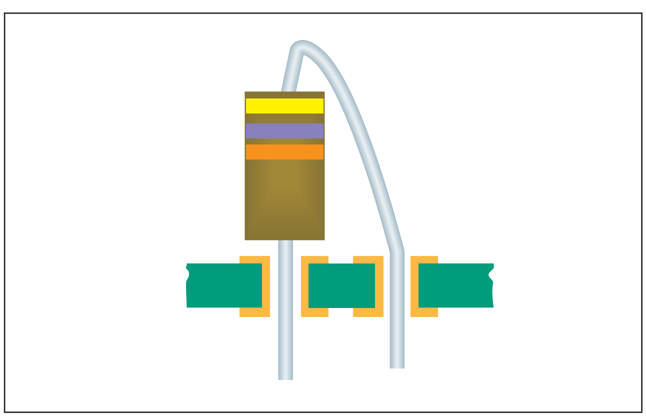

Figure 7-8

Defect – Class 1,2,3

- Lead is kinked.

7.1.2.2 Component Mounting – Lead Forming – Space between Seal/Weld and Bend

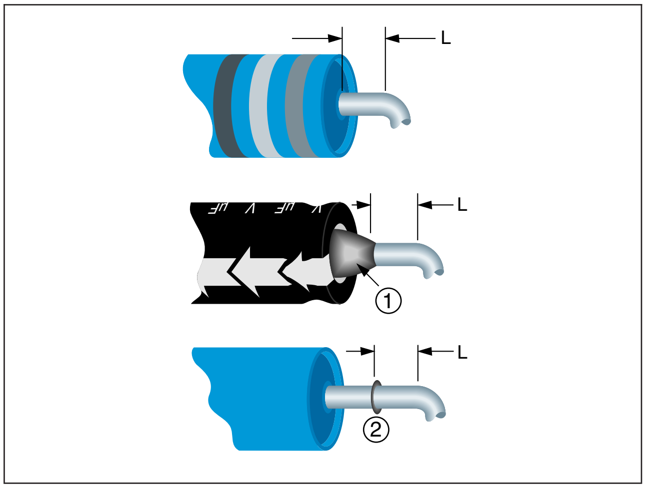

Figure 7-9
1. Solder bead
2. Weld

Acceptable – Class 1,2,3

- Leads of through-hole mounted component extend at least one lead diameter or thickness but not less than 0.8 mm [0.03 in] from the body, solder bead, or lead weld.

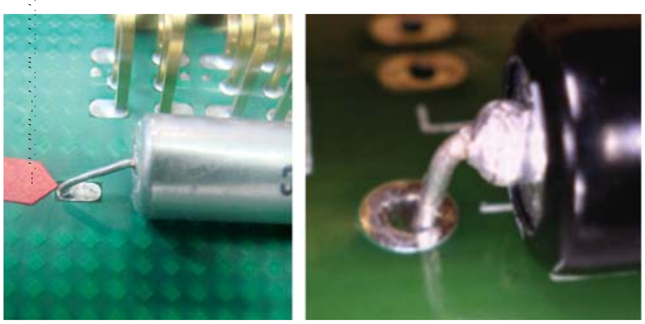

Figure 7-10

Figure 7-11

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Lead bend of through-hole mounted component is less than one lead diameter/thickness or less than 0.8 mm [0.03 in], from the component body, solder bead or component body lead seal.

Defect – Class 1,2,3

- Fractured lead weld, solder bead, or component body lead seal.
- Lead damage exceeds limits of 7.1.2.4 Through-Hole Technology – Component Mounting – Lead Forming – Stress Relief.

7.1.2.3 Component Mounting – Lead Forming – Stress Relief

Components are mounted in any one or a combination of the following configurations:

- In a conventional manner utilizing 90° (nominal) lead bends directly to the mounting hole.
- With camel hump bends. Configuration incorporating a single camel hump may have the body positioned off-center.
- Other configurations may be used with User approval or where design constraints exist.

Note: Prepped components with stress bends as shown in Figure 7-13 usually cannot meet the maximum clearance requirements of a straight-legged vertical – radial leaded component, see 7.1.6 Through-Hole Technology – Component Mounting – Radial Leads – Vertical. Maximum clearance between component and board surface is determined by design limitations and product use environments. The component preparation equipment and manufacturer's suggested component lead bend specifications and capabilities determine limitation. This may require change in tooling to meet requirements for end use.

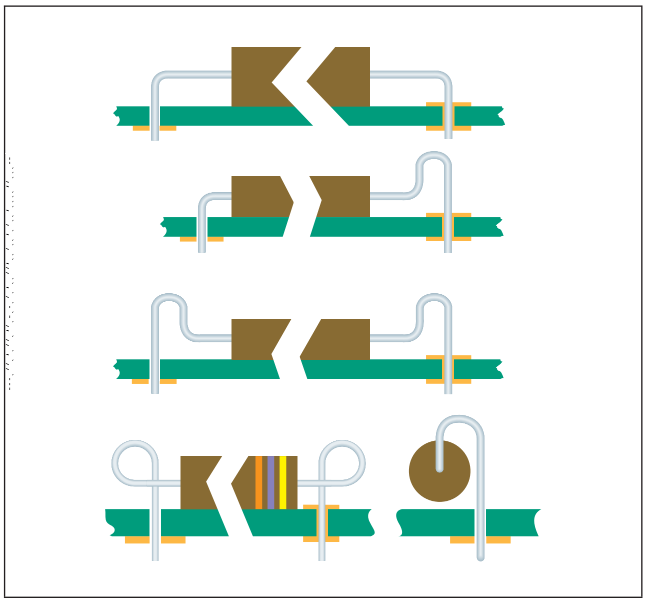

Figure 7-12

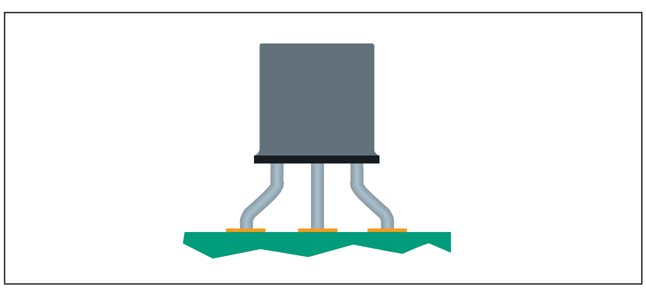

Figure 7-13

Acceptable – Class 1,2,3

- Leads are formed to provide stress relief.
- Component lead exiting component body is approximately parallel to major body axis.
- Component lead entering hole is approximately perpendicular to board surface.
- Component centering may be offset as a result of the type of stress relief bend.
- Loop bends present and allowed by engineering documentation.

7.1.2.3 Component Mounting – Lead Forming – Stress Relief (cont.)

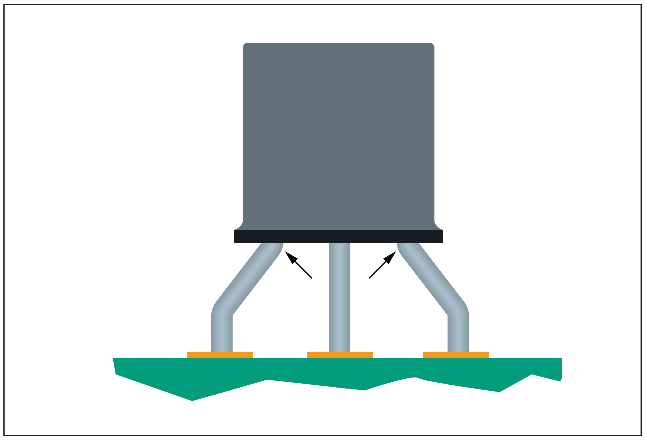

Figure 7-14

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Lead bends less than one lead diameter or thickness but not less than 0.8 mm [0.03 in] away from body seal.

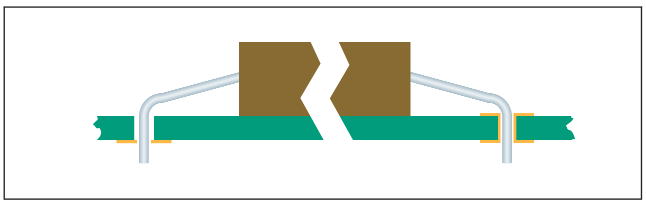

Figure 7-15

Defect – Class 1,2,3

- Damage or fracture of component body-to-lead seal.
- No stress relief.
- Loop bends present and not allowed by engineering documentation.

7.1.2.4 Component Mounting – Lead Forming – Damage

These criteria are applicable whether leads are formed manually or by machine or die.

Figure 7-16

Acceptable – Class 1,2,3

- No nicks or deformation exceeding 10% of the diameter, width or thickness of the lead. See 5.2.1 Soldering – Soldering Anomalies – Exposed Basis Metal for exposed basis metal criteria.

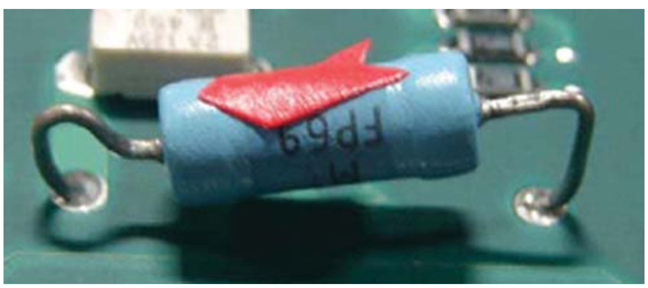

Figure 7-17

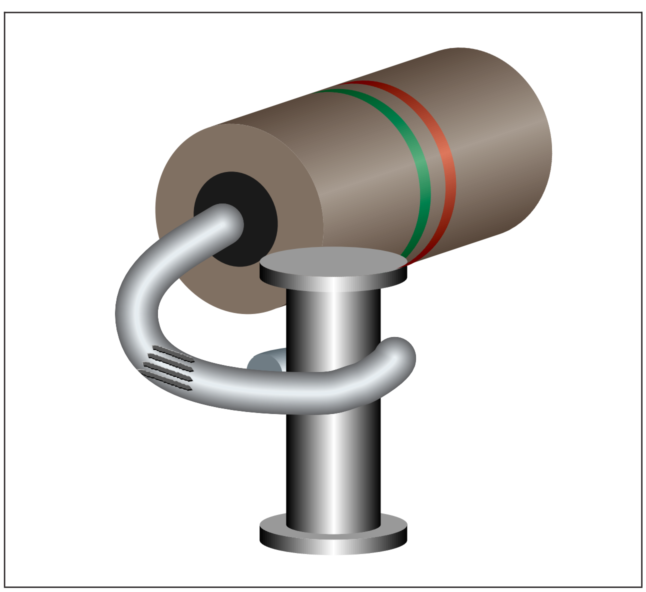

Figure 7-18

Defect – Class 1,2,3

- Lead is damaged more than 10% of the lead diameter or thickness.
- Lead deformed from repeated or careless bending.
- Heavy indentations such as serrated pliers mark.
- Lead diameter is reduced more than 10%.

7.1.3 Component Mounting – Leads Crossing Conductors

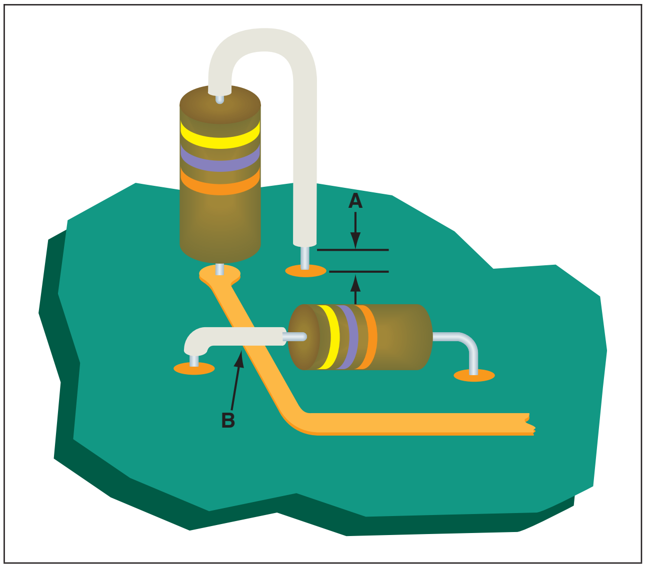

Figure 7-19

Acceptable – Class 1,2,3

- Sleeve does not interfere with formation of the required solder connection, see Figure 7-19-A.
- Sleeve covers area of protection designated, see Figure 7-19-B.

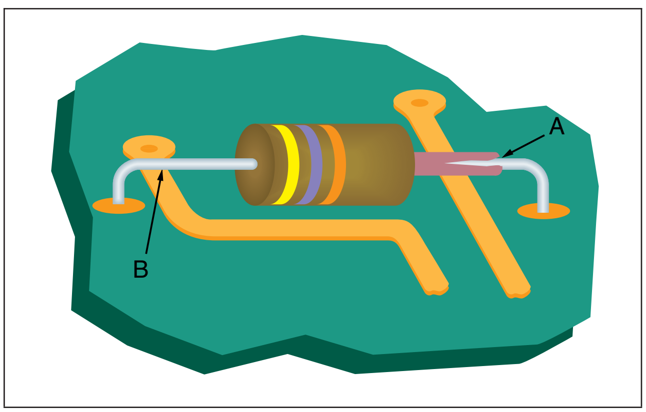

Figure 7-20

Not Established – Class 1
Defect – Class 2,3

- Splitting and/or unraveling of sleeving, see Figure 7-20-A.

Defect – Class 1,2,3

- Component leads and wires required to have sleeving are not sleeved, see Figure 7-20-B.
- Damaged/insufficient sleeving does not provide protection from shorting.
- Sleeving interferes with formation of the required solder connection.
- A component lead crossing an electrically noncommon conductor violates minimum electrical clearance, see Figure 7-20-B.

7.1.4 Component Mounting – Hole Obstruction

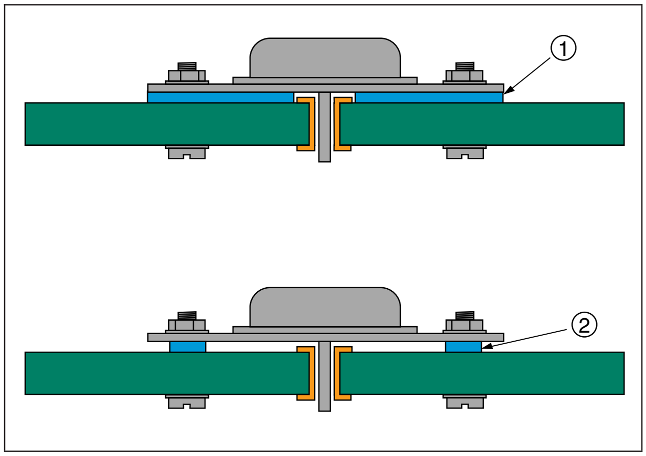

Figure 7-21
1. Insulating washer
2. Spacer

Acceptable – Class 1,2,3

- Parts and components are mounted such that they do not obstruct solder flow onto the primary side (solder destination side) lands of plated through-holes required to be soldered.

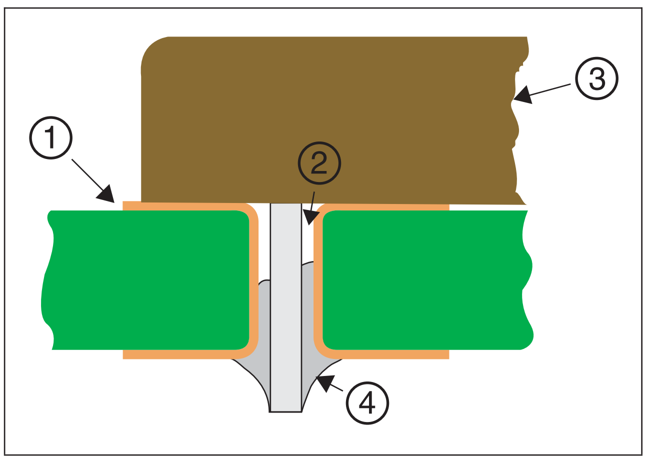

Figure 7-22
1. Component body contacts land and obstructs solder flow.
2. Air
3. Component body
4. Solder

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Parts and components obstruct solder flow onto the primary side (solder destination side) lands of plated through-holes required to be soldered.

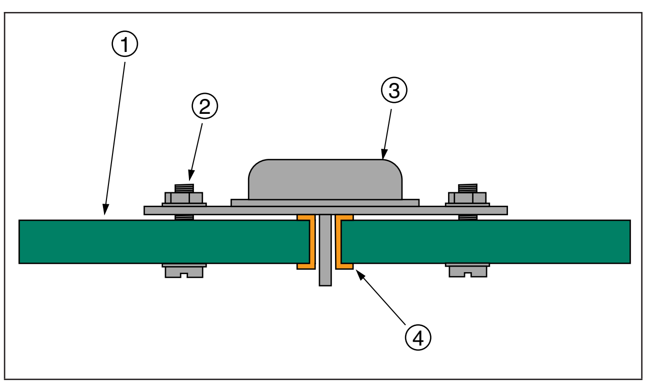

Figure 7-23
1. Nonmetal
2. Mounting hardware
3. Component case
4. Conductive pattern

Defect – Class 1,2,3

- Parts and components are mounted such that they violate minimum electrical clearance.

7.1.5 Component Mounting – DIP/SIP Devices and Sockets

These criteria are applicable to Dual-in-Line Packages (DIP), Single-in-Line Packages (SIP) and sockets.

Note: In some cases a heat sink may be located between the component and the printed board; in these cases other criteria may be specified.

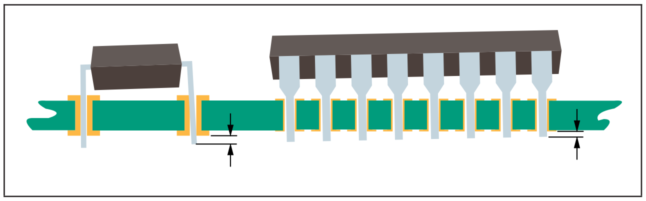

Figure 7-24

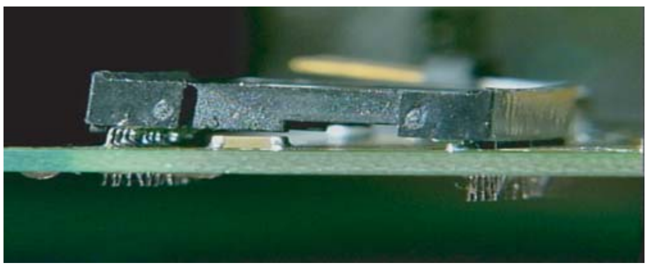

Figure 7-25

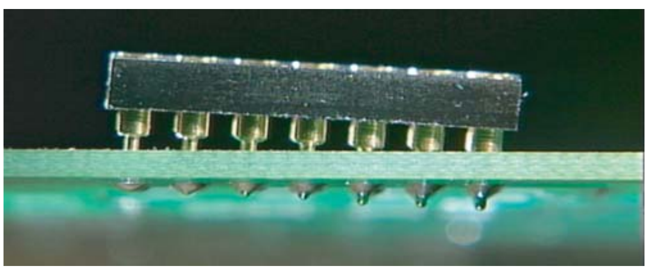

Figure 7-26

Acceptable – Class 1,2,3

- Amount of tilt is limited by minimum lead protrusion and height requirements.
- Lead protrusion meets requirements, see 7.3.3 Through-Hole Technology – Supported Holes – Wire/Lead Protrusion and 7.4.3 Through-Hole Technology – Unsupported Holes – Wire/Lead Protrusion.

7.1.5 Component Mounting – DIP/SIP Devices and Sockets (cont.)

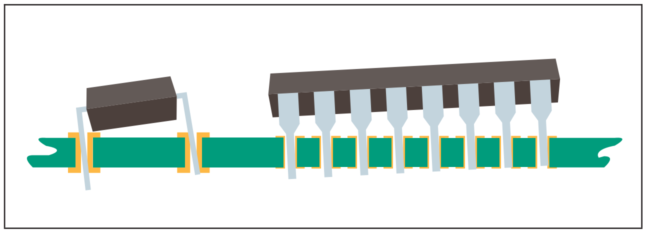

Figure 7-27

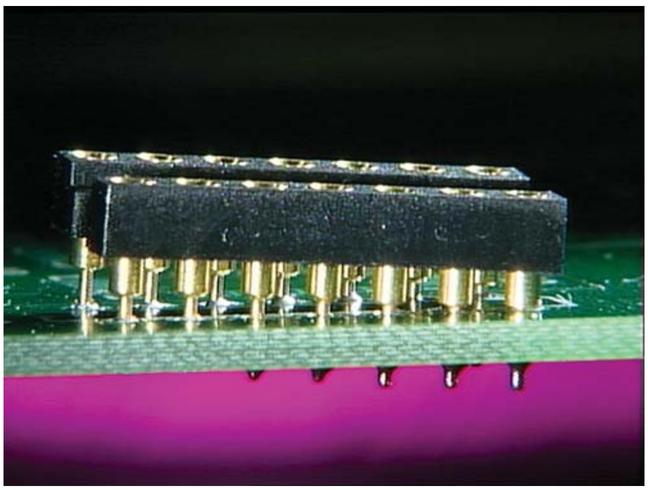

Figure 7-28

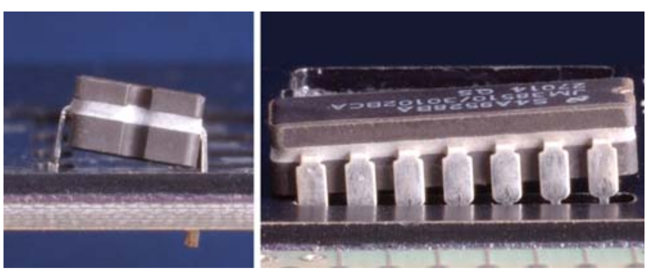

Figure 7-29

Defect – Class 1,2,3

- Tilt of the component exceeds maximum component height limits.
- Lead protrusion does not meet acceptance requirements due to tilt of component.

7.1.6 Component Mounting – Radial Leads – Vertical

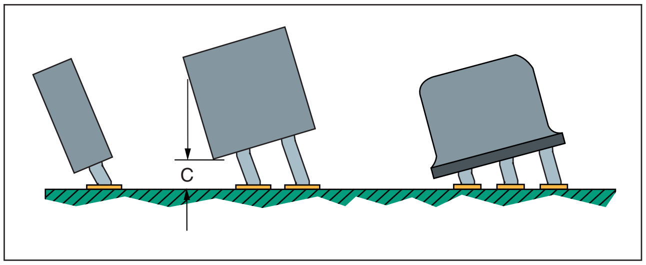

Figure 7-30
C – Clearance

Acceptable – Class 1,2,3

- Component tilt does not violate minimum electrical clearance, see Figure 7-30-C.
- Clearance between base of component and board surface/land is between 0.3 mm [0.01 in] and 2 mm [0.08 in].

Acceptable – Class 1
Process Indicator – Class 2,3

- Clearance between component base and board surface/land is less than 0.3 mm [0.01 in] or more than 2 mm [0.08 in], see 7.1.4 Through-Hole Technology – Component Mounting – Hole Obstruction.

Defect – Class 1,2,3

- Violates minimum electrical clearance.

Note: Some components cannot be tilted due to mating requirements with enclosures or panels, for example toggle switches, potentiometers, LCDs, and LEDs.

7.1.6.1 Component Mounting – Radial Leads – Vertical – Spacers

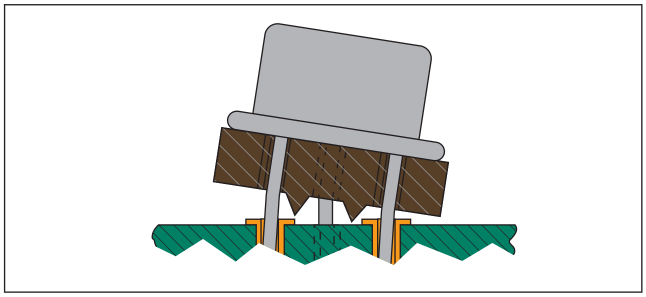

Figure 7-31

Acceptable (Supported Holes) – Class 1,2
Process Indicator (Supported Holes) – Class 3
Defect (Unsupported Holes) – Class 1,2,3

- Spacer is not in full contact with component and board.

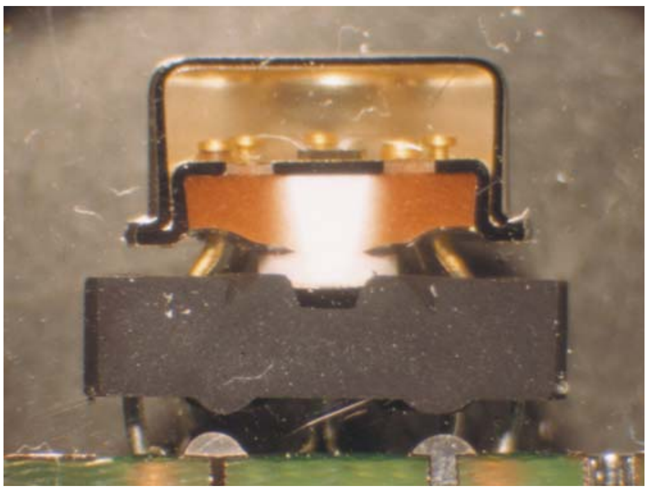

Figure 7-32

Acceptable (Supported Holes) – Class 1
Process Indicator (Supported Holes) – Class 2
Defect (Supported Holes) – Class 3
Defect (Unsupported Holes) – Class 1,2,3

- Spacer is not in contact with component and board, see Figure 7-33-A.
- Lead is improperly formed, see Figure 7-33-B.

Not Established – Class 1
Defect – Class 2,3

- Spacer is inverted, see Figure 7-33-C.

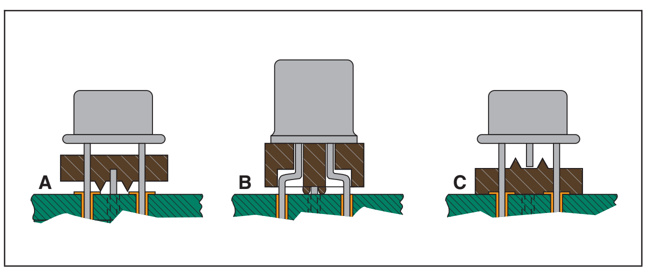

Figure 7-33

7.1.7 Component Mounting – Radial Leads – Horizontal

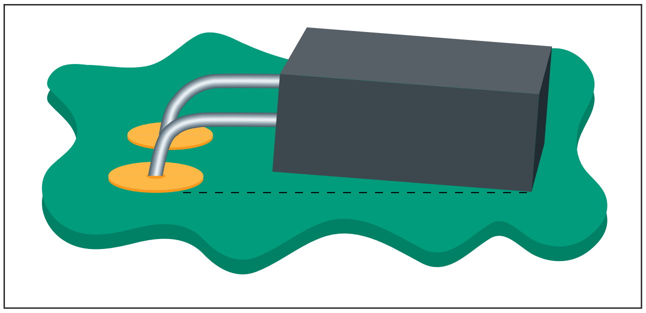

Figure 7-34

Acceptable – Class 1,2,3

- Component in contact with board on at least one side and/or surface.

Note: When documented on an approved assembly drawing, a component may be either side mounted or end mounted. The body may need to be bonded or otherwise secured to the board to prevent damage when vibration and shock forces are applied, see 7.2 Through-Hole Technology – Component Securing.

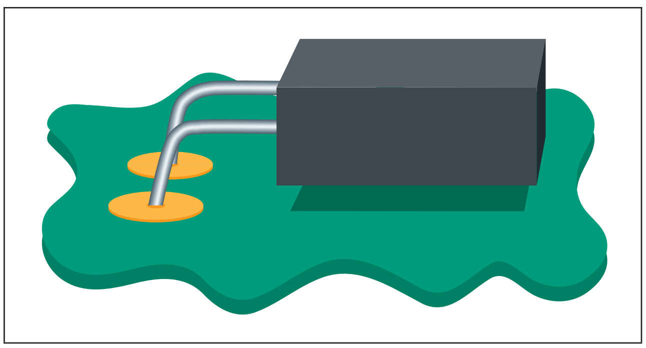

Figure 7-35

Defect – Class 1,2,3

- Unbonded component body not in contact with mounting surface.
- Bonding material not present if required.

7.1.8 Component Mounting – Connectors

These criteria apply to soldered connectors. For connector pin criteria see 4.3 Hardware – Hardware Installation – Connector Pins. For connector damage criteria see 9.5 Component Damage – Connectors.

Connector module/pin misalignment, defined in this section, is to be measured at the connector lead-in area/hole (for receptacles) or at the pin tip (for pin headers).

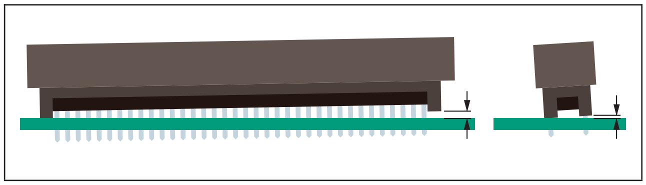

Figure 7-36

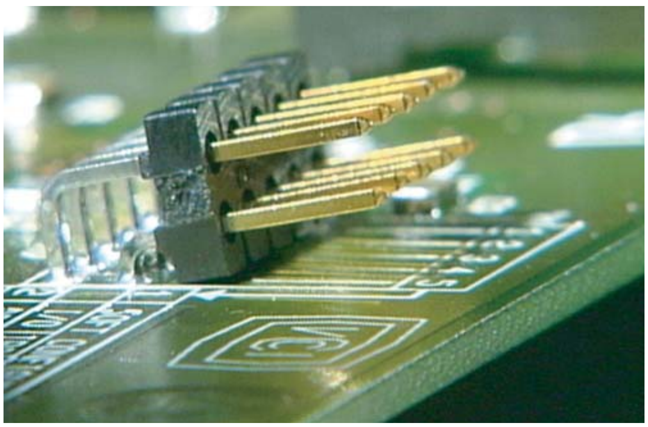

Figure 7-37

Acceptable – Class 1,2,3

- Board lock is fully inserted/snapped through the board.
- Any tilt or misalignment, provided:
  - – Minimum lead protrusion is met.
  - – Maximum height requirements are not exceeded.
  - – Mates correctly.

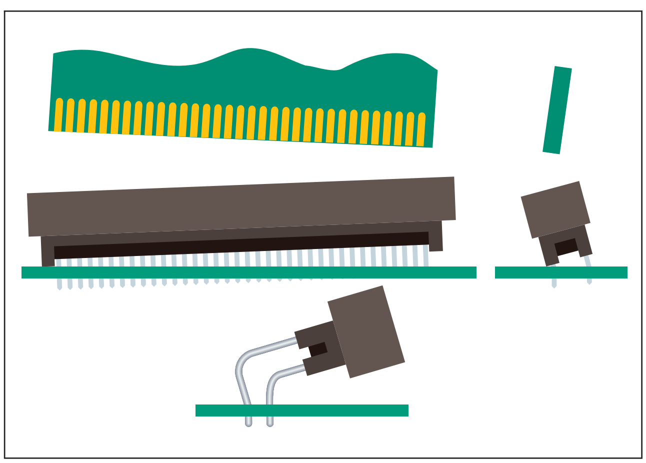

Figure 7-38

Defect – Class 1,2,3

- Will not mate when used in application due to angle or misalignment.
- Component violates height requirements.
- Board lock is not fully inserted/snapped into board.
- Lead protrusion does not meet acceptance requirements.

Note: A trial mating of connector to connector or to assembly may be required to assure the connectors meet form, fit and function requirement.

7.1.8.1 Component Mounting – Connectors – Right Angle

These criteria are applicable to right angle soldered connectors with pin spacing greater than or equal to 2.5 mm [0.1 in].

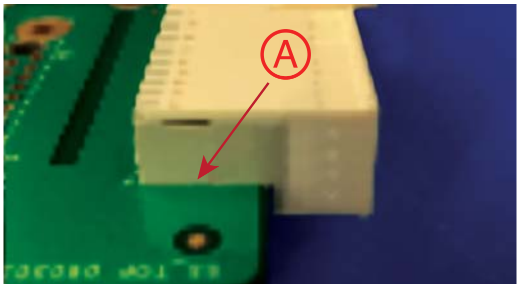

Figure 7-39

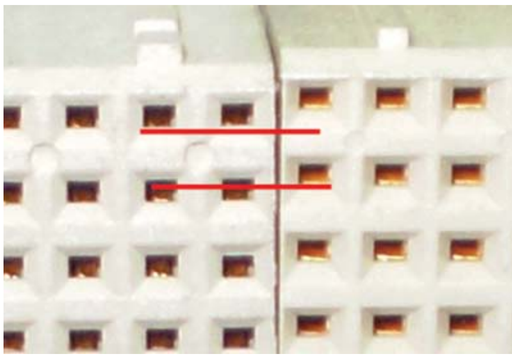

Figure 7-40

Acceptable – Class 1

- Connector spacing does not affect mating of connector with assembling requirements, e.g., face plates, bracket, mating connector, etc.

Acceptable – Class 2,3

- Connector-to-board spacing is equal to or less than 0.13 mm [0.005 in], see Figure 7-39.
- Maximum misalignment is less than 0.25 mm [0.01 in] across the contact openings of all connectors in the connector lineup, see Figure 7-40.

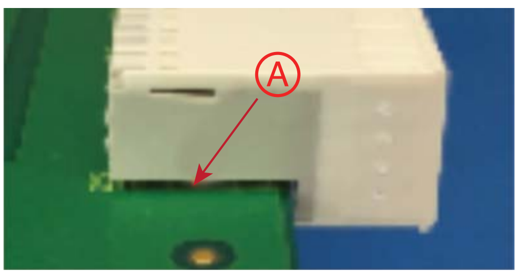

Figure 7-41

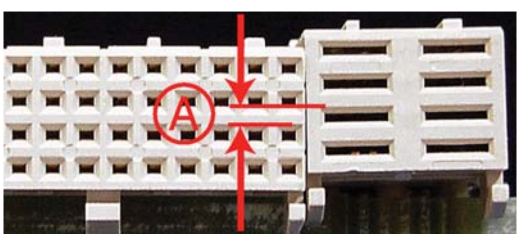

Figure 7-42

Defect – Class 1,2,3

- Connector spacing affects mating of connector with assembling requirements, e.g., face plates, bracket, mating connector, etc.

Defect – Class 2,3

- Connector-to-board spacing is greater than 0.13 mm [0.005 in], see Figure 7-41-A.
- Maximum misalignment is greater than 0.25 mm [0.01 in] across the faces (contact openings) of all modules (connectors) in the connector lineup, see Figure 7-42-A.

7.1.8.2 Component Mounting – Connectors – Vertical Shrouded Pin Headers and Vertical Receptacle Connectors

These criteria are applicable to vertical shrouded pin headers and vertical receptacle connectors that are 2 mm - 2.54 mm [0.08 - 0.1 in] pin spacing.

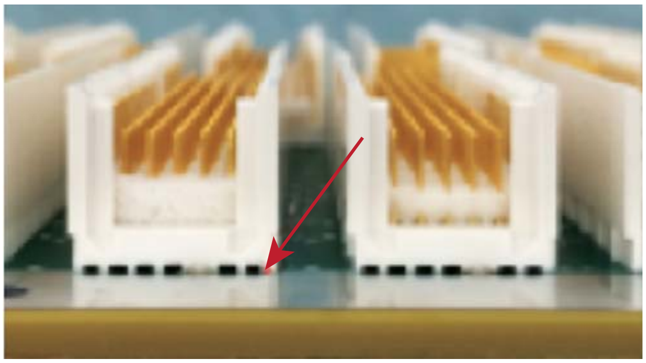

Figure 7-43

Acceptable – Class 1

- Connector spacing does not affect mating of connector with assembling requirements, e.g., face plates, bracket, mating connector, etc.

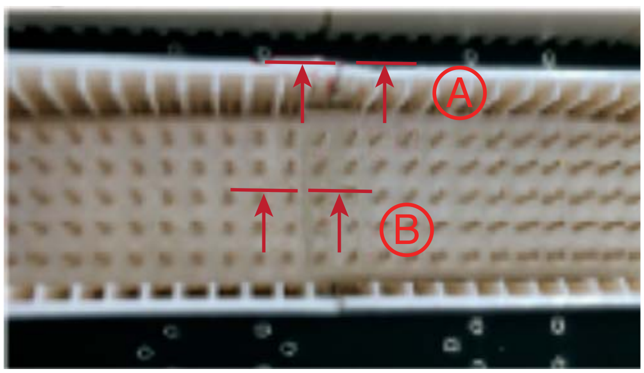

Figure 7-44

Acceptable – Class 2,3

- Connector-to-board spacing is equal to or less than 0.13 mm [0.005 in], see Figure 7-43.
- The misalignment of individual connector/modules contact openings is equal to, or less than, 0.25 mm [0.01 in], with adjacent modules, see Figure 7-44-A.
- Maximum misalignment between any two modules/pins in the connector lineup is less than 0.25 mm [0.01 in], see Figure 7-44-B.

Defect – Class 1,2,3

- Connector spacing affects mating of connector with assembling requirements, e.g., face plates, bracket, mating connector, etc.

Defect – Class 2,3

- Connector-to-board spacing is greater than 0.13 mm [0.005 in] (not shown).
- The misalignment of individual connector/modules contact openings are greater than 0.25 mm [0.01 in], with adjacent modules (not shown).
- Maximum misalignment between any two modules/pins in the connector lineup is greater than 0.25 mm [0.01 in] (not shown).

7.1.9 Component Mounting – Conductive Cases

Acceptable – Class 1,2,3

- Components with uninsulated conductive bodies do not violate minimum electrical clearance.

Defect – 1,2,3

- Components with uninsulated conductive bodies violate minimum electrical clearance.

7.2 Component Securing

7.2.1 Component Securing – Mounting Clips

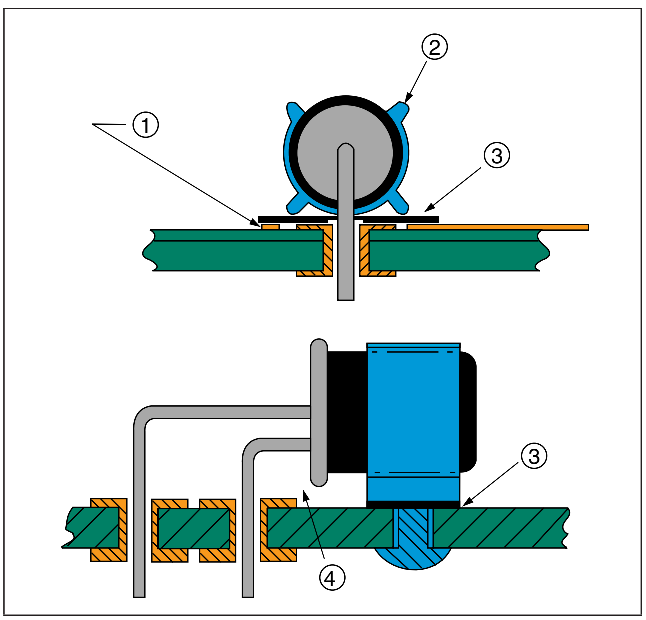

Figure 7-45

1. **Conductive patterns**
2. **Metallic mounting clip**
3. **Insulation material**
4. **Clearance**

7.2.1 Component Securing – Mounting Clips (cont.)

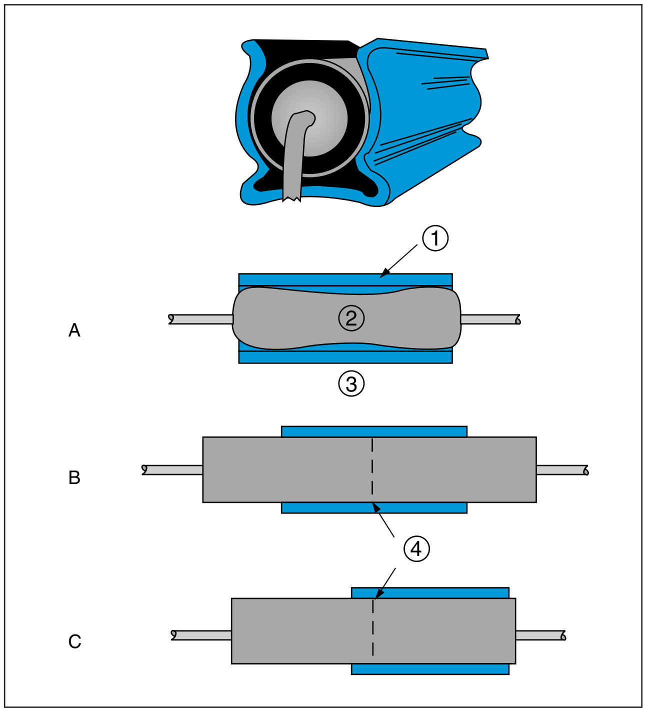

Figure 7-46
1. Clip
2. Nonsymmetrical body
3. Top view
4. Center of gravity

Acceptable – Class 1,2,3

- The clip makes contact to both sides of the component, see Figure 7-46-A.
- The component is mounted with the center of gravity within the confines of the clip, see Figure 7-46-B, C.
- The end of the component is flush with or extends beyond the end of the clip, see Figure 7-46-C.
- Spacing between land and uninsulated component body does not violate minimum electrical clearance.

7.2.1 Component Securing – Mounting Clips (cont.)

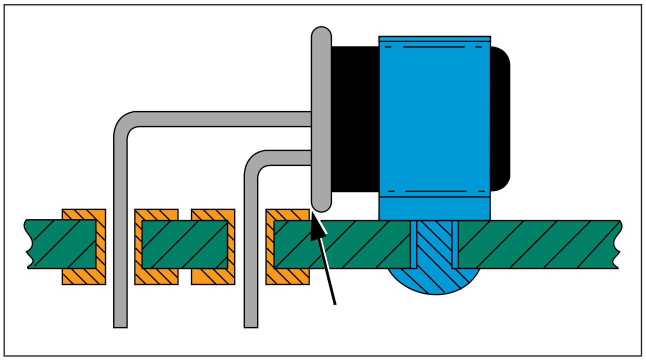

Figure 7-47

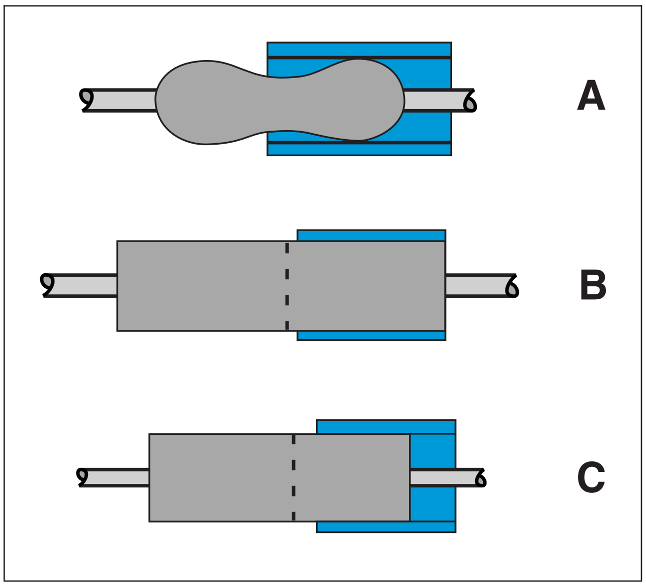

Figure 7-48

Defect – Class 1,2,3

- Spacing between land and uninsulated component body is less than minimum electrical clearance, see Figure 7-47.
- Uninsulated metallic clip or holding device is not insulated from underlying circuitry.
- Clip does not restrain component, see Figure 7-48-A.
- Component center or center of gravity not within the confines of the clip, see Figure 7-48-C.

7.2.2 Component Securing – Adhesive Bonding

These criteria do not apply to SMT components, see 8.1 Surface Mount Assemblies – Staking Adhesive.

Visual inspection of staking may be performed without magnification. Magnification from 1.75X to 4X may be used for referee purposes.

7.2.2.1 Component Securing – Adhesive Bonding – Nonelevated Components

These criteria are the same for sleeved or unsleeved components, see exception below for glass bodied components.

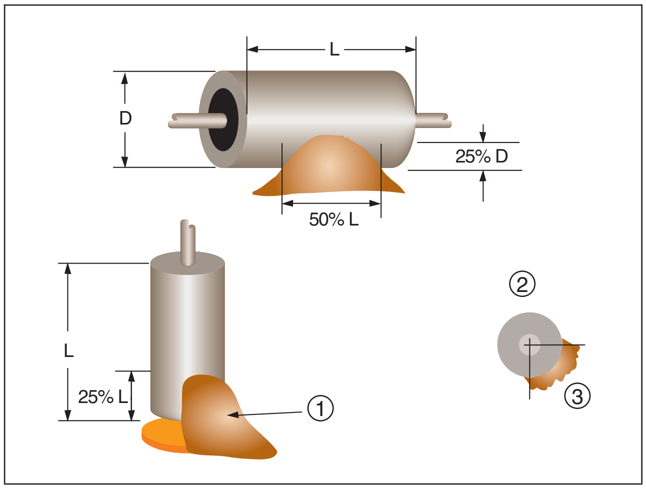

Figure 7-49
1. Adhesive
2. Top view
3. 25% Circumference

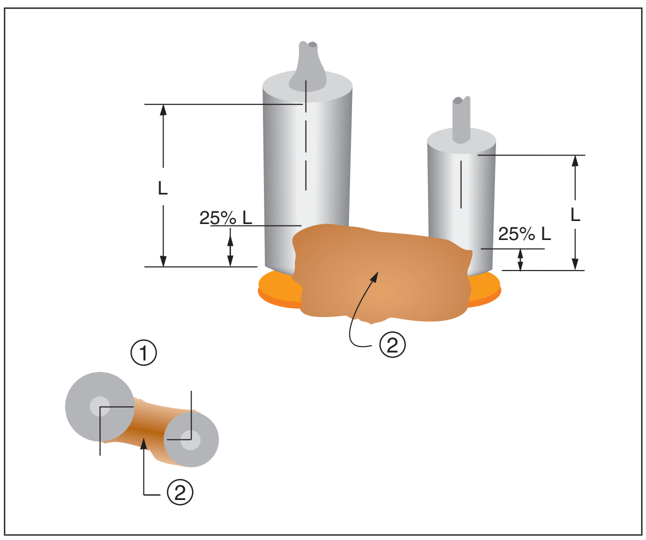

Figure 7-50
1. Top view
2. Adhesive

Acceptable – Class 1,2,3

- Continuous adhesion fillet to the mounting surface and component body.
- Adhesive is cured.
- No gap/separation/crack between staking and attachment surfaces.
- Staking material does not contact component body seals.
- On a horizontally mounted component the staking material:
  - Adheres to component for at least 50% of its length (L).
  - Maximum fillet height allows for the top of the component to be visible for the entire length of the component body.
  - Minimum fillet height of 25% component diameter (D).
- On a vertically mounted component:
  - The staking material bead(s) are continuous for least 25% of the component length (L) (height) with slight flow of staking material under the component body with no contact to the component body seal, see Figure 7-49-1.
  - The staking material adheres to the component for a minimum of 25% of the component circumference. Multiple beads adding up 25% may be used.
- On glass bodied components:
  - The component bodies are sleeved, when required, prior to staking material attachment.
  - Adhesives, e.g., staking, bonding, do not contact an unsleeved area of a sleeved glass body component.
- Multiple vertically mounted components:
  - Staking material adheres to each component for at least 25% of its length (L), and the adhesion is continuous between components, see Figure 7-50-2.
  - The staking material adheres to each component for a minimum 25% of its circumference, see Figure 7-50-1.
- Sleeved axial component (except glass body) have staking material in contact with one or both end faces of the component.

Acceptable – Class 3

- On a horizontally mounted component (sleeved or unsleeved) the staking material is applied to both sides of the component.

7.2.2.1 Component Securing – Adhesive Bonding – Nonelevated Components (cont.)

Not Established – Class 1,2
Defect – Class 3

- On a horizontally mounted component (sleeved or unsleeved) the staking material is less than 25% of the component's diameter (D) on both sides.

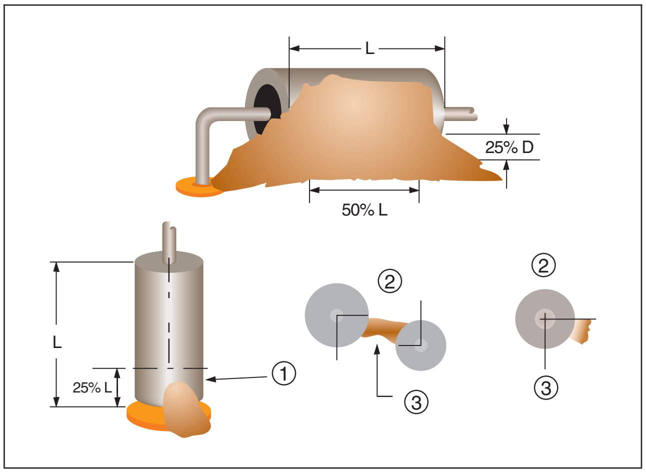

Figure 7-51
1. < 25% length (L)
2. Top view
3. < 25% circumference

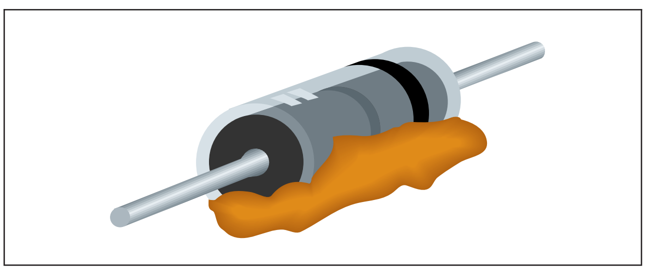

Figure 7-52

Not Established – Class 1
Process Indicator – Class 2
Defect – Class 3

- For horizontally mounted components (sleeved or unsleeved), the top of the component is not visible for the entire length of the component body due to excess staking material.

Not Established – Class 1,2
Defect – Class 3

- On a horizontally mounted component (sleeved or unsleeved) the staking material is not applied to both sides of the component.

Not Established – Class 1
Defect – Class 2,3

- Horizontally mounted axial leaded components having staking material contacting component body seals.
- Vertically mounted component:
  - The staking material adheres to less than 25% of the component circumference.
  - Adhesive is less than 25% of the component length (height).

7.2.2.1 Component Securing – Adhesive Bonding – Nonelevated Components (cont.)

Defect – Class 1,2,3

- There is not a continuous adhesion fillet to the mounting surface and component body.
- Uninsulated metallic case components bonded over conductive patterns.
- Staking material on areas to be soldered preventing compliance to Table 7-4.
- Rigid adhesives, e.g., staking, bonding, contact an unsleeved area of a sleeved glass body component, see Figure 7-52.
- Staking material is not cured.
- Horizontally mounted component the staking material adheres to:
  - Component and mounting surface less than 50% of the component length (L).
  - Less than 25% of the component's diameter (D), on one side.
- Multiple vertically mounted components:
  - The staking material adheres to each component for less than 25% of its length (L).
  - The staking material adheres for less than 25% of each component circumference.
  - The adhesion is not continuous between components.

7.2.2.2 Component Securing – Adhesive Bonding – Elevated Components

This applies to radial leaded components whose height is greater than or equal to their length or diameter and are not mounted flush to the board.

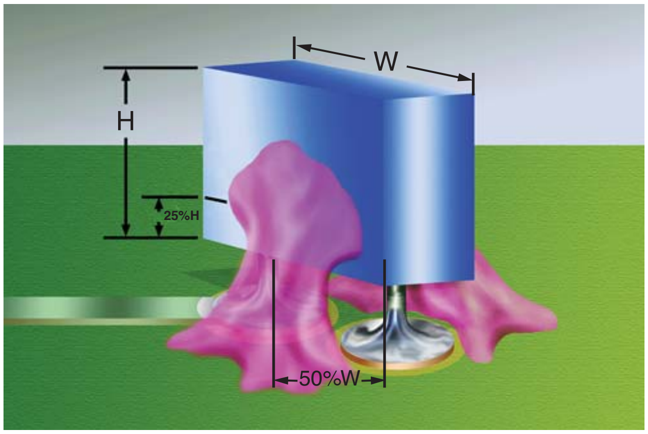

Figure 7-53

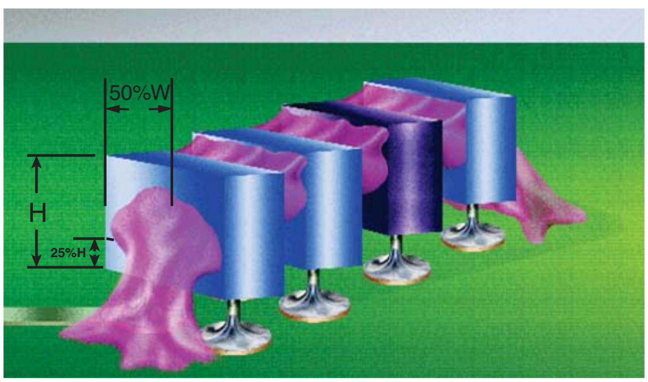

Figure 7-54

Not Established – Class 1
Acceptable – Class 2,3

- The staking material fillet height is at least 25 % of the height (H) of each individual component body, see Figure 7-53.
- The staking material fillet height is less than 100% of the height (H) of each individual component body, see Figure 7-53.
- The staking material is applied to both of the larger opposing faces, see Figure 7-53.
- The staking material/adhesive fillet covers a minimum of 25% of each of the component face's width (W).
- For closely spaced arrays consisting of up to four components:
  - The fillet height requirements for the two outer end-faces meet the requirements for an individual component, see Figure 7-54.
  - The top inner surfaces are bonded to each other for minimum of 50% of the components' width, see Figure 7-54.

7.2.2.2 Component Securing –– Adhesive Bonding – Elevated Components (cont.)

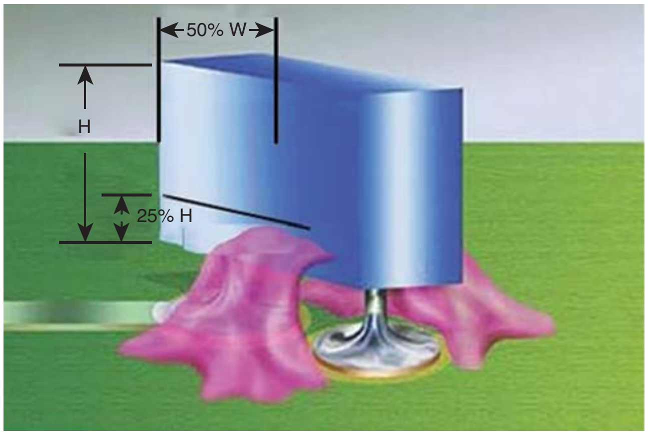

Figure 7-55

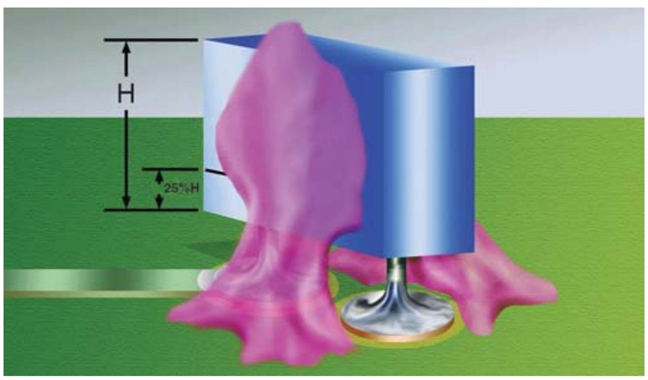

Figure 7-56

Not Established – Class 1
Defect – Class 2, 3

- The staking material fillet is less than 25% of the height (H) or 50% of the width (W) of each individual component body, see Figure 7-55.
- The staking material fillet extends above the top surface of the component, see Figure 7-56.
- The staking material is missing from one of the larger opposing faces, see Figure 7-57.
- For closely spaced arrays consisting of up to four components:
  - The fillet height requirements for the two outer end-faces do not meet the requirements for an individual component (not shown).
  - The top inner surfaces are not bonded to each other for at least 50% of the components' width, see Figure 7-58.
- For closely spaced arrays consisting of more than four components:
  - The staking material fillet requirements do not meet the requirements for arrays with up to four components (not shown).
  - Every other internal component does not have both of its sides staked to the board surface, see Figure 7-59.

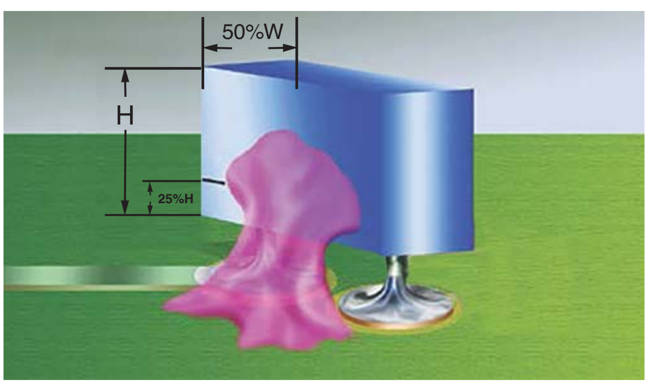

Figure 7-57

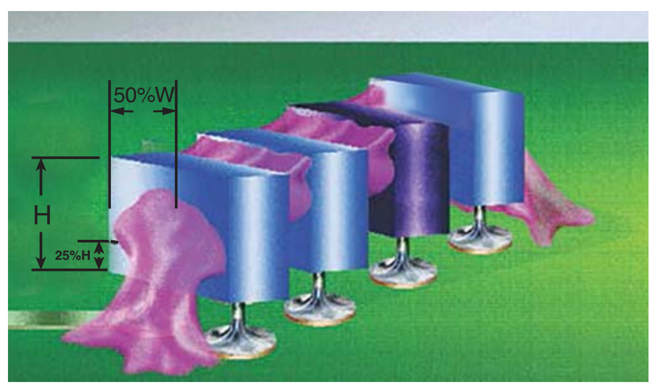

Figure 7-58

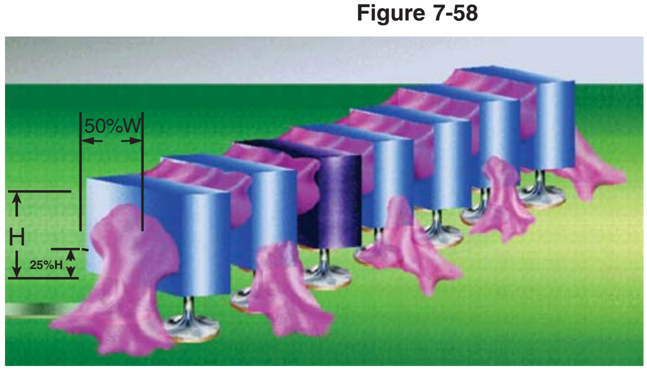

Figure 7-59

7.2.2.2 Component Securing –- Adhesive Bonding – Elevated Components (cont.)

This applies in particular to encapsulated or potted transformers and/or coils that are not mounted flush to the board.

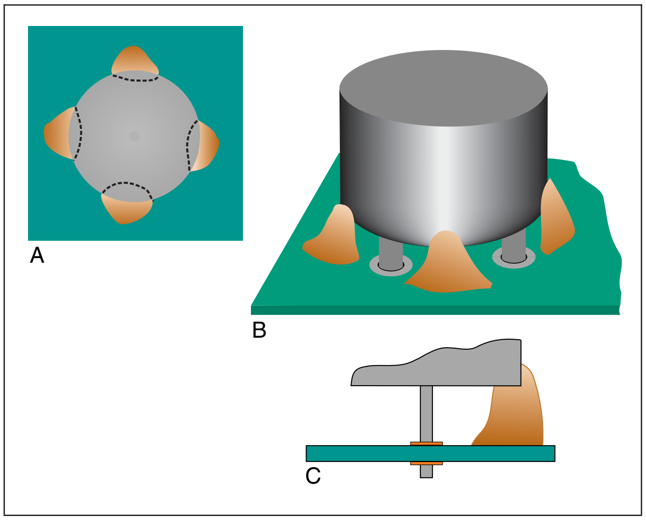

Figure 7-60

Acceptable – Class 1,2,3

- Bonding requirements should be specified in engineering documents, but at a minimum, components are bonded to mounting surface in at least four places evenly spaced around component when no mechanical support is used, see Figure 7-60-A.
- At least 20% of the total periphery of the component is bonded, see Figure 7-60-B.
- Bonding material firmly adheres to both the bottom and sides of the component and to the printed board, see Figure 7-60-C.
- Adhesive material does not interfere with formation of required solder connection.

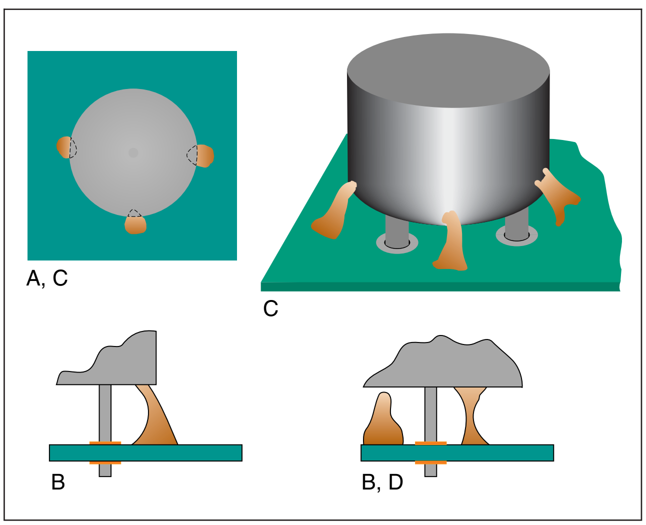

Figure 7-61

Defect – Class 1,2,3

- Bonding requirements are less than the specified requirements.
- Any bonding spots failing to wet and show evidence of adhesion to both the bottom and side of the component and the mounting surface, see Figure 7-61-B.
- Less than 20% of the total periphery of the component is bonded, see Figure 7-61-C.
- The bonding material forms too thin a column to provide good support, see Figure 7-61-D.
- Adhesive material interferes with formation of required solder connection.

7.2.3 Component Securing – Other Devices

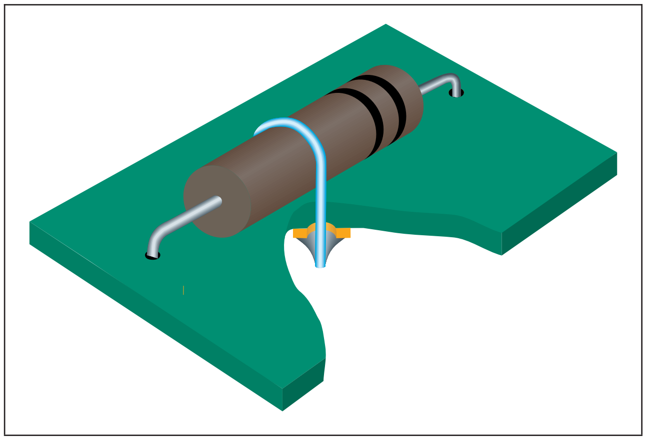

Figure 7-62

Acceptable – Class 1,2,3

- Component is held firmly against the mounting surface.
- There is no damage to the component body or insulation from the securing device.
- Conductive securing device does not violate minimum electrical clearance.

Defect – 1,2,3

- Component body damaged from securing device.
- Conductive securing device violates minimum electrical clearance.

7.3 Supported Holes

7.3.1 Supported Holes – Axial Leaded – Horizontal

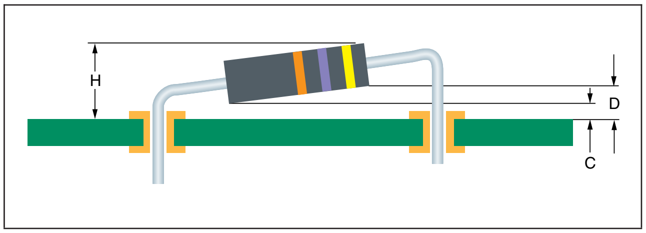

Figure 7-63

Acceptable – Class 1,2

- The maximum clearance (D) between the component and the board surface does not violate the requirements for lead protrusion, see 7.3.3 Through-Hole Technology – Supported Holes – Hole Technology – Supported Holes – Wire/ Lead Protrusion, or component height (H). (H) is a design-determined dimension.

Acceptable – Class 3

- Clearance (C) between the component body and the board does not exceed 0.7 mm [0.03 in] (for components that are not required to be mounted above the board surface).

Process Indicator – Class 3

- The farthest distance (D) between the component body and the board is larger than 0.7 mm [0.03 in] (for components that are not required to be mounted above the board surface).

Defect – Class 1,2,3

- Component height exceeds design-determined dimension (H).
- Components required to be mounted above the board surface are less than 1.5 mm [0.06 in] (C) from the board surface.

7.3.2 Supported Holes – Axial Leaded – Vertical

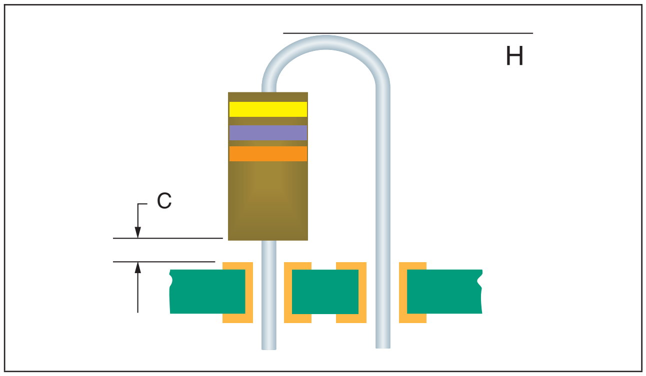

Figure 7-64

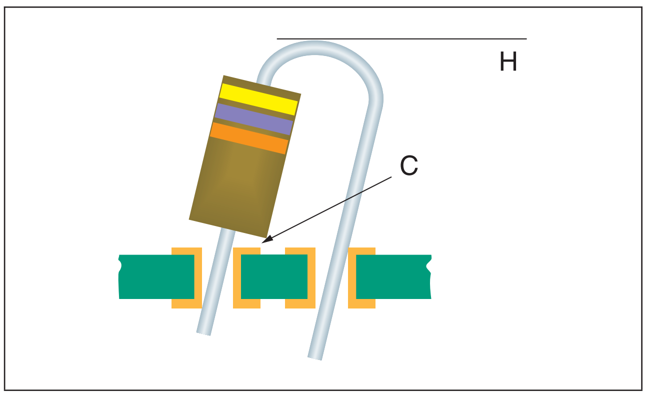

Figure 7-65

Acceptable – Class 1,2,3

- The component or weld bead clearance (C) above the land meets the requirements of Table 7-2, see Figure 7-64.
- The angle of the component lead does not cause a violation of minimum electrical clearance, see Figure 7-65.
- The overall height does not exceed maximum design height requirements (H).

Table 7-2 Component to Land Clearance

	Class 1	Class 2	Class 3
(C) Min.	0.1 mm [0.004 in]	0.4 mm [0.016 in]	0.8 mm [0.03 in]
(C) Max.	6 mm [0.24 in]	3 mm [0.12 in]	1.5 mm [0.06 in]

7.3.2 Supported Holes – Axial Leaded – Vertical (cont.)

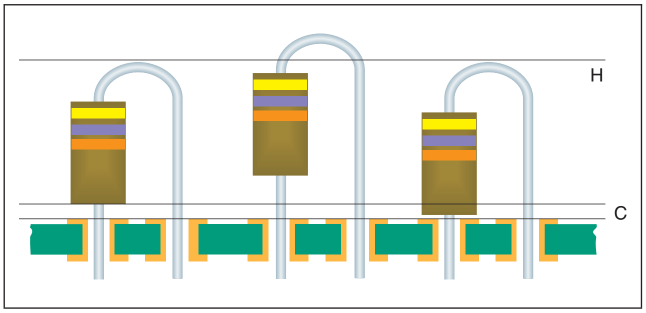

Figure 7-66
H. Design-determined dimension
C. Clearance or weld bead clearance
Note: C and H are measured from the board surface.

Defect – Class 1,2,3

- The component or weld bead clearance (C) is less than the minimum given in Table 7-2, see Figure 7-66.
- The component or weld bead clearance (C) is greater than the maximum given in Table 7-2, see Figure 7-66.
- Components violate minimum electrical clearance.
- Component height (H) does not meet form, fit or function.
- Component height (H) exceeds design-determined dimension, see Figure 7-66.

7.3.3 Supported Holes – Wire/Lead Protrusion

Lead protrusion **shall** be in accordance with Table 7-3.

Note: High frequency applications may require more precise control of lead extensions to prevent violation of functional design considerations.

Table 7-3 Protrusion of Wires/Leads in Supported Holes

	Class 1	Class 2	Class 3
(L) Min.	End is discernible in the solder, Notes 1, 3		
(L) Max., Note 2	No danger of shorts	2.5 mm [0.1 in]	1.5 mm [0.06 in]

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 discernible in the subsequent solder connection.
Note 2. 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.
Note 3. As an exception to discernible minimum lead length, see 7.3.5 Through-Hole Technology – Supported Holes – Solder.

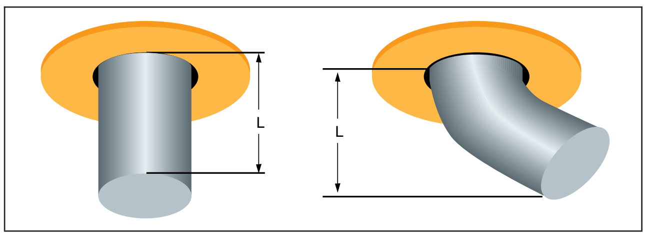

Figure 7-67

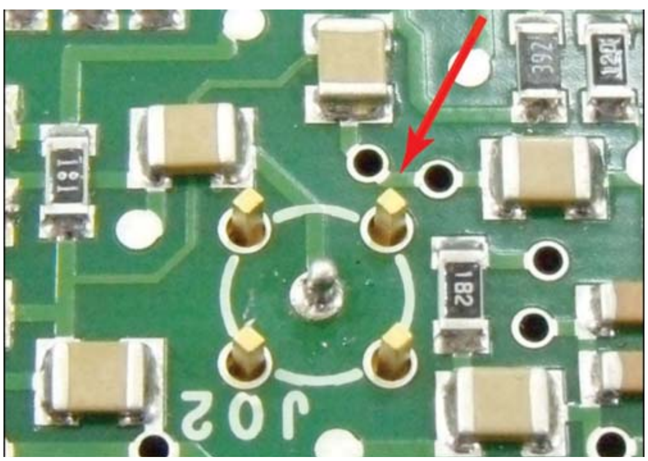

Figure 7-68

Acceptable – Class 1,2,3

- The leads protrude beyond the land within the specified minimum and maximum (L) of Table 7-3, provided there is no danger of violating minimum electrical clearance.
- The leads meet the design length (L) requirements when specified.

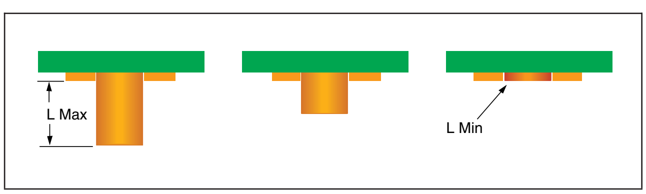

Figure 7-69

Defect – Class 1,2,3

- Lead protrusion does not meet the requirements of Table 7-3.
- Lead protrusion violates minimum electrical clearance.
- Lead protrusion exceeds maximum design height requirements.

7.3.4 Supported Holes – Wire/Lead Clinches

Component leads in through-hole connections 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. Leads greater than 1.3 mm [0.050 in] thick or diameter should not be bent nor formed for mounting purposes.

The lead meets the protrusion requirements of Table 7-3 when measured vertically from the land surface and does not violate minimum electrical clearance requirements.

This section applies to terminations with a clinching requirement. Other requirements may be specified on relevant specifications or drawings. Partially clinched leads for part retention are considered as unclinched leads and **shall** meet protrusion requirements.

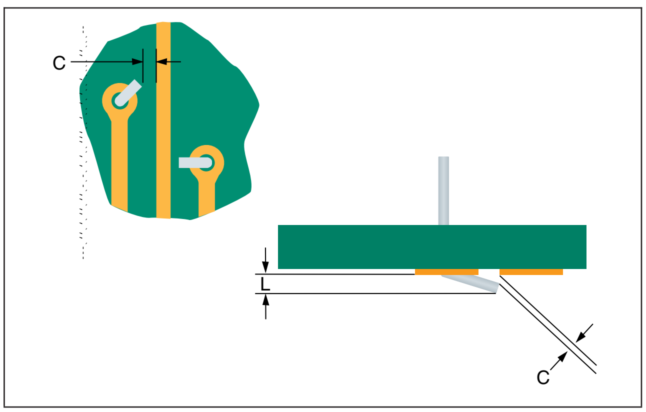

Figure 7-70

Acceptable – Class 1,2,3

- The clinched lead does not violate the minimum electrical clearance (C) between noncommon conductors.
- The protrusion (L) beyond the land is not greater than the similar length allowed for straight-through leads, see Figure 7-70 and Table 7-3.
- Tempered leads are not terminated with a full clinched configuration.

7.3.4 Supported Holes – Wire/Lead Clinches (cont.)

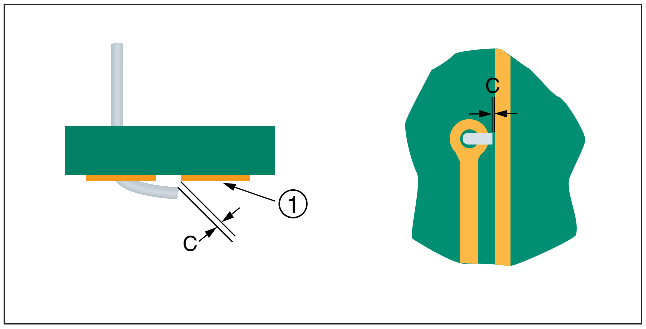

Figure 7-71
1. Noncommon conductor

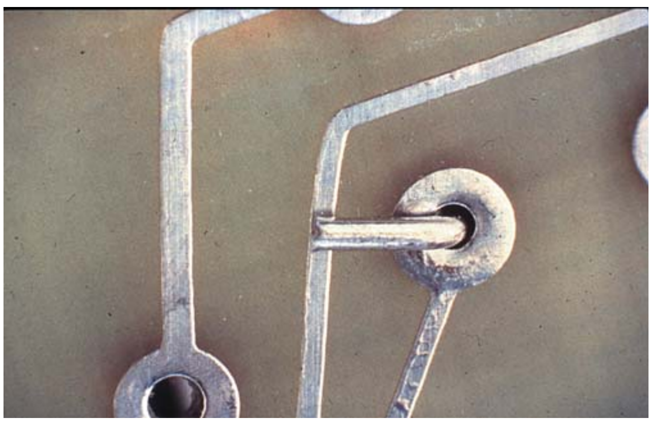

Figure 7-72

Defect – Class 1,2,3

- The lead is clinched toward an electrically noncommon conductor and violates minimum electrical clearance (C).
- Tempered leads are terminated with a full clinched configuration.

7.3.5 Supported Holes – Solder

Criteria for soldered supported holes are provided in 7.3.5.1 through 7.3.5.12. These criteria are applicable regardless of the soldering process, e.g., hand soldering, wave soldering, intrusive soldering, etc.

Figure 7-73

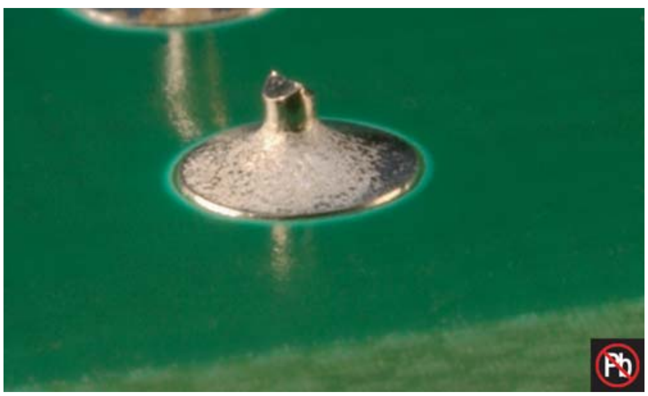

Figure 7-74

Acceptable – Class 1,2,3

- Lead is discernible in the solder.

7.3.5 Supported Holes – Solder (cont.)

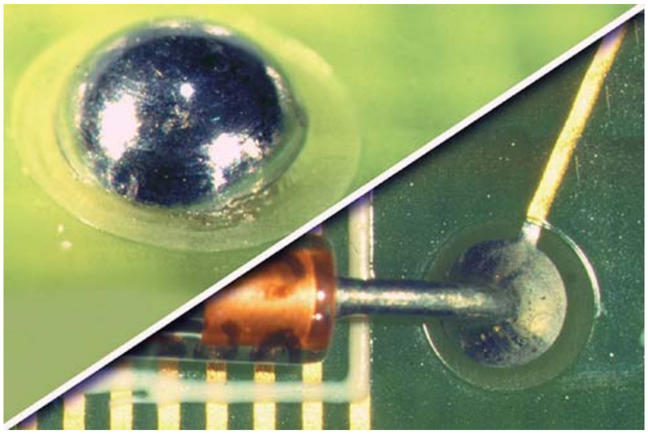

Figure 7-75

Acceptable – Class 1
Process Indicator – Class 2,3

- Fillet convex, and as an exception to Tables 7-3 and 7-4, lead not discernible due to excess solder, providing visual evidence of the lead in the hole can be determined on the primary side.

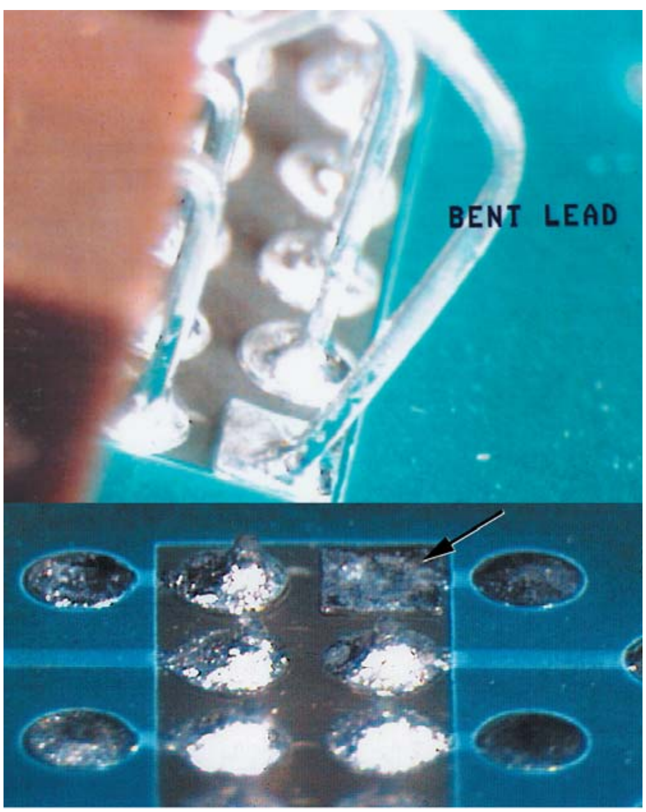

Figure 7-76

Defect – Class 1,2,3

- Lead not discernible due to bent lead.
- Solder not wetted to lead or land.
- Solder coverage does not comply with Table 7-4.

7.3.5 Supported Holes – Solder (cont.)

Table 7-4 Plated Through-Holes with Component Leads – Minimum Acceptable Solder Conditions[1]

<table>
<tr><th colspan="2">Criteria</th><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr>
<tr><td rowspan="3">A.</td><td>Vertical solder fill for components with less than 14 leads not connected to an internal thermal plane, Notes 2 and 3 (see 7.3.5.1 Through-Hole Technology – Supported Holes – Vertical Fill (A)).</td><td rowspan="3">Not Specified</td><td>75%</td><td rowspan="3">75%</td></tr>
<tr><td>Vertical solder fill for each lead that is connected to an internal thermal plane, on components with less than 14 leads, Notes 2, 3 and 4 (see 7.3.5.1 Through-Hole Technology – Supported Holes – Vertical Fill (A)).</td><td rowspan="2">50% or 1.2 mm [0.05 in], whichever is less</td></tr>
<tr><td>Vertical solder fill for components with 14 leads or more, Notes 2 and 3 (see 7.3.5.1 Through-Hole Technology – Supported Holes – Vertical Fill (A)).</td></tr>
<tr><td>B.</td><td>Circumferential wetting of lead and barrel on solder destination side (see 7.3.5.2 Through-Hole Technology – Supported Holes – Solder Destination Side – Lead to Barrel (B)).</td><td>Not Specified</td><td>180°</td><td>270°</td></tr>
<tr><td>C.</td><td>Percentage of land area covered with wetted solder on solder destination side (see 7.3.5.3 Through-Hole Technology – Supported Holes – Solder Destination Side – Land Area Coverage (C)).</td><td colspan="3">0%</td></tr>
<tr><td>D.</td><td>Circumferential wetting of lead and barrel on solder source side (see 7.3.5.4 Through-Hole Technology – Supported Holes – Solder Source Side – Lead to Barrel (D))</td><td colspan="2">270°</td><td>330°</td></tr>
<tr><td>E.</td><td>Percentage of land area covered with wetted solder on solder source side (see 7.3.5.5 Through-Hole Technology – Supported Holes – Solder Source Side – Land Area Coverage (E)).</td><td colspan="3">75%</td></tr>
</table>

Note 1. Wetted solder refers to solder applied by the solder process. For intrusive soldering there may not be an external fillet between the lead and the land.
Note 2. The unfilled height includes both source and destination side depressions.
Note 3. Less than 100% solder fill may not be acceptable in some applications, e.g., thermal shock, electrical performance. The User is responsible for identifying these situations to the Manufacturer.
Note 4. For Class 2 vertical solder fill, 50% or 1.2 mm [0.05 in], whichever is less, is allowed provided there is 360° wetting to the PTH lead and barrel wall on the solder source side.

Defect – Class 1,2,3

- Solder connections are not in compliance with Table 7-4.

7.3.5.1 Supported Holes – Solder – Vertical Fill (A)

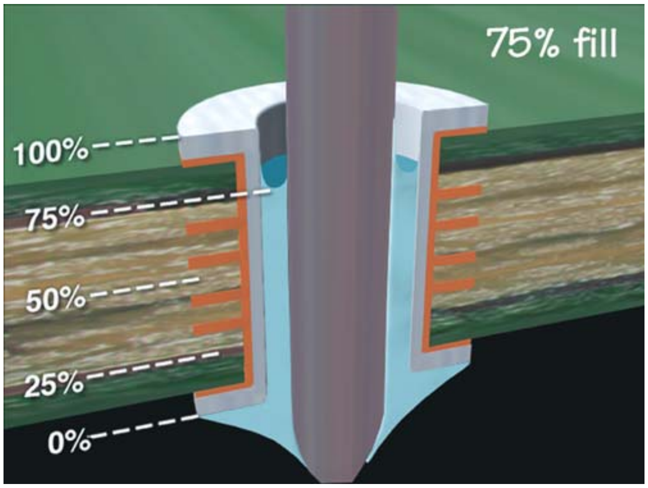

Figure 7-77

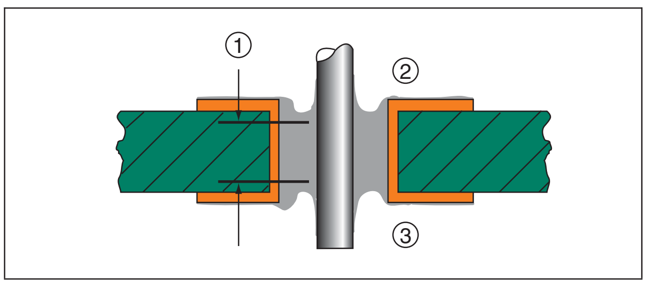

Figure 7-78
1. **Vertical fill meets requirements of Table 7-4**
2. **Solder destination side**
3. **Solder source side**

Acceptable – Class 2

- Minimum vertical fill of 50% or 1.2 mm [0.05 in], whichever is less, for components with 14 or more leads (not shown).
- Component lead is discernible in the solder source side of the solder connection.
- Minimum vertical fill of hole is 50% or 1.2 mm [0.05 in], whichever is less, for components with less than 14 leads and having an internal thermal plane providing the solder fillet of Side B of Figure 7-79 has wetted 360° of the PTH barrel wall and 360° of the lead and the surrounding PTHs meet requirements of Table 7-4.

Acceptable – Class 2,3

- Minimum 75% fill. A maximum of 25% total depression, including both solder source and solder destination sides is permitted.

Note: For Class 2, this criteria is specific to components with less than 14 leads and not having an internal thermal plane.

7.3.5.1 Supported Holes – Solder – Vertical Fill (A) (cont.)

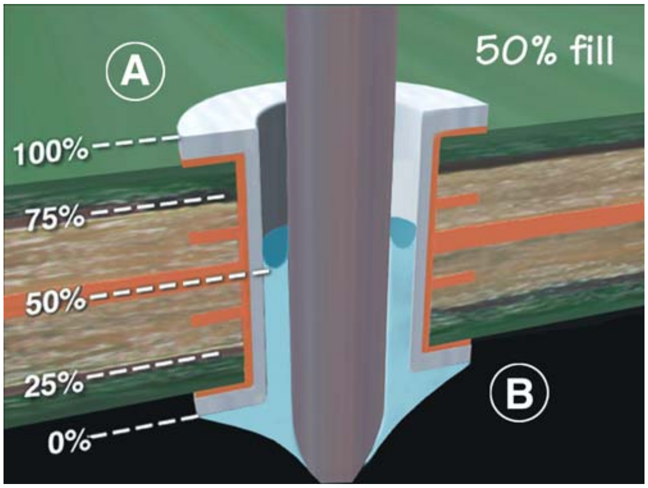

Figure 7-79

Defect – Class 2

- Vertical fill of hole is less than 75% for component with less than 14 leads and not having an internal thermal plane.
- Vertical fill of hole is less than 50% or 1.2 mm [0.05 in], whichever is less, for components with less than 14 leads and having an internal thermal plane and the solder fillet on Side B of Figure 7-79 has wetted less than 360° of the PTH barrel wall and less than 360° of the lead.
- Vertical fill of hole is less than 50% or 1.2 mm [0.05 in], whichever is less, for component with 14 leads or more.

Defect – Class 3

- Vertical fill of hole is less than 75%.

Note: Less than 100% solder fill may not be acceptable in some applications, e.g., thermal shock, electrical performance. The User is responsible for identifying these situations to the Manufacturer.

7.3.5.2 Supported Holes – Solder – Solder Destination Side – Lead to Barrel (B)

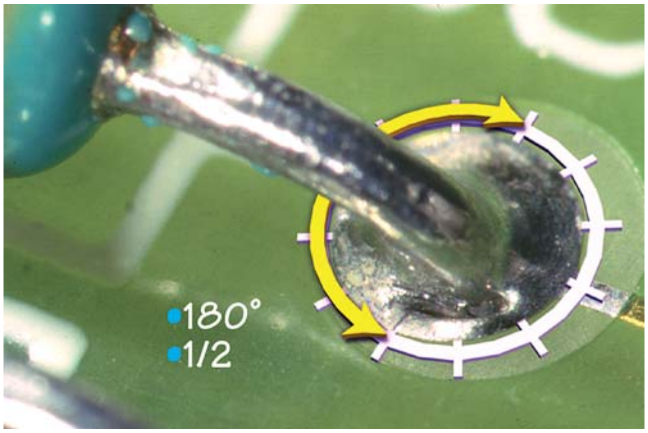

Figure 7-80

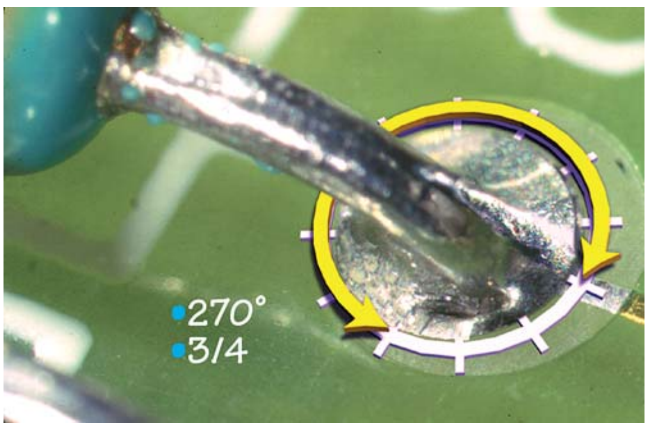

Figure 7-81

Not Established – Class 1
Acceptable – Class 2

- Minimum 180° wetting present on lead and barrel, see Figure 7-80.

Acceptable – Class 3

- Minimum 270° wetting present on lead and barrel, see Figure 7-81.

7.3.5.2 Supported Holes – Solder – Solder Destination Side – Lead to Barrel (B) (cont.)

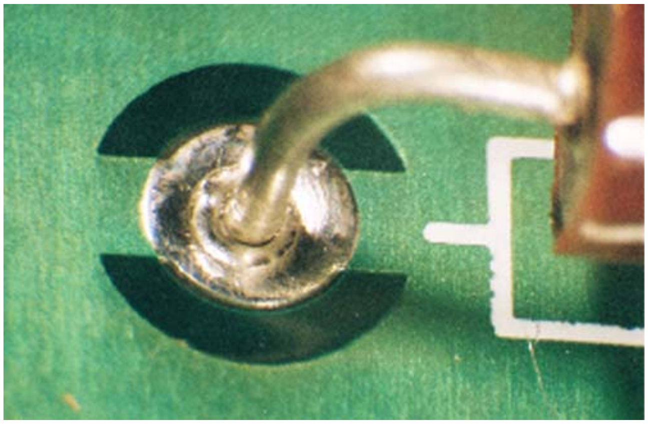

Figure 7-82

Figure 7-83

Defect – Class 2

- Less than 180° wetting on lead or barrel.

Defect – Class 3

- Less than 270° wetting on lead or barrel.

7.3.5.3 Supported Holes – Solder – Solder Destination Side – Land Area Coverage (C)

Figure 7-84

Acceptable – Class 1,2,3

- The land area does not need to be wetted with solder on the solder destination side.

7.3.5.4 Supported Holes – Solder – Solder Source Side – Lead to Barrel (D)

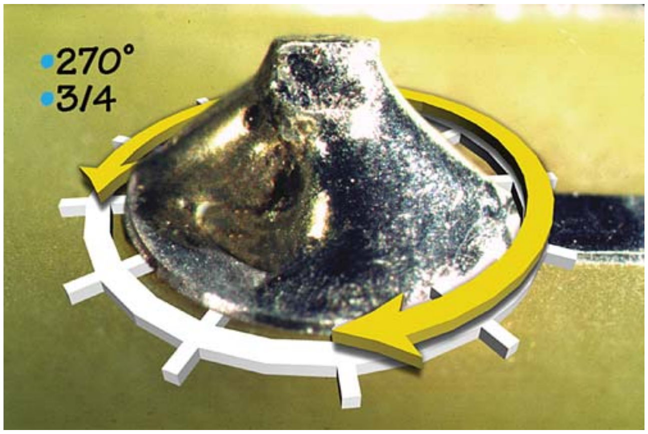

Figure 7-85

Acceptable – Class 1,2

- Minimum 270° fillet and wetting (lead, barrel).

Acceptable – Class 3

- Minimum 330° fillet and wetting (lead, barrel), not shown.

Figure 7-86

Defect – Class 1,2,3

- Does not meet requirements of Table 7-4.

7.3.5.5 Supported Holes – Solder – Solder Source Side – Land Area Coverage (E)

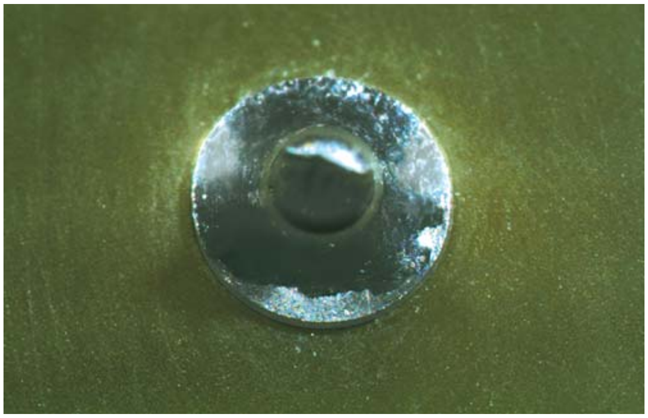

Figure 7-87

Acceptable – Class 1,2,3

- Minimum 75% of land area covered with wetted solder on the solder source side, see Figure 7-87.

Defect – Class 1,2,3

- Does not meet requirements of Table 7-4.

7.3.5.6 Supported Holes – Solder Conditions – Solder in Lead Bend

Solder in the bend radius is not cause for rejection provided the lead is properly formed and the topside bend radius is discernible.

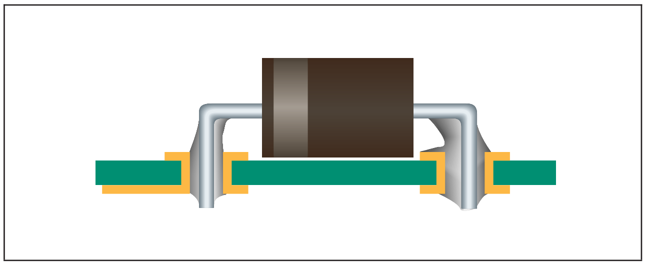

Figure 7-88

Acceptable – Class 1,2,3

- Solder in lead bend area does not contact the component body.
- Solder does not obscure the stress relief bend of through-hole components.

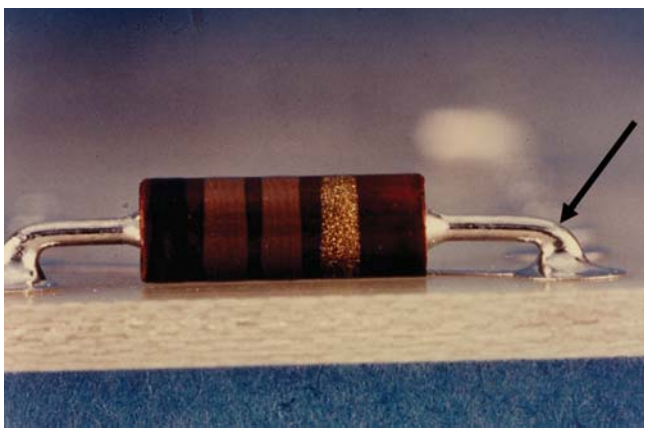

Figure 7-89

Defect – Class 1,2,3

- Solder in lead bend area contacts the component body.
- Solder that obscures the stress relief bend of through-hole components, see Figure 7-89.

7.3.5.7 Supported Holes – Solder Conditions – Touching Through-Hole Component Body

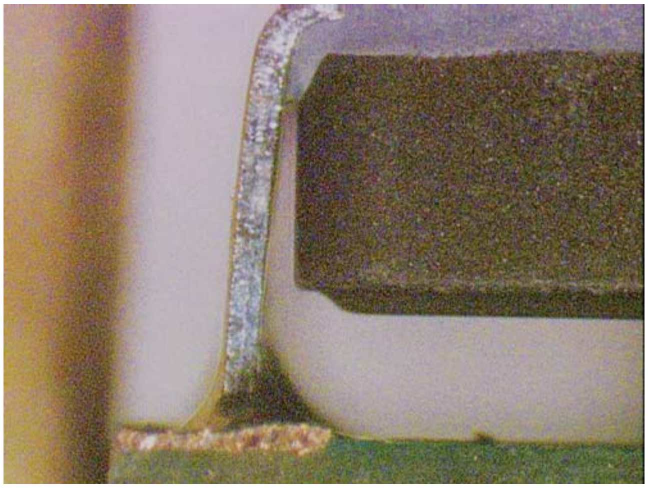

Figure 7-90

Acceptable – Class 1,2,3

- Solder does not touch the component body or end seal.

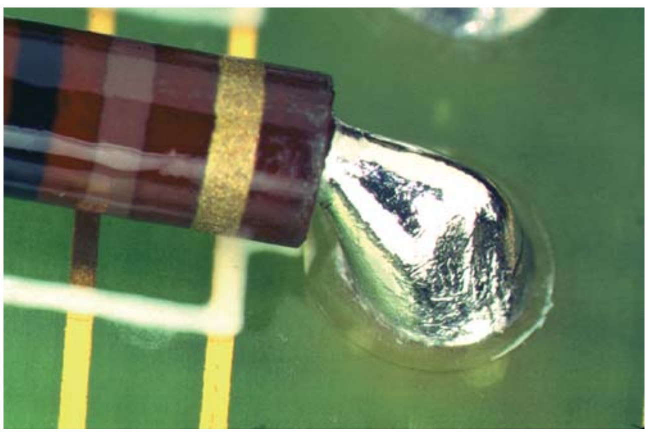

Figure 7-91

Defect – Class 1,2,3

- Solder contacts the component body or end seal. Exception, see 7.3.5.8 Through-Hole Technology – Supported Holes – Solder Conditions – Meniscus in Solder.
- Solder obscures the stress relief bend.

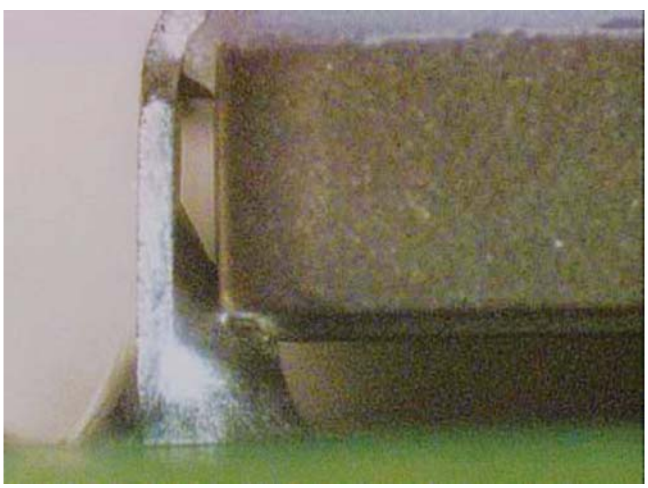

Figure 7-92

7.3.5.8 Supported Holes – Solder Conditions – Meniscus in Solder

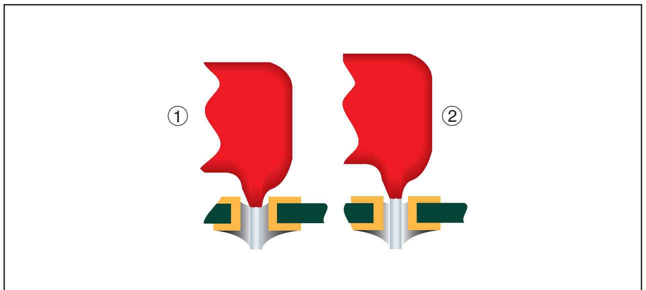

Figure 7-93

1. Coating meniscus embedded in solder.
2. Coating meniscus in plated through-hole but not in solder.

Acceptable – Class 1,2,3

- Coating meniscus is not embedded in the solder and the solder connections meet the requirements of Table 7-4.

Acceptable – Class 1,2

- Components with a coating meniscus can be mounted with the meniscus into the solder provided, see Figure 7-93-1:
  - 360° wetting lead to land on the solder source side.
  - Lead coating meniscus is not discernible within the connection on the solder source side.

Process Indicator – Class 2,3

- Coating meniscus is in the plated through-hole but not embedded in the solder joint, see Figure 7-93-2.

Defect – Class 3

- Coating meniscus is embedded in the solder connection, see Figure 7-93-1.
- Does not meet requirements of Table 7-4.

7.3.5.8 Supported Holes – Solder Conditions – Meniscus in Solder (cont.)

Figure 7-94

Defect – Class 1,2

- The meniscus is discernible in the solder on the solder source side.
- When components are mounted with coating meniscus into the solder, do not exhibit 360° wetting on solder source side.

7.3.5.9 Supported Holes – Lead Cutting after Soldering

The following criteria apply to assemblies where the connections have been trimmed after soldering. Leads may be trimmed after soldering provided the cutters do not damage the component or solder connection due to physical shock. For Classes 2 and 3, when lead cutting is performed after soldering, the solder terminations **shall** be visually inspected at 10X to ensure that the original solder connection has not been damaged, i.e., fractured or deformed. As an alternative to visual inspection, the solder connections may be reflowed. If the solder connection is reflowed this is considered part of the soldering process and is not to be considered rework. This requirement is not intended to apply to components that are designed such that a portion of the lead is intended to be removed after soldering, i.e., break away tie bars.

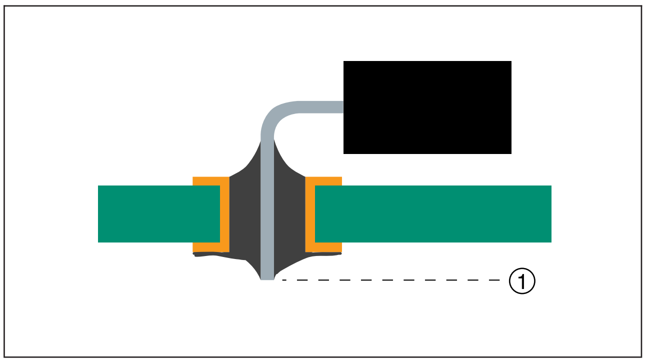

Figure 7-95
1. Lead protrusion

Acceptable – Class 1,2,3

- No fractures between lead and solder.
- Lead protrusion within specification, see 7.3.3 Through-Hole Technology – Supported Holes – Wire/Lead Protrustion.

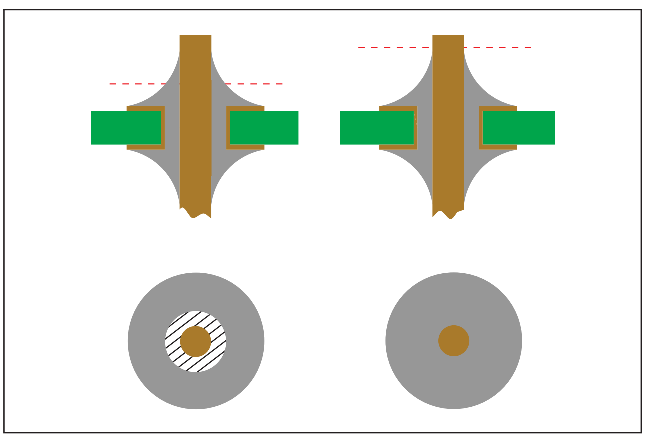

Figure 7-96

Defect – Class 1,2,3

- Evidence of fracture between lead and solder fillet.

Defect – Class 3

- Lead trimming that cuts into the solder fillet and is not reflowed.

7.3.5.10 Supported Holes – Coated Wire Insulation in Solder

These requirements apply when the solder connection meets the minimum requirements of Table 7-4. See 6.2.2 Terminal Connections – Insulation – Clearance for extruded insulation clearance requirements.

Figure 7-97

Acceptable – Class 1,2,3

- Coating is entering solder connection on primary side and meets minimum requirements of Table 7-4.

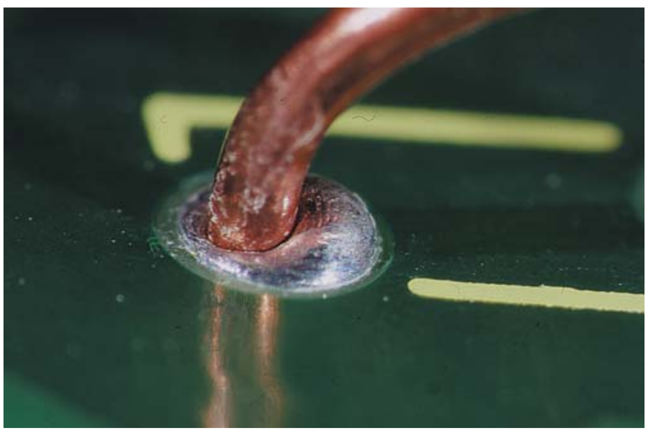

Figure 7-98

Defect – Class 1,2,3

- Solder connection exhibits poor wetting and does not meet the minimum requirements of Table 7-4.
- Coating is discernible on secondary side.

7.3.5.11 Supported Holes – Interfacial Connection without Lead – Vias

Supported holes used for interfacial connection not exposed to solder because of permanent or temporary masks need not be filled with solder. Supported holes or vias without leads, after exposure to wave, dip or drag soldering equipment are to meet these acceptability requirements.

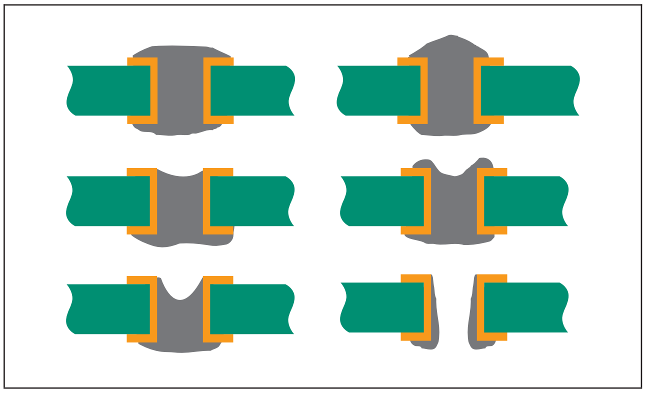

Figure 7-99

Acceptable – Class 1,2,3

- Sides of holes are wetted with solder.

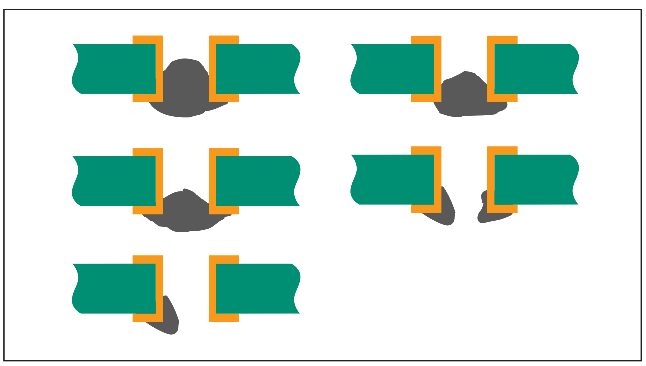

Figure 7-100

Acceptable – Class 1
Process Indicator – Class 2,3

- Solder has not wetted side of holes.

Note: There is no defect condition for this.

Note: Solder capped PTHs have the possibility of entrapping contaminants that are difficult to remove if cleaning is required.

7.3.5.12 Supported Holes – Board in Board

No board in board criteria have been established for Class 3 assemblies.

From IPC-T-50: ''Daughterboard – An assembly that is fastened and electrically connected to a motherboard or backplane.''

When required, attachment will include additional mechanical support aids, e.g., adhesives or hardware, to ensure the connections will not be damaged in the intended service environment.

Table 7-5 Board in Board – Minimum Acceptable Solder Conditions[1]

Criteria	Class 1	Class 2
Vertical fill of solder, Note 2	75%	
Fillet and wetting solder connection width on primary side (solder destination side) of assembly (motherboard) to lands on both sides of daughterboard.	50%	75%
Percentage of land area on assembly (motherboard) covered with wetted solder on primary side (solder destination side).	0%	
Fillet and wetting solder connection width on secondary side (solder source side) of assembly (motherboard) to lands on both sides of daughterboard.	50%	75%
Percentage of land area on assembly (motherboard) covered with wetted solder on secondary side (solder source side)	75%	

Note 1. Wetted solder refers to solder applied by the solder process.
Note 2. The 25% unfilled height includes both source and destination side depressions.

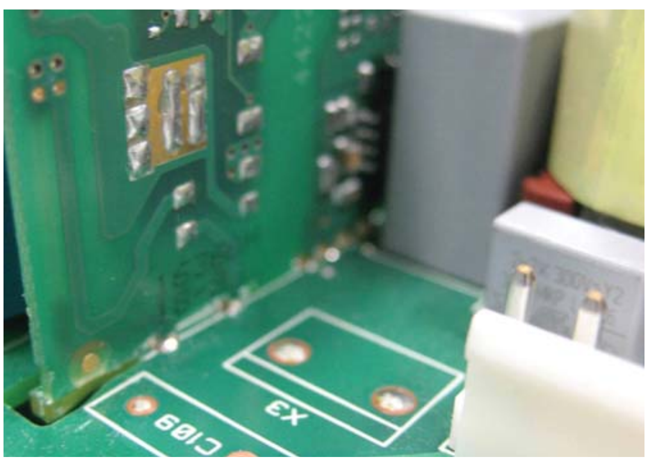

Figure 7-101

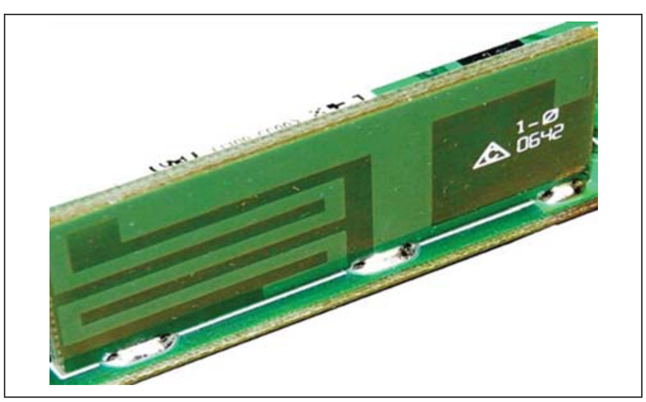

Figure 7-102

Acceptable – Class 1,2

- Daughterboard is mounted perpendicular to assembly.
- Daughterboard is flush to assembly.
- Mechanical constraints, if required, are properly attached.
- Vertical fill of solder is 75%.

7.3.5.12 Supported Holes – Board in Board (cont.)

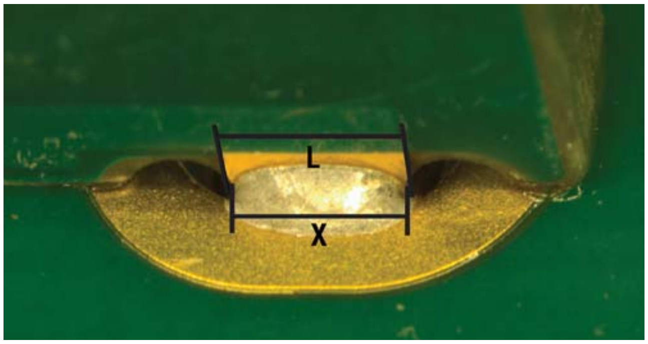

Figure 7-103

Acceptable – Class 1

- Solder is wetted a minimum of 50% width (X) of each of the sides of the daughterboard lands (L) to assembly on secondary side (solder source side).
- Solder is wetted a minimum of 50% width (X) of each of the sides of the daughterboard land (L) to assembly on primary side (solder destination side).

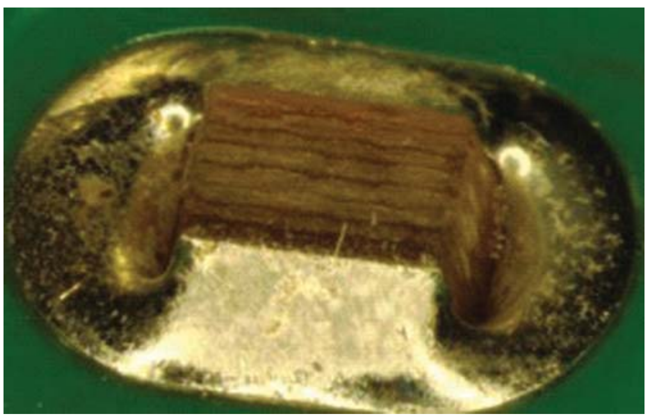

Figure 7-104

Figure 7-105

Acceptable – Class 2

- Solder is wetted a minimum of 75% width (X) of each of the sides of the daughterboard land (L) to assembly on secondary side (solder source side).
- Solder is wetted a minimum of 75% width (X) of each of the sides of the daughterboard land (L) to assembly on primary side (solder destination side).

7.3.5.12 Supported Holes – Board in Board (cont.)

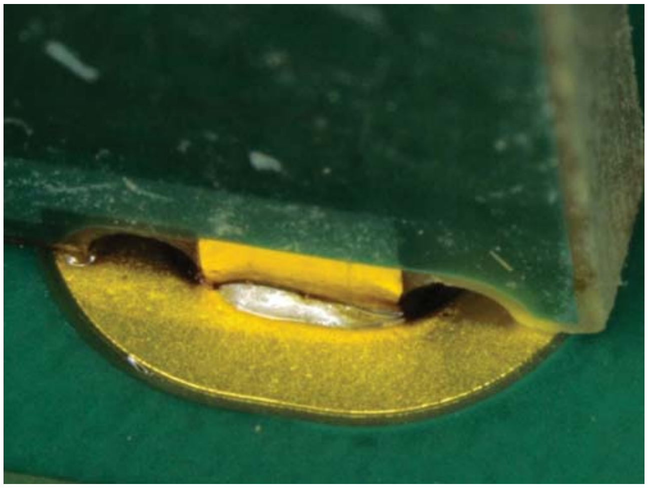

Figure 7-106

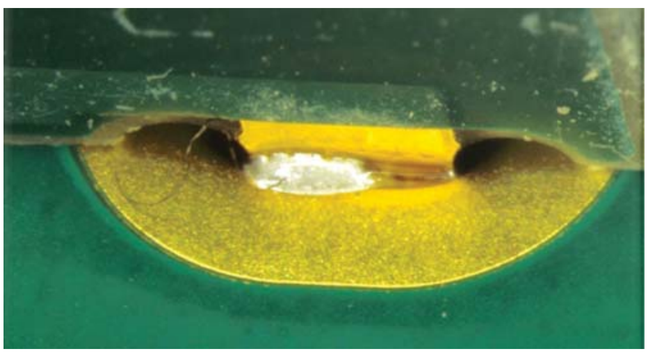

Figure 7-107

Defect – Class 1,2

- Daughterboard angle stresses mounting through-hole tabs.
- Required mechanical constraints not present or not properly attached.
- Vertical fill of solder is less than 75%.
- Solder not wetted to each of the sides of daughterboard lands or assembly land.

Defect – Class 1

- Solder is wetted less than 50% width (X) of both sides of the daughterboard land (L) to assembly on secondary side (solder source side).
- Solder is wetted less than 50% width (X) of each of the sides of the daughterboard land (L) to assembly on primary side (solder destination side).

Defect – Class 2

- Solder is wetted less than 75% width (X) of each of the sides of the daughterboard land (L) to assembly on secondary side (solder source side).
- Solder is wetted less than 75% width (X) of each of the sides of the daughterboard land (L) to assembly on primary side (solder destination side).

7.4 Unsupported Holes

7.4.1 Unsupported Holes – Axial Leads – Horizontal

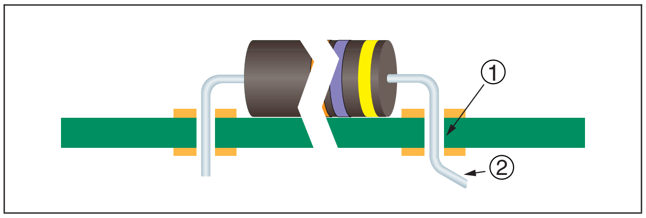

Figure 7-108
1. No plating in barrel.
2. Clinch required for Class 3, see 7.4.4 Through-Hole Technology – Unsupported Holes – Wire/Lead Clinches.

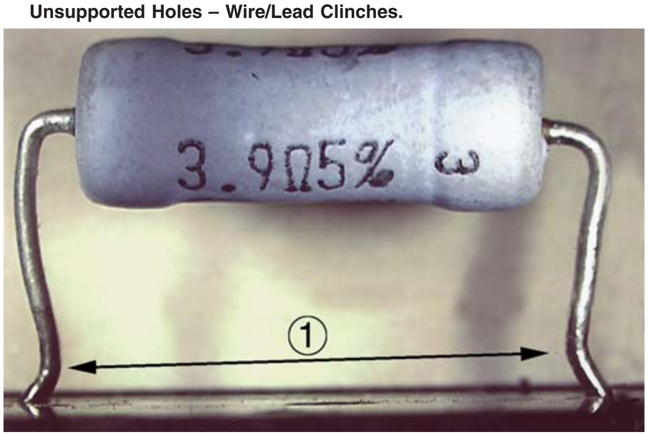

Figure 7-109
1. Lead form

Acceptable – Class 1,2,3

- Components required to be mounted off the board are at minimum 1.5 mm [0.06 in] from the board surface, e.g., high heat dissipating.
- Components required to be mounted off the board are provided with lead forms at the board surface or other mechanical support to prevent lifting of solder land.

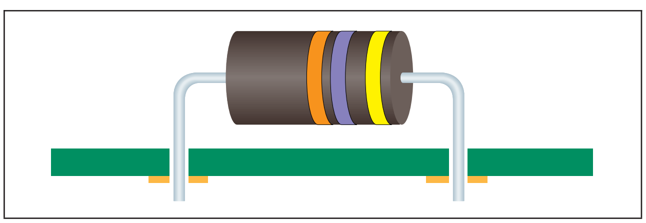

Figure 7-110

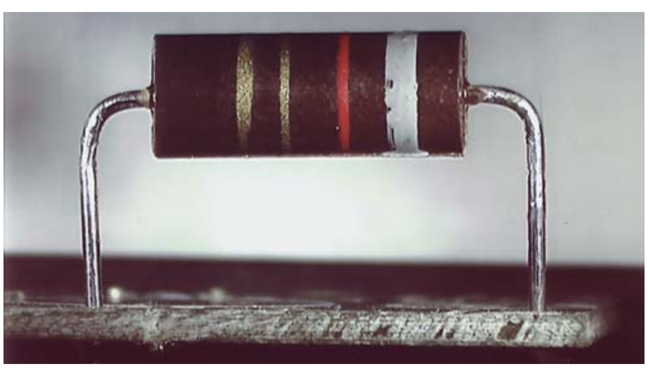

Figure 7-111

Defect – Class 1,2,3

- Components required to be mounted off the board are not provided with lead forms at the board surface or other mechanical support to prevent lifting of solder land.
- Components required to be mounted above the board surface are less than 1.5 mm [0.06 in].
- Component height exceeds design-determined dimension.

7.4.2 Unsupported Holes – Axial Leads – Vertical

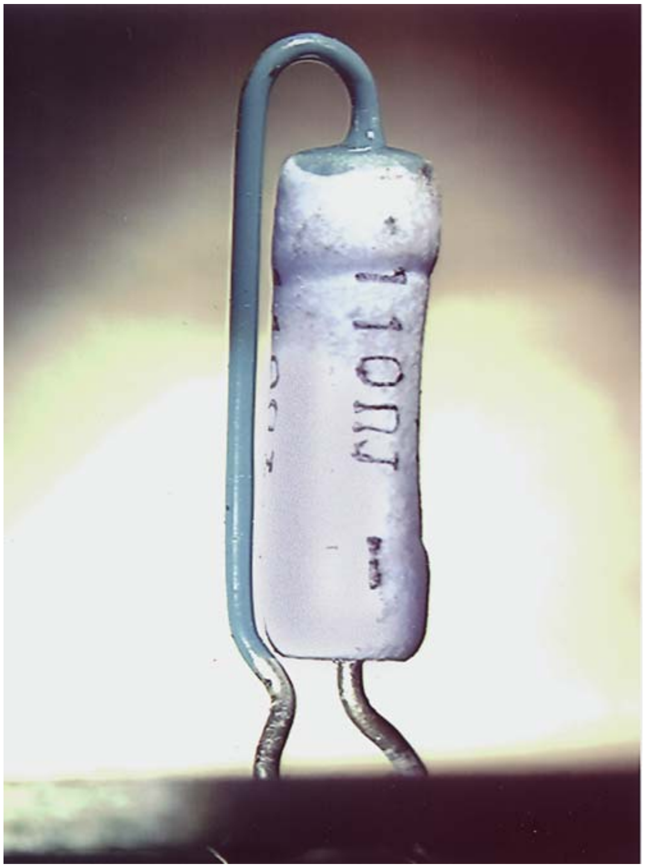

Figure 7-112

Acceptable – Class 1,2,3

- Components that are mounted above the board surface in unsupported holes are provided with lead forms or other mechanical support to prevent lifting of solder land.

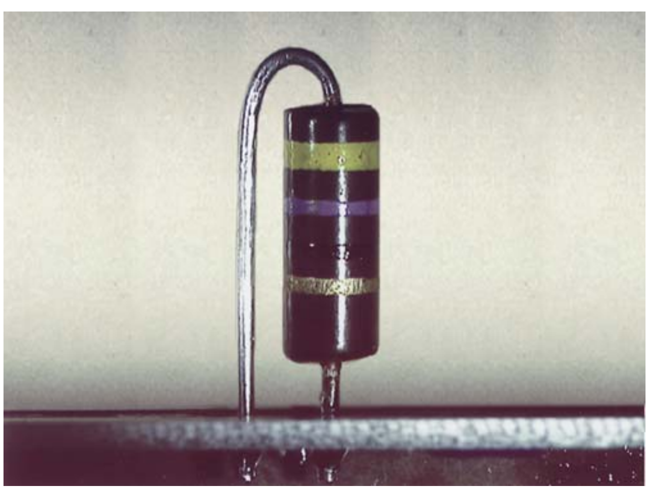

Figure 7-113

Defect – Class 1,2,3

- Components mounted above the board in unsupported holes are mounted without lead form at the board surface or other mechanical support.

7.4.3 Unsupported Holes – Wire/Lead Protrusion

Note: High frequency applications may require more precise control of lead extensions to prevent violation of functional design considerations.

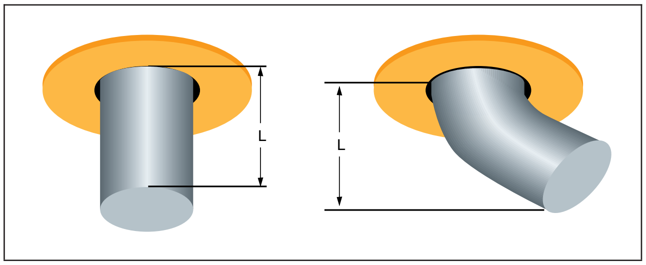

Figure 7-114

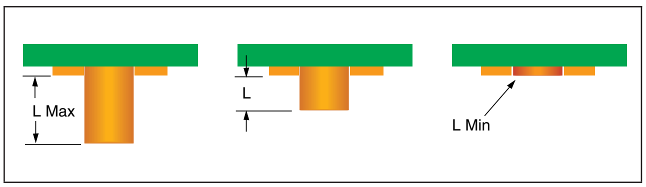

Figure 7-115

Acceptable – Class 1,2,3

- The leads protrude beyond the land within the specified minimum and maximum (L) of Table 7-6, provided there is no danger of violating minimum electrical clearance.

Table 7-6 Protrusion of Leads in Unsupported Holes

	Class 1	Class 2	Class 3
(L) Min.	End is discernible in solder		Sufficient to clinch
(L) Max.[1]	Does not violate minimum electrical clearance		

Note 1. Lead protrusion should not exceed 2.5 mm [0.1 in] if there is a possibility of violation of minimum electrical clearance or damage to soldered connections due to lead deflection.

Defect – Class 1,2,3

- Lead protrusion does not meet Table 7-6 requirements.
- Lead protrusion violates minimum electrical clearance.
- Lead protrusion exceeds maximum design height requirements.

7.4.4 Unsupported Holes – Wire/Lead Clinches

This section applies to terminations with a clinching requirement. Other requirements may be specified on relevant specifications or drawings. Partially clinched leads for part retention are considered as unclenched leads and need to meet protrusion requirements.

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. Tempered leads and leads greater than 1.3 mm [0.05 in] should not be bent nor formed for mounting purposes.

The lead meets the requirements of Table 7-6 when measured vertically from the land surface and does not violate minimum electrical clearance requirements.

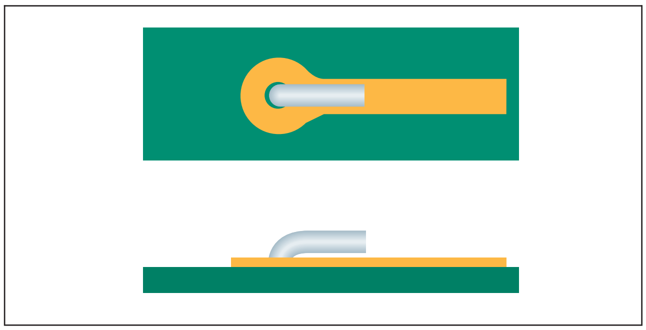

Figure 7-116

7.4.4 Unsupported Holes – Wire/Lead Clinches (cont.)

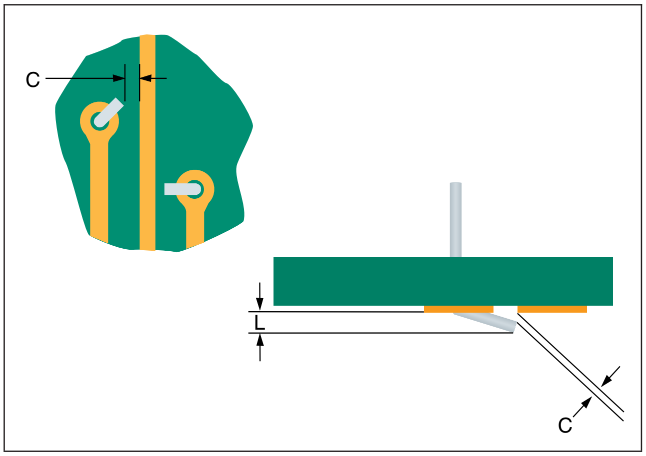

Figure 7-117

Acceptable – Class 1,2,3

- The clinched lead does not violate the minimum electrical clearance (C) between noncommon conductors.
- The protrusion (L) beyond the land is not greater than the similar length allowed for straight-through leads.
- The leads protrude beyond the land within the specified minimum and maximum (L) of Table 7-6, provided there is no violation of minimum electrical clearance.
- Tempered leads are not terminated with a full clinched configuration.

Acceptable – Class 3

- Lead in unsupported hole is clinched a minimum of 45°.

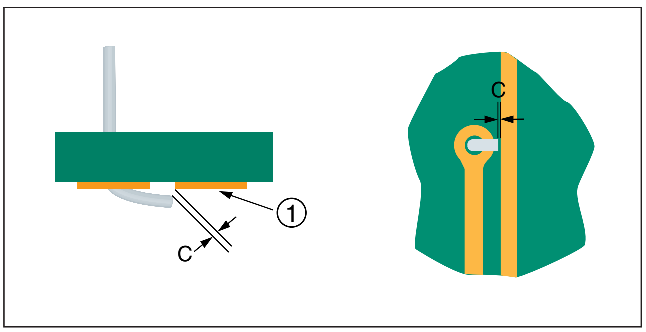

Figure 7-118
1. Noncommon conductor

Defect – Class 1,2,3

- The lead is clinched toward an electrically noncommon conductor and violates minimum electrical clearance (C).
- Lead protrusion is insufficient for clinch, if required.
- Tempered leads are terminated with a full clinched configuration.

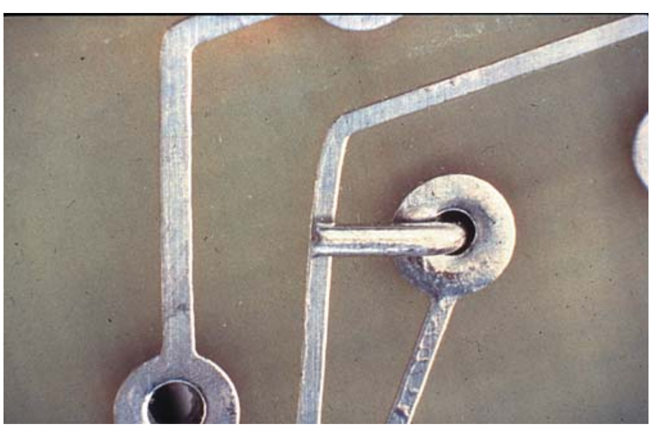

Figure 7-119

Defect – Class 3

- Lead in unsupported hole is not clinched a minimum of 45° (not shown).

7.4.4 Unsupported Holes – Wire/Lead Clinches (cont.)

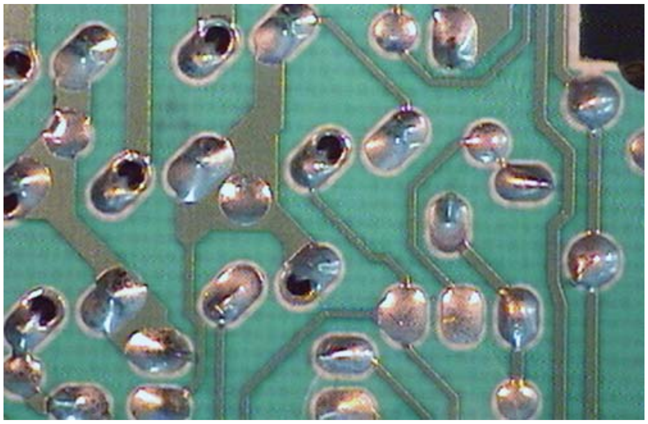

Figure 7-120

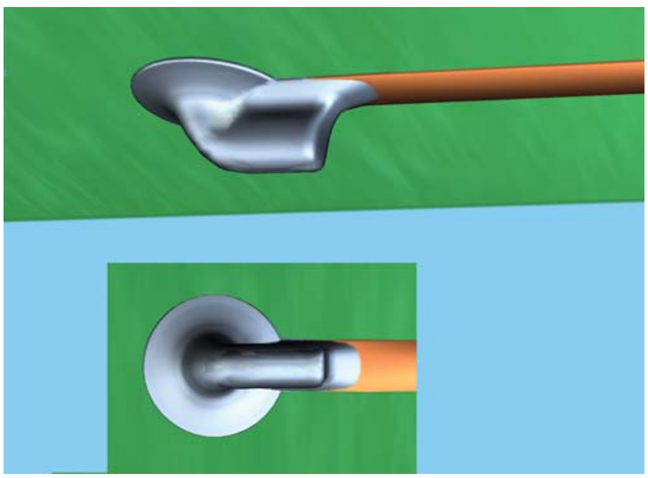

Figure 7-121

Table 7-7 Unsupported Holes with Component Leads, Minimum Acceptable Conditions[1,4]

Criteria	Class 1	Class 2	Class 3
A. Fillet wetted to lead and land	270°		330°, Note 2
B. Percentage of land area covered with wetted solder, Note 3	75%		

Note 1. A and B are applicable to both sides of double-sided boards with functional lands on both sides.
Note 2. For Class 3, lead is wetted in the clinched area.
Note 3. Solder is not required to cap or cover the hole.
Note 4. Wetted solder refers to solder applied by the solder process.

7.4.5 Unsupported Holes – Solder

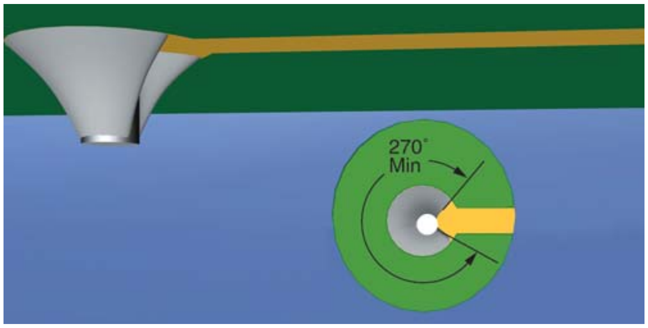

Figure 7-122

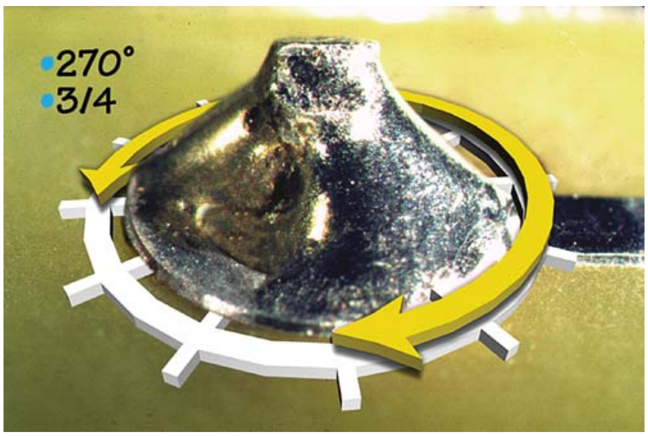

Figure 7-123

Acceptable – Class 1,2

- Solder coverage meets requirements of Table 7-7.

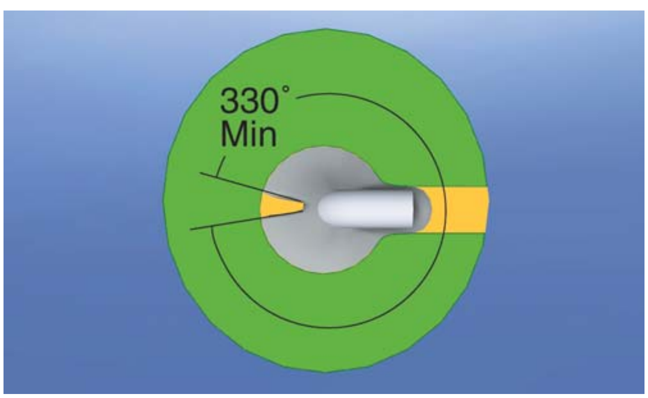

Figure 7-124

Acceptable – Class 3

- Lead is wetted in the clinched area.
- Minimum of 330° fillet and wetting.

Acceptable – Class 1,2,3

- Minimum 75% of land area covered with wetted solder on the secondary side (not shown).

7.4.5 Unsupported Holes – Solder (cont.)

Figure 7-125

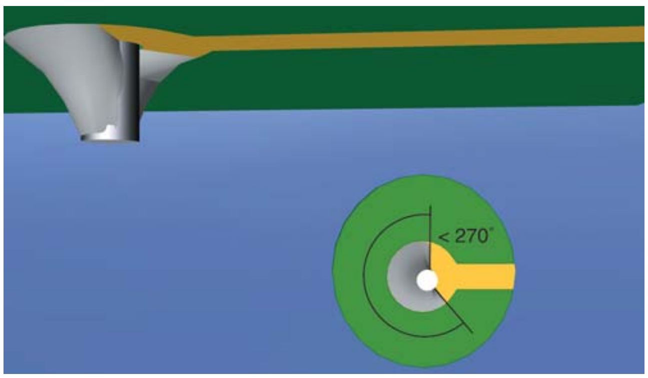

Figure 7-126

Defect – Class 1,2

- Less than 75% land coverage.
- Solder connection of straight through termination does not meet minimum of 270° circumferential fillet or wetting.

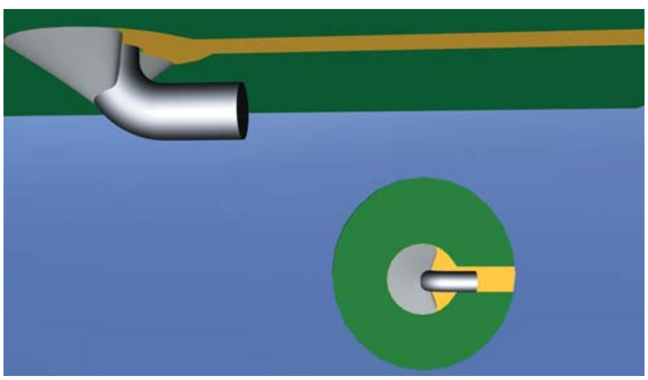

Figure 7-127

Defect – Class 3

- Solder connection does not meet 330° circumferential fillet or wetting.
- Lead not clinched (not shown).
- Lead not wetted in clinched area.
- Less than 75% land coverage.

Figure 7-128

Defect – Class 1,2,3

- Lead not discernible due to excess solder.

7.4.6 Unsupported Holes – Lead Cutting after Soldering

The criteria in 7.3.5.9 are also applicable to solder connections in unsupported holes.

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8 Surface Mount Assemblies

This section covers acceptability requirements for the fabrication of surface mount assemblies.

In addition to the criteria in this section the criteria of 5 Soldering are applicable.

The following topics are addressed in this section.

8 Surface Mount Assemblies (cont.)

8.1 Staking Adhesive

8.1.1 Staking Adhesive – Component Bonding

These criteria are for adhesive added before component soldering.

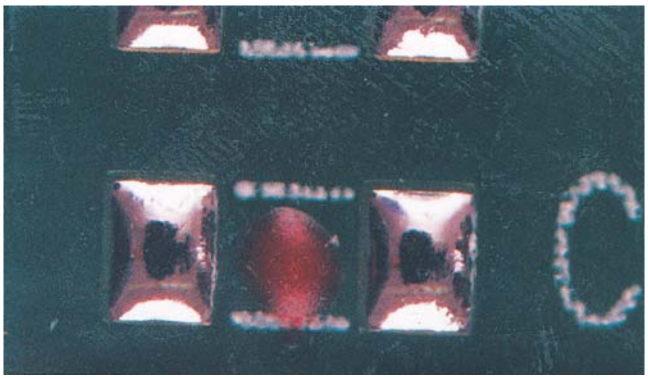

Figure 8-1

Acceptable – Class 1,2,3

- No adhesive present on solderable surfaces of the termination area.

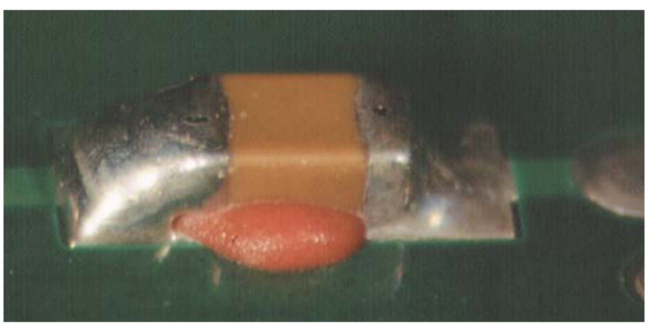

Figure 8-2

Acceptable – Class 1
Process Indicator – Class 2

- Adhesive material extending from under the component is visible in the termination area, but end joint width meets minimum requirements.

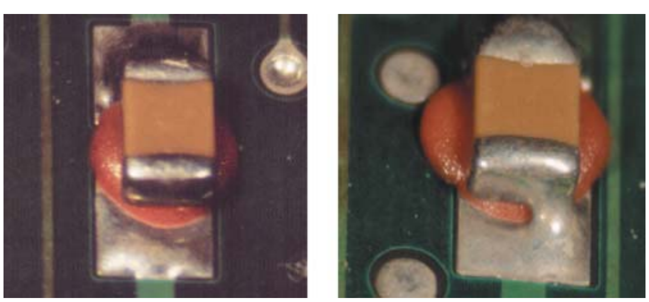

Figure 8-3

Defect – Class 1,2

- Adhesive material is visible in the termination area and the solder connection does not meet minimum requirements.

Defect – Class 3

- Adhesive materials extending from under the component are visible in the termination area.

8.1.2 Staking Adhesive – Mechanical Strength

These criteria are for adhesive added after component soldering.

Note: The circumference bonding may have one or more adhesive points.

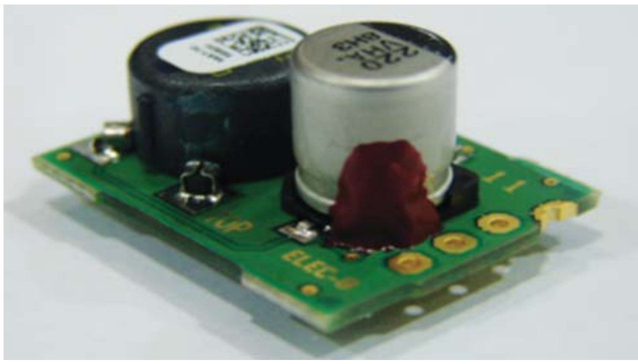

Figure 8-4

Acceptable – Class 1,2,3

- On round components adhesive adheres to a minimum 25% of the component height.
- On round components a minimum of three beads of staking material placed approximately evenly around the periphery of the component.
- Rectangular components are staked at each corner a minimum 25% of the height of the component body.
- Adhesion to mounting surfaces is evident.
- Staking is completely cured and homogenous.
- Staking does not interfere with stress relief.
- Slight flow under the component body does not damage the components or affect form, fit and function.

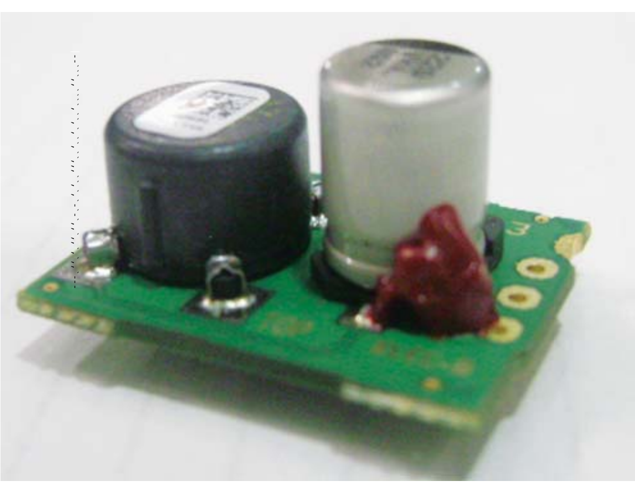

Figure 8-5

Acceptable – Class 1
Process Indicator – Class 2,3

- Adhesive on lands or conductive patterns does not interfere with the formation of solder connection.

8.1.2 Staking Adhesive – Mechanical Strength (cont.)

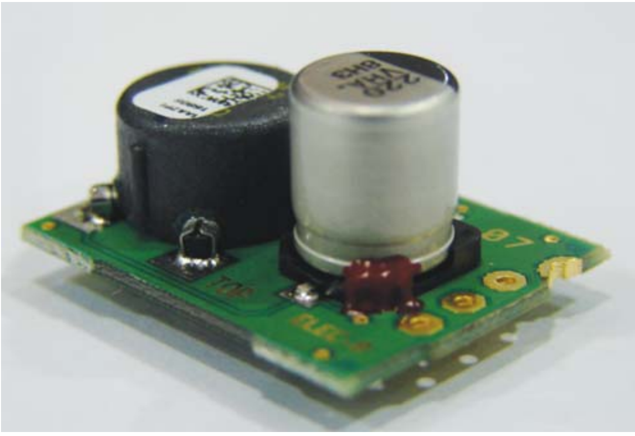

Figure 8-6

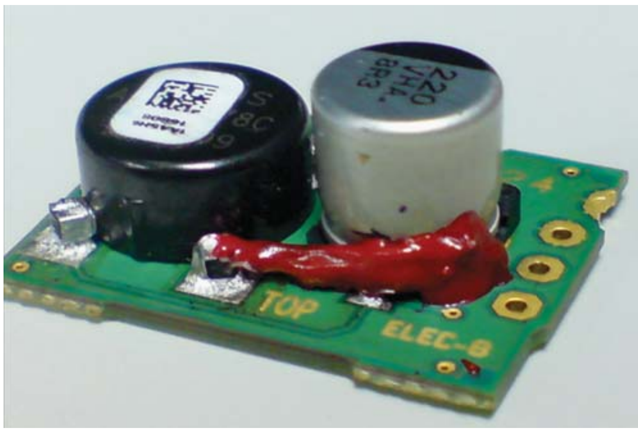

Figure 8-7

Not Established – Class 1
Defect – Class 2,3

- Round components where adhesive adheres to less than 25% of the component height.
- On round components there are less than three beads of staking material.
- Rectangular components are not staked at each corner a minimum 25% of the height of the component body.

Defect – Class 1,2,3

- No evidence of adhesion to mounting surfaces.
- Adhesive is not completely cured and homogenous.
- Adhesive interferes with stress relief.

8.2 SMT Leads

8.2.1 SMT Leads – Plastic Components

In the following criteria, the words ''plastic component'' are used in the generic sense to differentiate between plastic components and those made of other materials, e.g., ceramic/alumina or metal (normally hermetically sealed).

Unless otherwise specified, solder **shall not** touch a package body or end seal. Exceptions are when a copper lead or termination configuration causes the solder fillet to contact a plastic component body, such as:

- Plastic SOIC family (small outline packages such as SOT, SOD).
- Space from the top of the lead to the bottom of a plastic component is 0.15 mm [0.006 in] or less.
- Connectors, provided solder does not go into the cavity.
- Wrapped terminals, see 8.3.19 Surface Mount Assemblies – Wrapped Terminals.
- Leadless components where the designed land extends past the component termination area.
- When agreed between Manufacturer and User.

8.2.2 SMT Leads – Damage

These criteria are applicable whether leads are formed manually or by machine or die.

Acceptable – Class 1,2,3

- No nicks or deformation exceeding 10% of the diameter, width or thickness of the lead. See 5.2.1 Soldering – Soldering Anomalies – Exposed Basis Metal for exposed basis metal criteria.

Defect – Class 1,2,3

- Lead is damaged or deformed more than 10% of the diameter, width or thickness of the lead.
- Lead is deformed from repeated or careless bending.
- Heavy indentations such as serrated pliers mark.

8.2.3 SMT Leads – Flattening

Components with axial leads of round cross-section may be flattened (coined) for positive seating in surface mounting. Intentionally flattened areas of leads are excluded from the 10% deformation requirement of 8.2.2 Surface Mount Assemblies – SMT Leads – Damage.

Acceptable – Class 1,2
Defect – Class 3

- The thickness of the flattened lead is less than 40% of the original diameter.

8.3 SMT Connections

SMT connection criteria are provided in 8.3.1 through 8.3.16, as appropriate.

Some dimensions, e.g., solder thickness, are not inspectable conditions and are identified by notes.

Dimension (G) is the solder fillet from the top of the land to the bottom of the termination. Dimension (G) is the prime parameter in the determination of solder connection reliability for leadless components. A thick (G) is desirable. Additional information related to reliability of surface mount connections is available in IPC-D-279, IPC-SM-785 and IPC-9701.

Designs with via in land may preclude meeting fillet height criteria. Solder acceptance criteria should be defined between the Manufacturer and User.

Components with surfaces and/or termination ends or sides that are not wettable by design are exempt from solder wetting requirements in those areas. Solder fillet wetting to the sides or ends of the leads is not required unless specifically stated.

Solder fillet may extend through the top bend. Solder should not extend under the body of surface mount components whose leads are made of Alloy 42 or similar metals.

Some components cannot be tilted due to mating requirements with enclosures or panels, for example toggle switches, potentiometers, LCDs, and LEDs. Such restrictions should be identified in drawings.

For components with multiple termination types, e.g., TO-252 (D-Pak), each termination type **shall** meet the requirements of its applicable individual termination type.

8.3 SMT Connections (cont.)

Acceptable – Class 1,2,3

- Component tilted/raised does not:
  - Violate minimum electrical clearance.
  - Exceed maximum component height requirements.
  - Affect form, fit or function.

Defect – Class 1,2,3

- Component tilted/raised:
  - Violates minimum electrical clearance.
  - Exceeds maximum component height requirements.
  - Affects form, fit or function.

8.3.1 Chip Components – Bottom Only Terminations

Connections formed to chip components with bottom only terminations **shall** meet dimensional and solder fillet requirements in Table 8-1 and 8.3.1.1 through 8.3.1.8. The widths of the component termination and land are (W) and (P), respectively, and the termination overhang describes the condition where the smaller extends beyond the larger termination, i.e., W or P. The length of the component termination is (R) and the length of the land is (S).

Criteria for tall profile components with bottom only terminations are in 8.3.10 Surface Mount Assemblies – Tall Profile Components Having Bottom Only Terminations.

Table 8-1 Dimensional Criteria – Chip Component – Bottom Only Termination Features

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W) or 50% (P), whichever is less, Note 1		25% (W) or 25% (P), whichever is less, Note 1
End Overhang	B	Not permitted		
Minimum End Joint Width	C	50% (W) or 50% (P), whichever is less, Note 4		75% (W) or 75% (P), whichever is less, Note 4
Minimum Side Joint Length	D	Note 3		
Maximum Fillet Height	E	Note 3		
Minimum Fillet Height	F	Note 3		
Solder Thickness	G	Note 3		
Minimum End Overlap	J	Note 3	50% (R)	75% (R)
Land Width	P	Note 2		
Termination Length	R	Note 2		
Land Length	S	Note 2		
Termination 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. (C) is inspected at the narrowest point of the required fillet.

8.3.1.1 Chip Components – Bottom Only Terminations – Side Overhang (A)

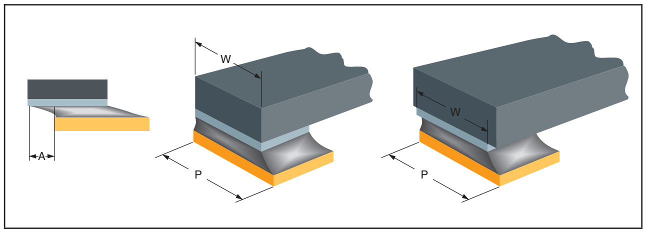

Figure 8-8

Acceptable – Class 1,2

- Side overhang (A) is less than or equal to 50% width of component termination area (W) or 50% width of land (P), whichever is less.

Acceptable – Class 3

- Side overhang (A) is less than or equal to 25% width of component termination area (W) or 25% width of land (P), whichever is less.

Defect – Class 1,2

- Side overhang (A) is greater than 50% component termination width (W) or 50% land width (P), whichever is less.

Defect – Class 3

- Side overhang (A) is greater than 25% component termination width (W) or 25% land width (P), whichever is less.

8.3.1.2 Chip Components – Bottom Only Terminations – End Overhang (B)

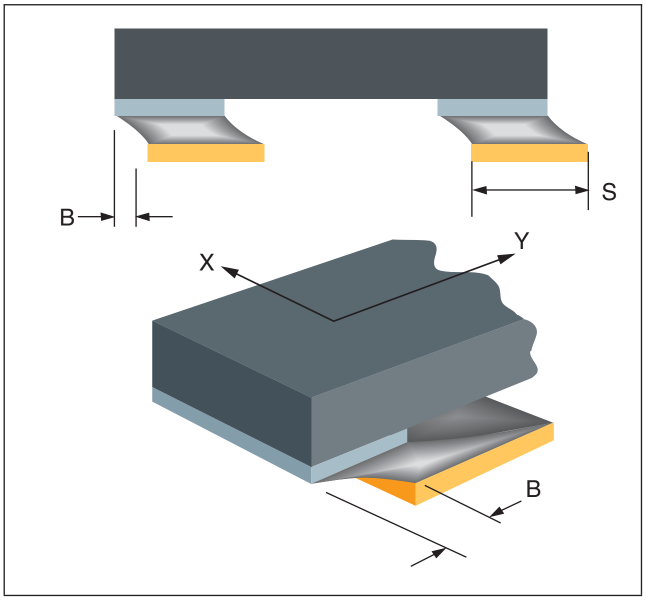

Figure 8-9

Defect – Class 1,2,3

- End overhang (B) in Y axis is not permitted.

8.3.1.3 Chip Components – Bottom Only Terminations – End Joint Width (C)

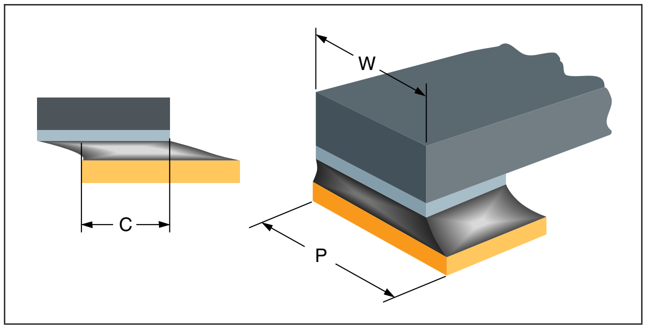

Figure 8-10

Acceptable – Class 1,2

- Minimum end joint width (C) is 50% width of component termination (W) or 50% width of land (P), whichever is less.

Acceptable – Class 3

- Minimum end joint width (C) is 75% width of component termination (W) or 75% width of land (P), whichever is less.

Defect – Class 1,2

- End joint width (C) is less than 50% width of component termination (W) or less than 50% width of land (P), whichever is less.

Defect – Class 3

- End joint width (C) is less than 75% width of component termination (W) or less than 75% width of land (P), whichever is less.

8.3.1.4 Chip Components – Bottom Only Terminations – Side Joint Length (D)

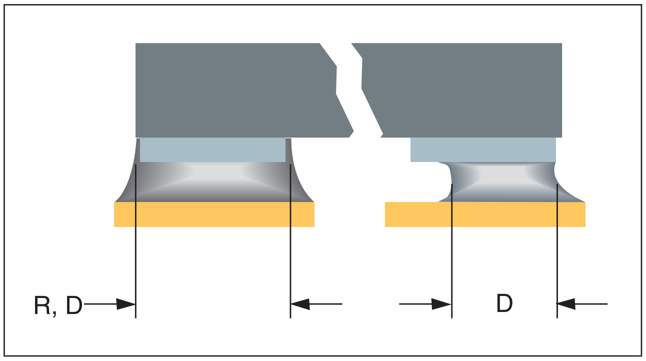

Figure 8-11

Acceptable – Class 1,2,3

- Wetting is evident.

Defect – Class 1,2,3

- Wetting is not evident.

8.3.1.5 Chip Components – Bottom Only Terminations – Maximum Fillet Height (E)

Maximum fillet height (E) requirements are not specified for Classes 1, 2 or 3. However, wetting is evident.

Defect – Class 1,2,3

- No wetting evident.

8.3.1.6 Chip Components – Bottom Only Terminations – Minimum Fillet Height (F)

Minimum fillet height (F) requirements are not specified for Classes 1, 2 or 3. However, wetting is evident.

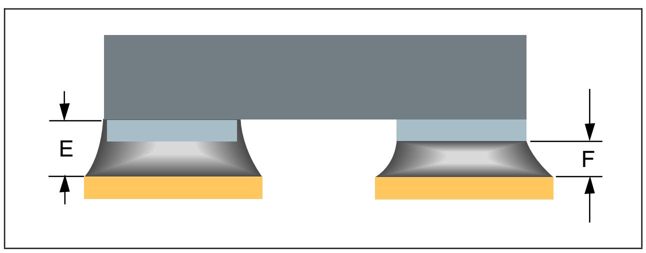

Figure 8-12

Defect – Class 1,2,3

- No wetting evident.

8.3.1.7 Chip Components – Bottom Only Terminations – Solder Thickness (G)

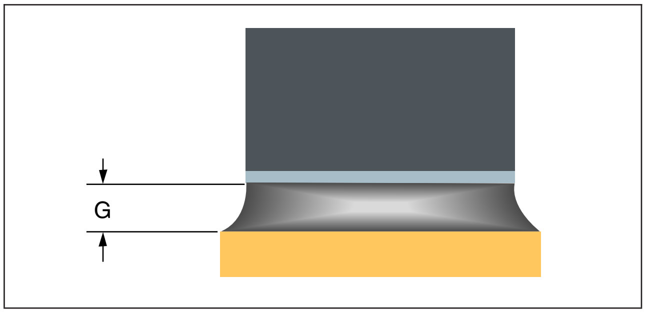

Figure 8-13

Acceptable – Class 1,2,3

- Wetting is evident.

Defect – Class 1,2,3

- No wetting evident.

8.3.1.8 Chip Components – Bottom Only Terminations – End Overlap (J)

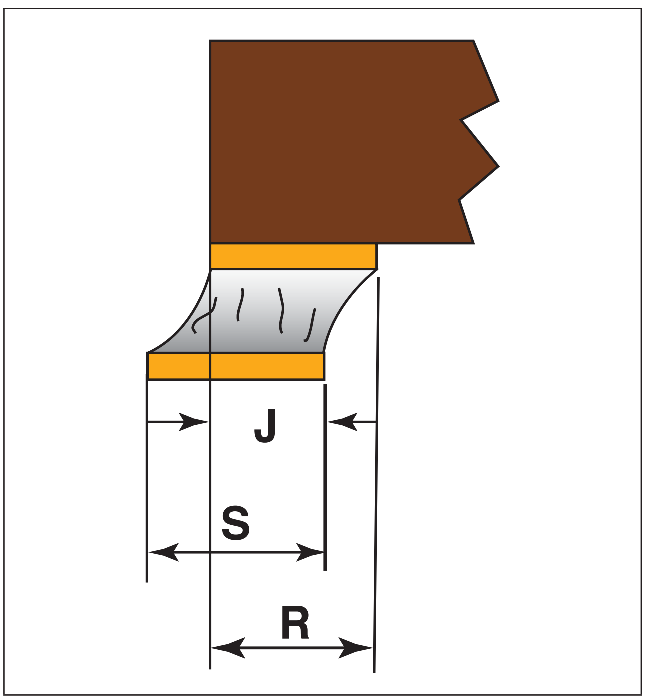

Figure 8-14

Acceptable – Class 1

- Wetted fillet is evident.

Acceptable – Class 2

- End overlap (J) between the component termination and the land is minimum 50% the length of component termination (R).

Acceptable – Class 3

- End overlap (J) between the component termination and the land is minimum of 75% the length of component termination (R).

Defect – Class 1,2,3

- Component termination area and land do not overlap.

Defect – Class 2

- End overlap (J) is less than 50% of the length of component termination (R).

Defect – Class 3

- End overlap (J) is less than 75% of the length of component termination (R).

8.3.2 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s)

These criteria apply to component types such as chip resistor, chip capacitor, network passive parts (R-NET, etc., that have this style of termination) and cylindrical components with square ends.

Solder connections to components having terminations of a square or rectangular configuration **shall** meet the dimensional and solder fillet requirements in Table 8-2 and 8.3.2.1 through 8.3.2.10.2. For one-sided termination, the solderable side is the vertical end face of the component.

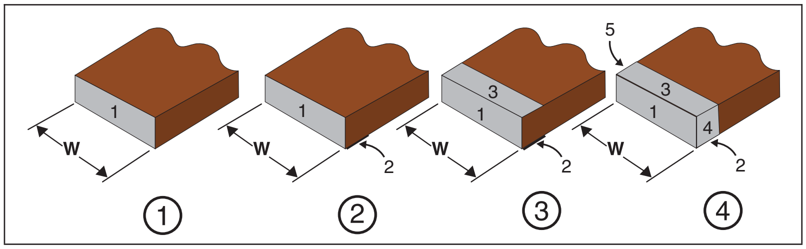

Figure 8-15

1. One face termination
2. Two face termination
3. Three face termination
4. Five face termination

Table 8-2 Dimensional Criteria – Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s)

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W) or 50% (P), whichever is less, Note 1		25% (W) or 25% (P), whichever is less, Note 1
End Overhang	B	Not permitted		
Minimum End Joint Width	C	50% (W) or 50% (P), whichever is less, Note 5		75% (W) or 75% (P), whichever is less, Note 5
Minimum Side Joint Length	D	Note 3		
Maximum Fillet Height	E	Note 4		
Minimum Fillet Height	F	Wetting is evident on the vertical surface(s) of the component termination.		(G) + 25% (H) or (G) + 0.5 mm [0.02 in], whichever is less.
Solder Thickness	G	Note 3		
Termination Height	H	Note 2		
Minimum End Overlap	J	Required		25% (R)
Width of Land	P	Note 2		
Termination Length	R	Note 2		
Termination Width	W	Note 2		
Side Mounting/Billboarding, Notes 6,7				
Width to Height Ratio		Does not exceed 2:1		
End Cap and Land Wetting		100% wetting land to end metallization contact areas		
Minimum End Overlap	J	100%		
Maximum Side Overhang	A	Not permitted		
End Overhang	B	Not permitted		
Maximum Component Size		No limits		1206, Note 8

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. The maximum fillet may overhang the land and/or extend onto the top or side metallization but does not touch the top or side of the component.
Note 5. (C) is inspected at the narrowest point of the required fillet.
Note 6. These criteria are for chip components that may flip (rotate) onto the narrow edge during assembly, and only apply to component with 3 or 5 side terminations.
Note 7. These criteria may not be acceptable for certain high frequency or high vibration applications.
Note 8. Component size may be larger than 1206 if the component is less than a 1.25:1 width to height ratio and has five termination faces.

8.3.2.1 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Side Overhang (A)

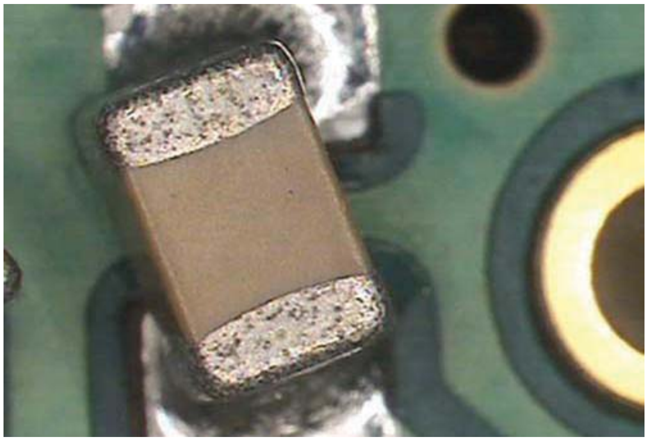

Figure 8-16

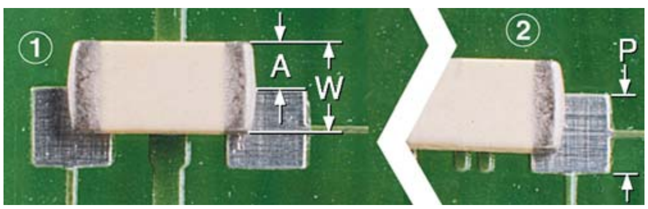

Figure 8-17
1. Class 1,2
2. Class 3

Acceptable – Class 1,2

- Side overhang (A) is less than or equal to 50% width of component termination area (W) or 50% width of land (P), whichever is less.

Acceptable – Class 3

- Side overhang (A) is less than or equal to 25% width of component termination area (W) or 25% width of land (P), whichever is less.

8.3.2.1 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Side Overhang (A) (cont.)

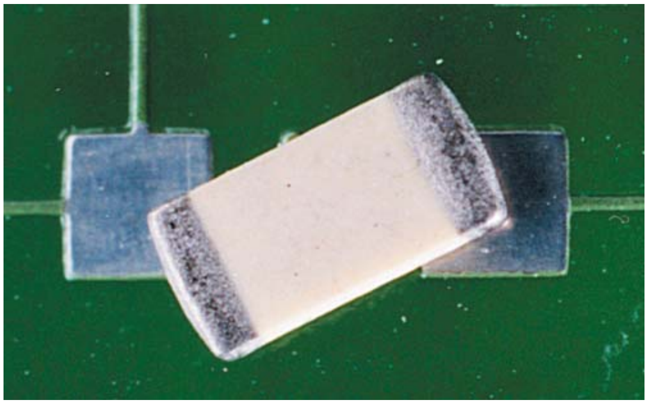

Figure 8-18

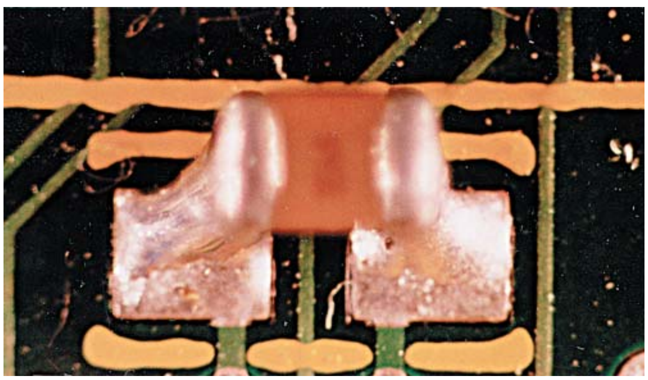

Figure 8-19

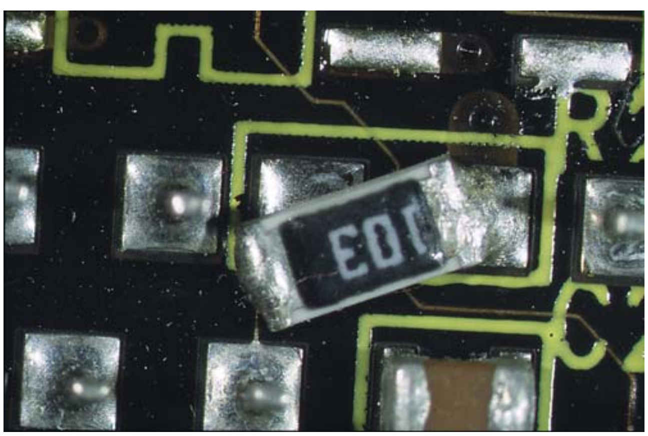

Figure 8-20

Defect – Class 1,2

- Side overhang (A) is greater than 50% component termination width (W) or 50% land width (P), whichever is less.

Defect – Class 3

- Side overhang (A) is greater than 25% component termination width (W) or 25% land width (P), whichever is less.

8.3.2.2 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – End Overhang (B)

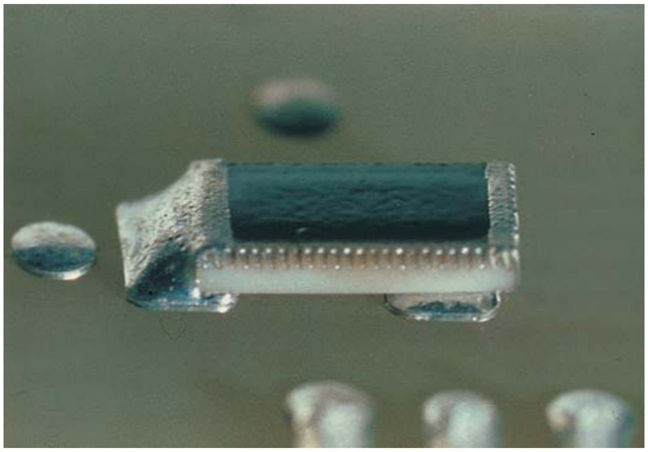

Figure 8-21

Defect – Class 1,2,3

• Termination overhangs land.

8.3.2.3 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – End Joint Width (C)

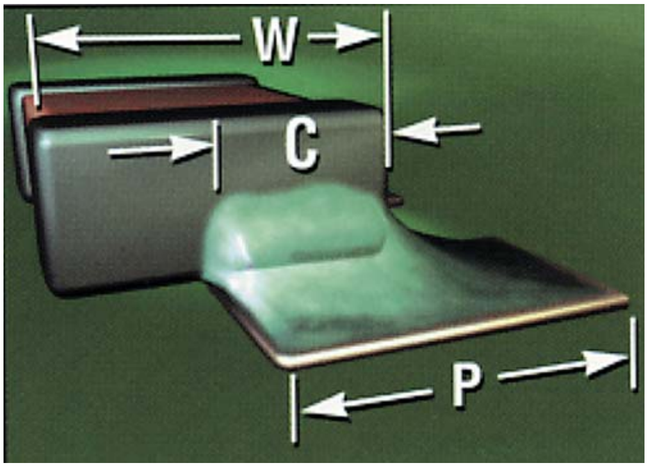

Figure 8-22

Figure 8-23

Acceptable – Class 1,2

- End joint width (C) is minimum 50% of component termination width (W) or 50% land width (P), whichever is less.

8.3.2.3 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – End Joint Width (C) (cont.)

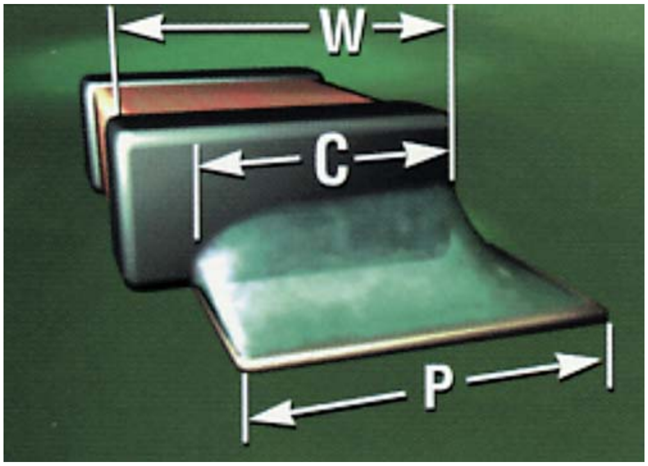

Figure 8-24

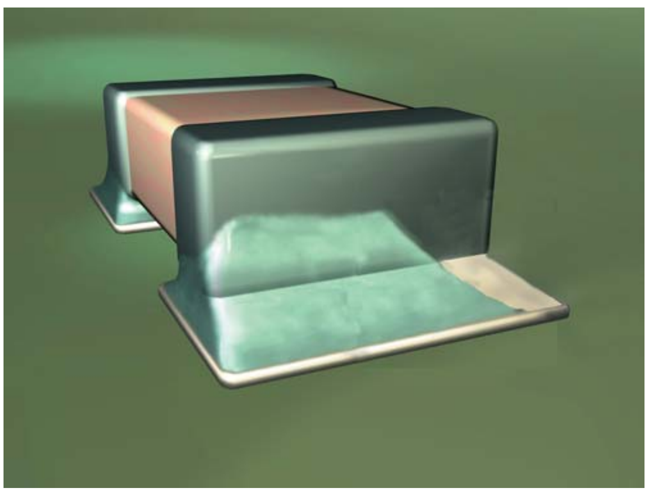

Figure 8-25

Acceptable – Class 3

- End joint width (C) is minimum 75% of component termination (W) or 75% land width (P), whichever is less.

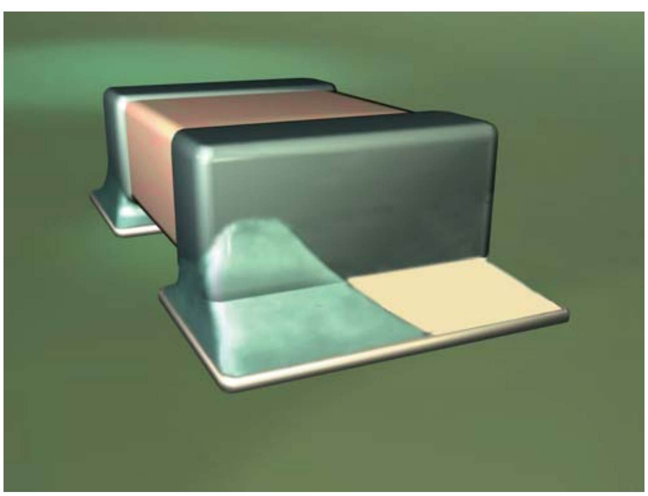

Figure 8-26

Defect – Class 1,2,3

- Less than minimum acceptable end joint width.

8.3.2.4 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Side Joint Length (D)

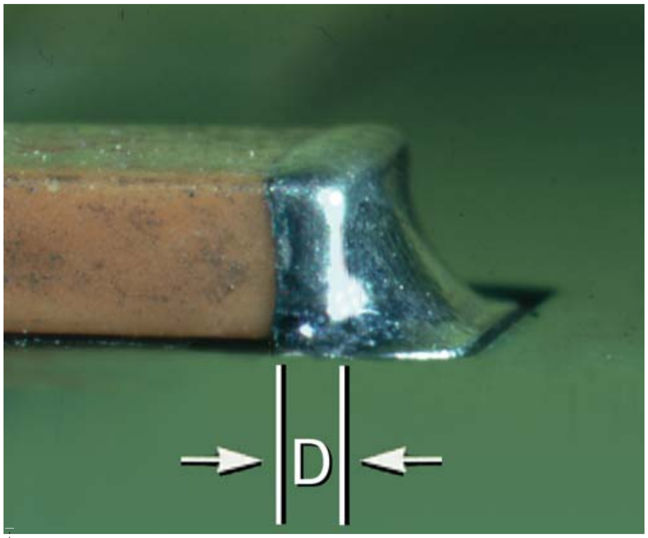

Figure 8-27

Acceptable – Class 1,2,3

- Side joint length is not required. However, a wetted fillet is evident.

Defect – Class 1,2,3

- No wetted fillet.

8.3.2.5 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Maximum Fillet Height (E)

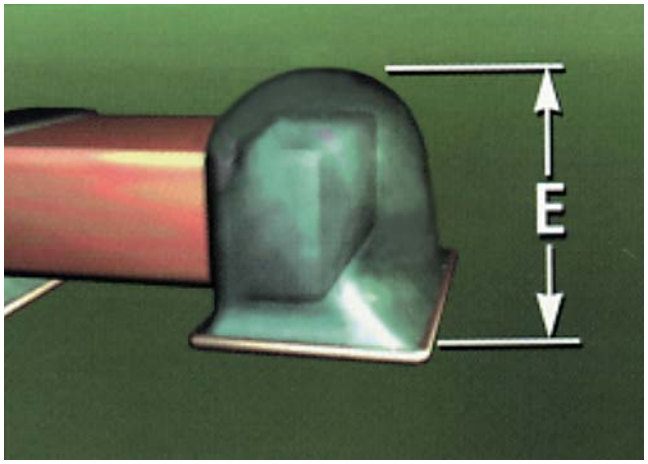

Figure 8-28

Acceptable – Class 1,2,3

- Maximum fillet height (E) may overhang the land and/or extend onto the top or side metallization, but does not touch the top or side of the component.

Defect – Class 1,2,3

- Solder fillet extends onto the top of the component body.

8.3.2.6 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Minimum Fillet Height (F)

Figure 8-29

Acceptable – Class 1,2

- Minimum fillet height (F) exhibits wetting on the vertical surface(s) of the component termination.

Acceptable – Class 3

- Minimum fillet height (F) is solder thickness (G) plus either 25% termination height (H), or 0.5 mm [0.02 in], whichever is less.

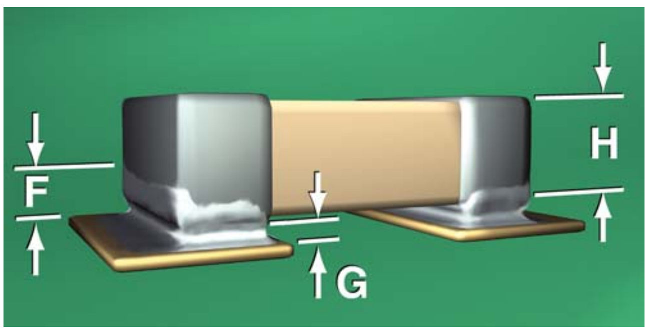

Figure 8-30

Defect – Class 1,2

- No fillet height evident on face of component.

Defect – Class 3

- Minimum fillet height (F) is less than solder thickness (G) plus either 25% (H), or solder thickness (G) plus 0.5 mm [0.02 in], whichever is less.

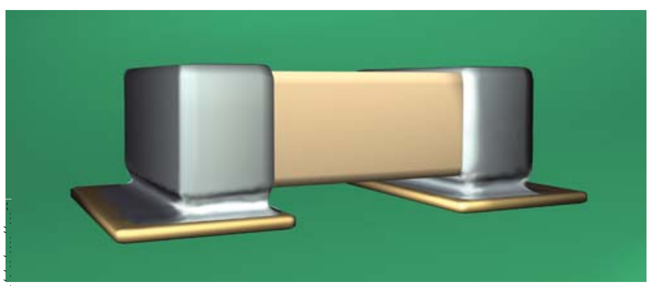

Figure 8-31

Defect – Class 1,2,3

- Insufficient solder.
- A wetted fillet is not evident.

8.3.2.7 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Solder Thickness (G)

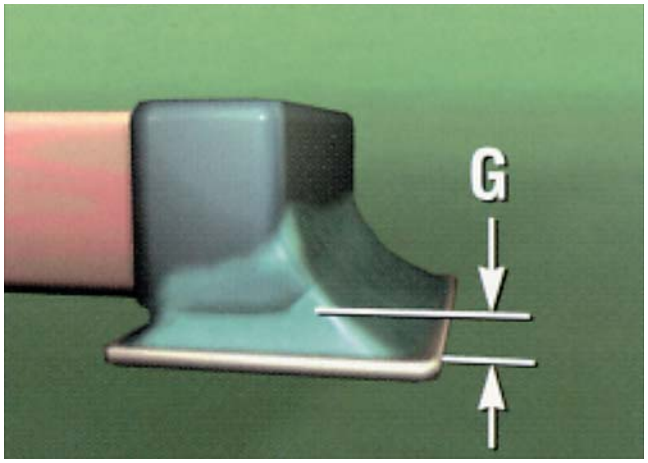

Figure 8-32

Acceptable – Class 1,2,3

- Wetted fillet evident.

Defect – Class 1,2,3

- No wetted fillet.

8.3.2.8 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – End Overlap (J)

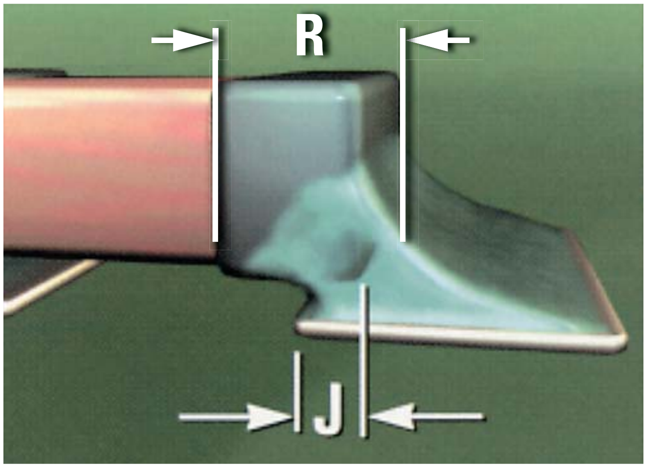

Figure 8-33

Acceptable – Class 1,2

- Evidence of overlap contact (J) between the component termination and the land is required.

Acceptable – Class 3

- End overlap (J) is 25% or more of component termination length (R).

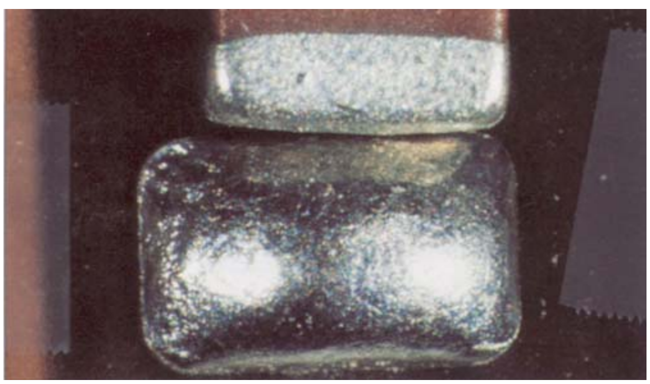

Figure 8-34

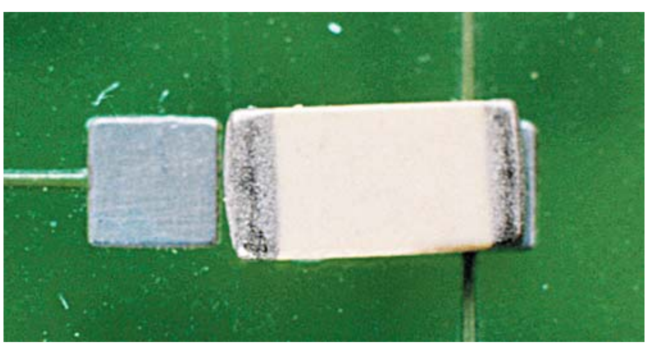

Figure 8-35

Defect – Class 1,2,3

- Insufficient end overlap.

Defect – Class 3

- End overlap (J) is less than 25% of component termination length (R).

8.3.2.9 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Termination Variations

8.3.2.9.1 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Termination Variations – Mounting on Side (Billboarding)

This section provides criteria for chip components that may flip (rotate) onto the narrow edge during assembly.

These criteria may not be acceptable for certain high frequency or high vibration applications.

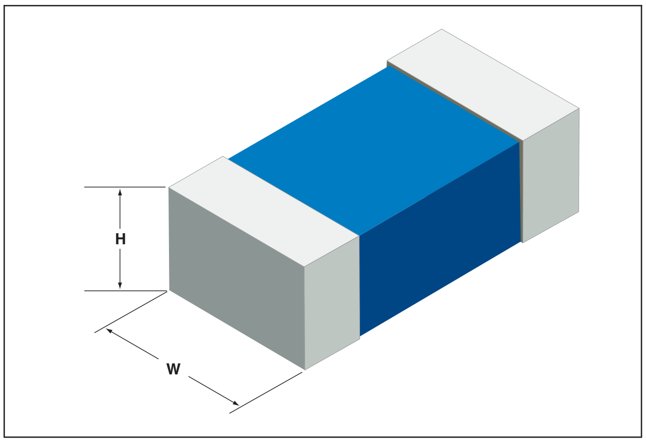

Figure 8-36

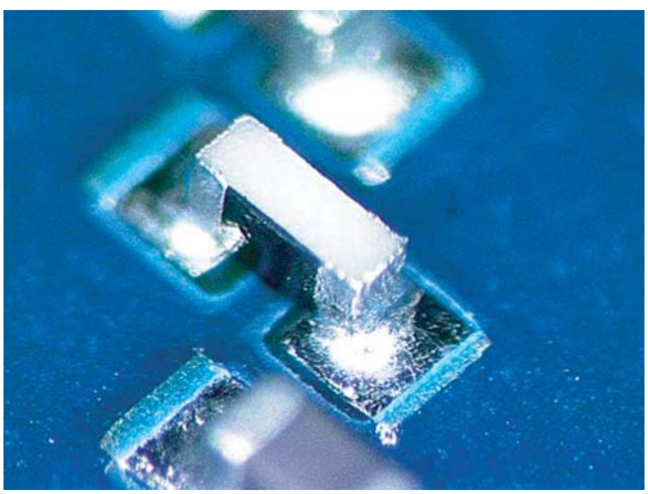

Figure 8-37

Acceptable – Class 1,2

- Width (W) to height (H) ratio does not exceed two to one (2:1) ratio; see Figure 8-36.
- Complete wetting to land and end cap metallization.
- Overlap contact between 100% of the component termination (metallization) and the land.
- Component has three or more termination faces (metallization).
- There is evidence of wetting on the three vertical faces of the termination area.

Acceptable – Class 3

- For components size 1206 or smaller:
  - Width (W) to height (H) ratio does not exceed two to one (2:1); see Figure 8-37.
  - Complete wetting at land to end cap metallization.
  - Overlap contact between 100% of the component termination (metallization) and the land.
  - Component has three or more termination faces (metallization).
  - There is evidence of wetting on the three vertical faces of the termination area.
- For components larger than size 1206:
  - Width (W) to height (H) ratio that does not exceed 1.25:1 ratio.
  - Component has five termination faces (metallization).
  - Complete wetting at land to end cap metallization.
  - Overlap contact between 100% of the component termination (metallization) and the land.
  - There is evidence of wetting on the three vertical faces of the termination area.

8.3.2.9.1 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Termination Variations – Mounting on Side (Billboarding) (cont.)

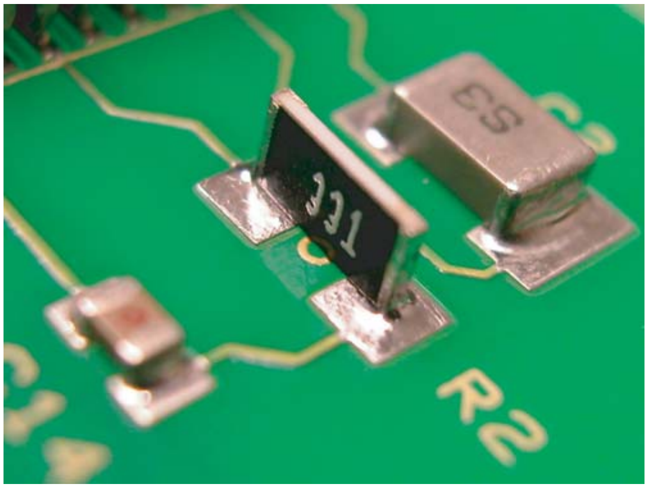

Figure 8-38

Defect – Class 1,2

- Width to height ratio exceeds two to one (2:1) ratio.
- Incomplete wetting at land or end cap metallization.
- Less than 100% overlap of the component termination (metallization) and the land.
- Component overhangs the end or side of the land.
- Component has less than three termination faces (metallization).

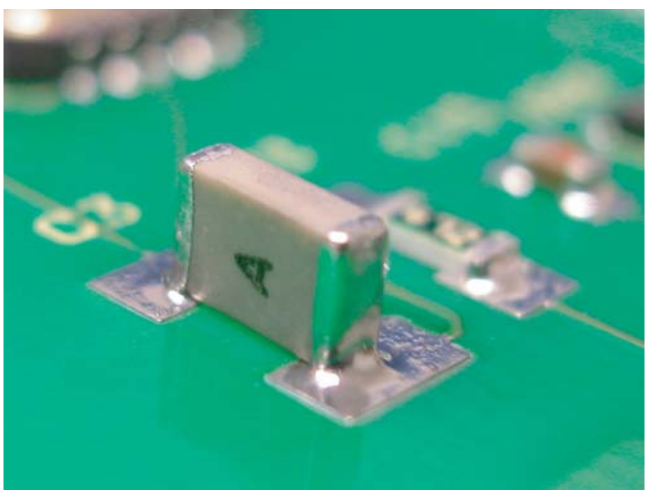

Figure 8-39

Defect – Class 3

- For components size 1206 or smaller:
  - Width (W) to height (H) ratio exceeds two to one (2:1).
  - Incomplete wetting of at least three component termination faces to the land.
  - Less than 100% overlap of the component termination (metallization) and the land.
  - Component overhangs the end or side of the land.
  - Component has less than three termination faces (metallization).
- For components larger than size 1206, see Figure 8-39.
  - Incomplete wetting of at least three component termination faces to the land.
  - Less than 100% overlap of the component termination (metallization) and the land.
  - Component overhangs the end or side of the land.
  - Width (W) to height (H) ratio exceeds 1.25 to 1.
  - Component does not have five termination sides.

8.3.2.9.2 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Termination Variations – Mounting Upside Down

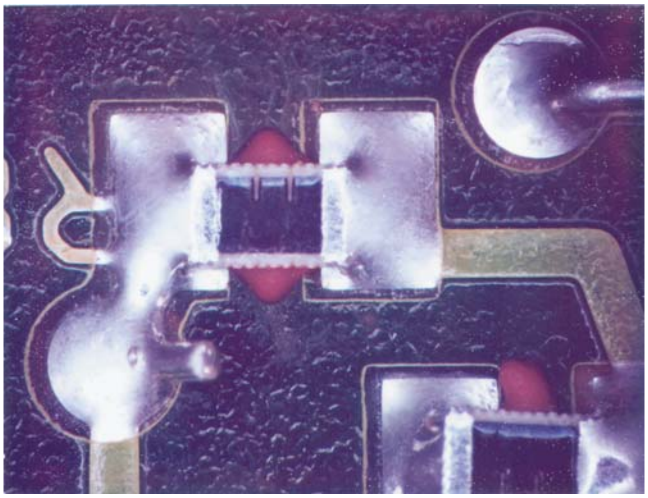

Figure 8-40

Acceptable – Class 1,2,3

- Element of chip component with surface deposited electrical element is mounted away from the board.

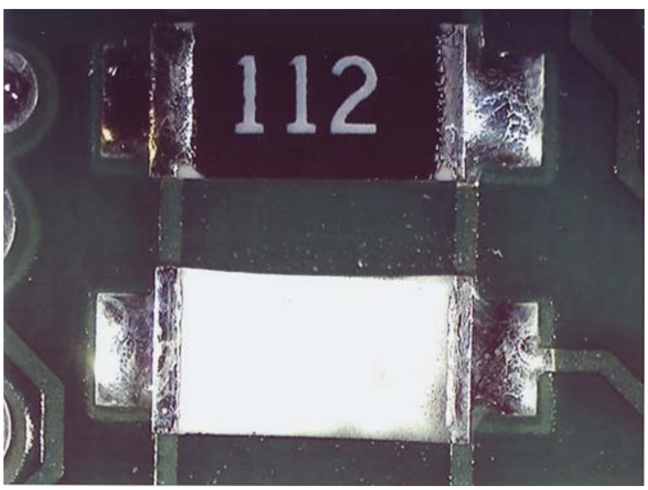

Figure 8-41

Acceptable – Class 1
Process Indicator – Class 2,3

- 1, 3, 5 side termination chip components with surface deposited electrical element is mounted toward the board.

Defect – 1,2,3

- Two-sided termination with component mounted upside down.

8.3.2.9.3 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Termination Variations – Stacking

These criteria are applicable when stacking is a requirement.

When stacking components, the top termination area of a component becomes the land for the next higher component.

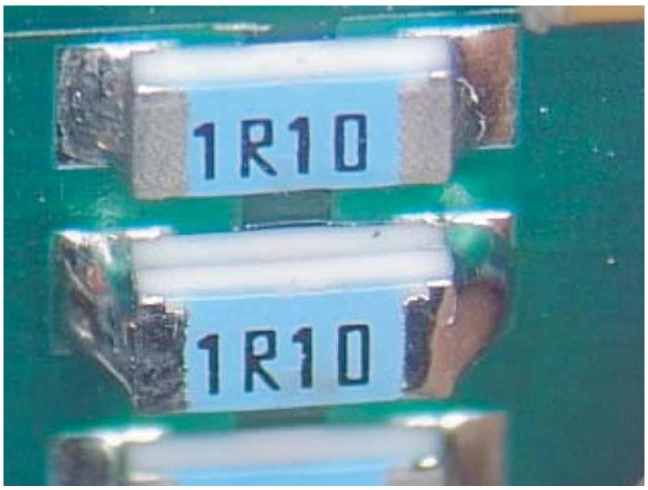

Figure 8-42

Acceptable – Class 1,2,3

- When permitted by drawing.
- Stacking order meets drawing requirements.
- Stacked components meet the criteria of Table 8-2, for the applicable class of acceptance.
- Side overhang does not preclude formation of required solder fillets.

Defect – Class 1,2,3

- Stacked components when not required by drawing.
- Stacking order does not meet drawing requirements.
- Stacked components do not meet the criteria of Table 8-2, for the applicable class of acceptance.
- Side overhang precludes formation of required solder fillets.

8.3.2.9.4 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Termination Variations – Tombstoning

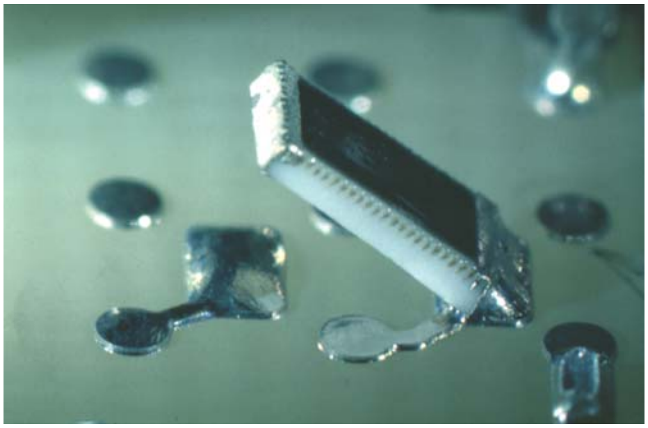

Figure 8-43

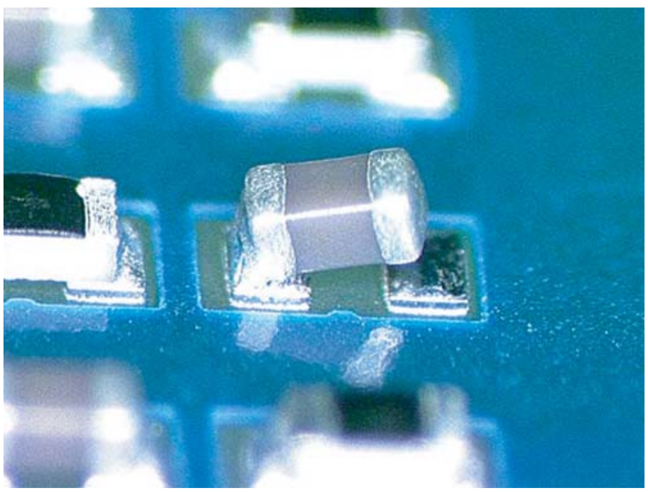

Figure 8-44

Defect – Class 1,2,3

- Chip components standing on a terminal end (tombstoning).

8.3.2.10 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Termination Variations – Center Terminations

These criteria are also applicable to cylindrical chip components with side terminations, see Figure 8-46.

8.3.2.10.1 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Termination Variations – Center Terminations – Solder Width of Side Termination

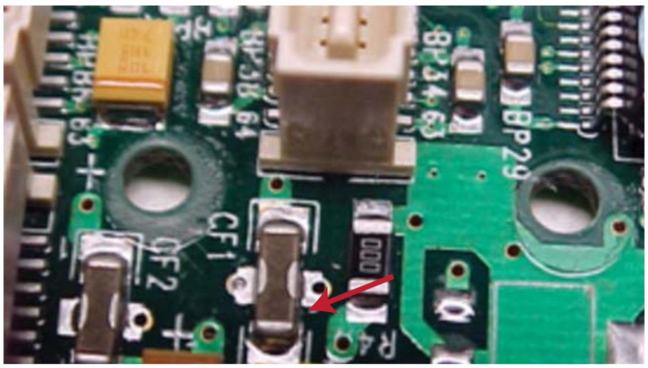

Figure 8-45

Acceptable – Class 1,2

- Width of the side termination(s) is minimum 50% of component termination width or 50% land width, whichever is less.

Acceptable – Class 3

- Width of the side termination is minimum 75% of component termination or 75% land width, whichever is less.

Defect – Class 1,2,3

- Less than minimum acceptable end joint width.

8.3.2.10.2 Rectangular or Square End Chip Components – 1, 2, 3 or 5 Side Termination(s) – Termination Variations – Center Terminations – Minimum Fillet Height of Side Termination

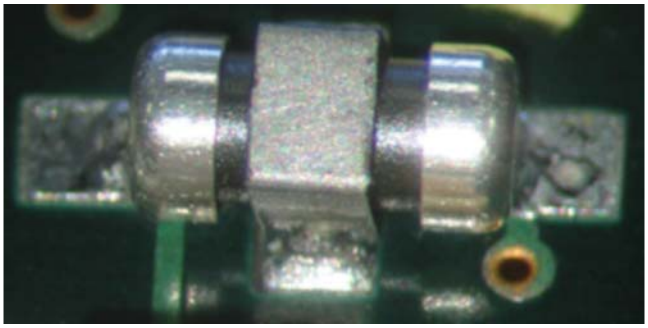

Figure 8-46

Acceptable – Class 1,2,3

- Wetting is evident on the vertical surface(s) of the component side termination.

Figure 8-47

Defect – Class 1,2,3

- No fillet height evident on side termination of component.
- A wetted fillet is not evident.

8.3.3 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 in Table 8-3 and 8.3.3.1 through 8.3.3.8. 8.3.2.10 has criteria for cylindrical components that also have side terminations, see Figure 8-46.

Table 8-3 Dimensional Criteria – Cylindrical End Cap Termination

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

Note 1. Does not violate minimum electrical clearance.
Note 2. (C) is inspected at the narrowest point of the required fillet.
Note 3. Unspecified dimension, 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 body. Solder may touch the bottom half of the component body.
Note 6. Does not apply to components with end-only terminations.

8.3.3.1 Cylindrical End Cap Terminations – Side Overhang (A)

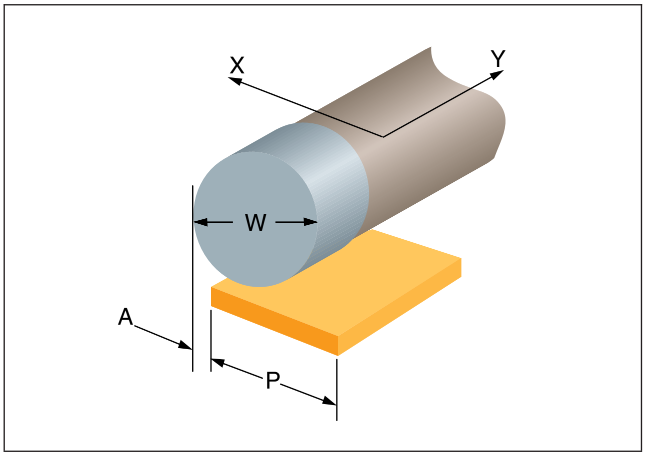

Figure 8-48

Acceptable – Class 1,2,3

- Side overhang (A) is 25% or less of the diameter of component width (W) or land width (P), whichever is less.

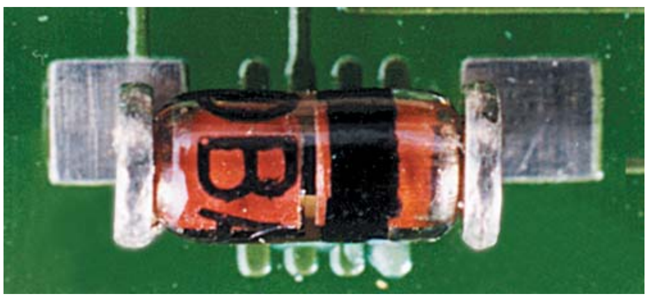

Figure 8-49

Defect – Class 1,2,3

- Side overhang (A) is greater than 25% of component diameter, (W), or land width (P), whichever is less.

8.3.3.2 Cylindrical End Cap Terminations – End Overhang (B)

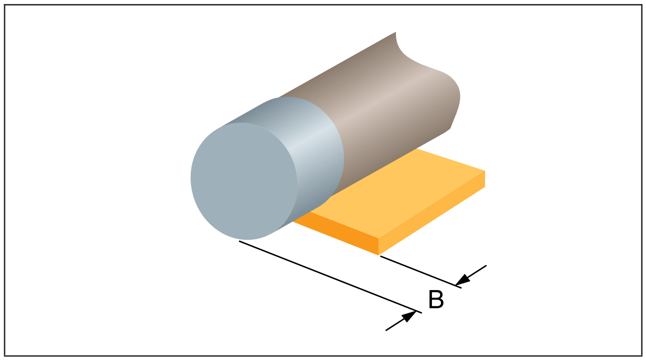

Figure 8-50

Defect – Class 1,2,3

- Any end overhang (B).

8.3.3.3 Cylindrical End Cap Terminations – End Joint Width (C)

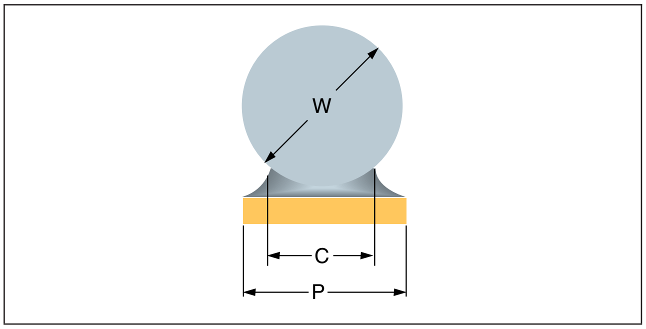

Figure 8-51

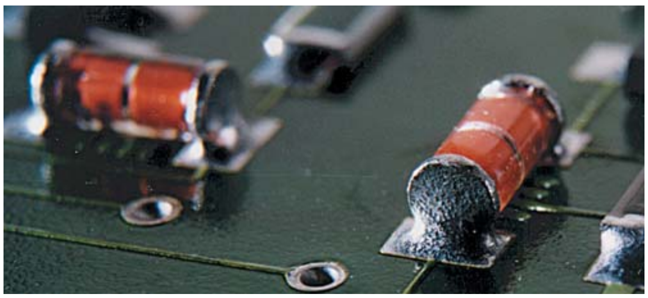

Figure 8-52

Figure 8-53

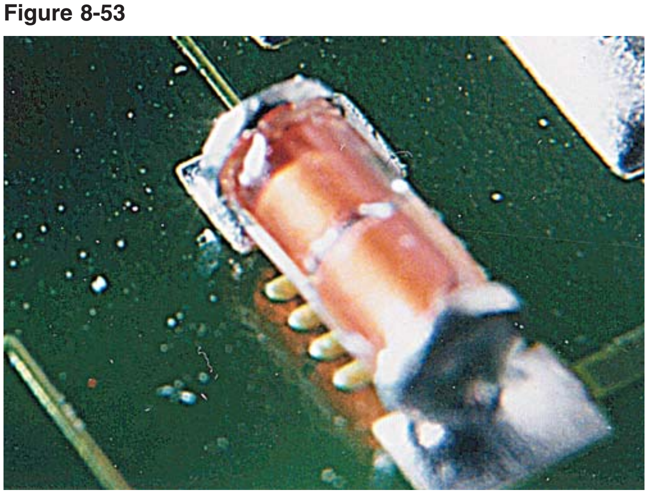

Figure 8-54

Acceptable – Class 1

- End solder joint exhibits a wetted fillet.

Acceptable – Class 2,3

- End joint width (C) is minimum 50% component diameter (W) or land width (P), whichever is less.

Defect – Class 1

- End solder joint does not exhibit a wetted fillet.

Defect – Class 2,3

- End joint width (C) is less than 50% component diameter (W), or land width (P), whichever is less.

8.3.3.4 Cylindrical End Cap Terminations – Side Joint Length (D)

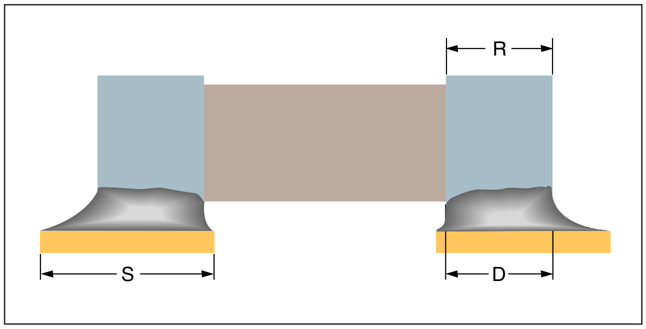

Figure 8-55

Figure 8-56

Acceptable – Class 1

- Side joint length (D) exhibits a wetted fillet.

Acceptable – Class 2

- Side joint length (D) is minimum 50% length of component termination (R) or land length (S), whichever is less.

Acceptable – Class 3

- Side joint length (D) is minimum 75% length of component termination (R) or land length (S), whichever is less.

Defect – Class 1

- Side joint length (D) does not exhibit a wetted fillet.

Defect – Class 2

- Side joint length (D) is less than 50% length of component termination (R) or land length (S), whichever is less.

Defect – Class 3

- Side joint length (D) is less than 75% length of component termination (R) or land length (S), whichever is less.

8.3.3.5 Cylindrical End Cap Terminations – Maximum Fillet Height (E)

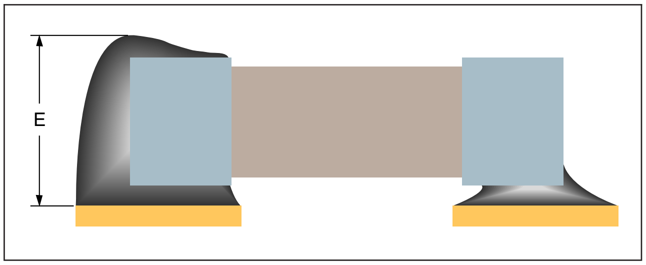

Figure 8-57

Acceptable – Class 1,2,3

- Maximum fillet height (E) may overhang the land and/or extend onto the top of the end cap metallization, but not extend further onto the component body. Solder may touch the bottom half of the component body.

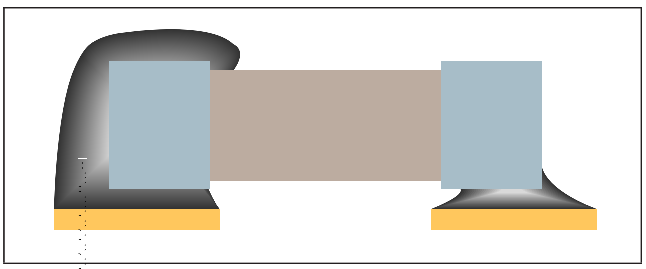

Figure 8-58

Defect – Class 1,2,3

- Solder fillet extends onto the component body top.

8.3.3.6 Cylindrical End Cap Terminations – Minimum Fillet Height (F)

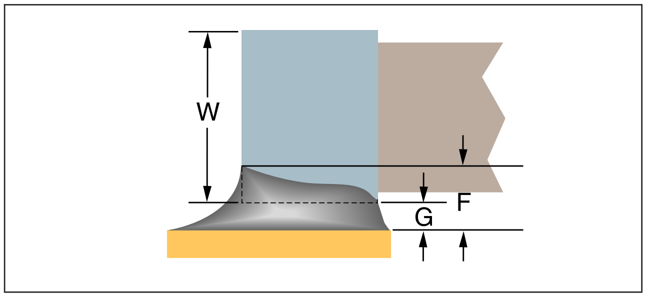

Figure 8-59

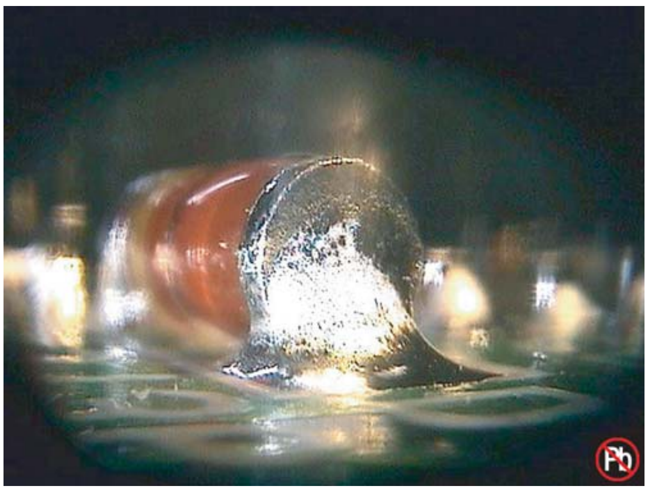

Figure 8-60

Acceptable – Class 1,2

- Minimum fillet height (F) exhibits wetting on the vertical surfaces of the component termination.

Acceptable – Class 3

- Minimum fillet height (F) is solder thickness (G) plus either 25% diameter (W) of the component end cap or 1 mm [0.04 in], whichever is less.

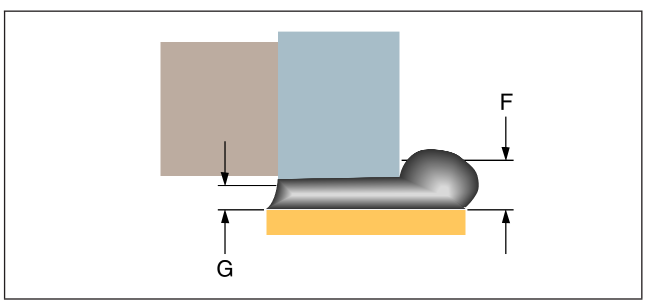

Figure 8-61

Defect – Class 1,2,3

- Minimum fillet height (F) does not exhibit wetting.

Defect – Class 3

- Minimum fillet height (F) is less than the solder thickness (G) plus either 25% diameter (W) of the component end cap or 1 mm [0.04 in], whichever is less.

8.3.3.7 Cylindrical End Cap Terminations – Solder Thickness (G)

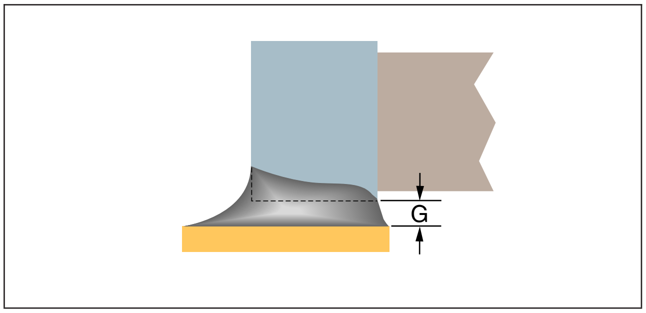

Figure 8-62

Acceptable – Class 1,2,3

• Wetted fillet evident.

Defect – Class 1,2,3

• No wetted fillet.

8.3.3.8 Cylindrical End Cap Terminations – End Overlap (J)

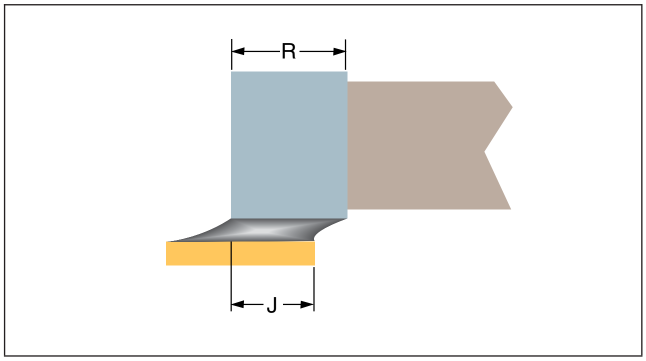

Figure 8-63

Acceptable – Class 1

- Wetted fillet is evident.

Acceptable – Class 2

- End overlap (J) between the component termination and the land is minimum 50% the length of component termination (R).

Acceptable – Class 3

- End overlap (J) between the component termination and the land is minimum of 75% the length of component termination (R).

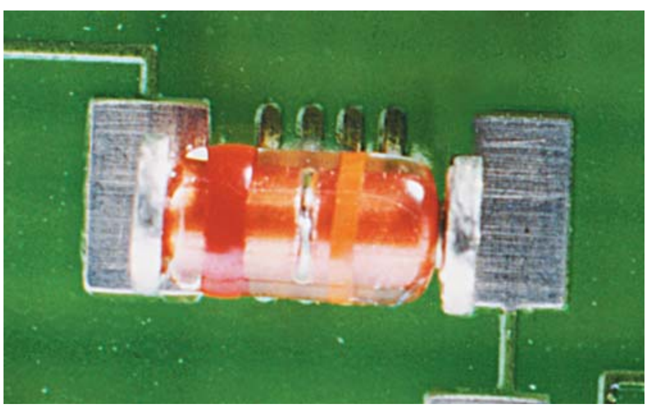

Figure 8-64

Defect – Class 1,2,3

- Component termination area and land do not overlap.

Defect – Class 2

- End overlap (J) is less than 50% of the length of component termination (R).

Defect – Class 3

- End overlap (J) is less than 75% of the length of component termination (R).

8.3.4 Castellated Terminations

Connections formed to castellated terminations of leadless chip components **shall** meet the dimensional and solder fillet requirements in Table 8-4 and 8.3.4.1 through 8.3.4.7. The solder fillet may contact the bottom of the component.

Table 8-4 Dimensional Criteria – Castellated Terminations

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W), Note 1		25% (W), Note 1
End Overhang	B	Not permitted		
Minimum End Joint Width	C	50% (W), Note 5		75% (W), Note 5
Minimum Side Joint Length	D	Note 3	Depth of castellation	
Maximum Fillet Height	E	Notes 1, 4		
Minimum Fillet Height	F	Note 3	(G) + 25% (H)	(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 dimension, 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 component body.
Note 5. (C) is inspected at the narrowest point of the required fillet.

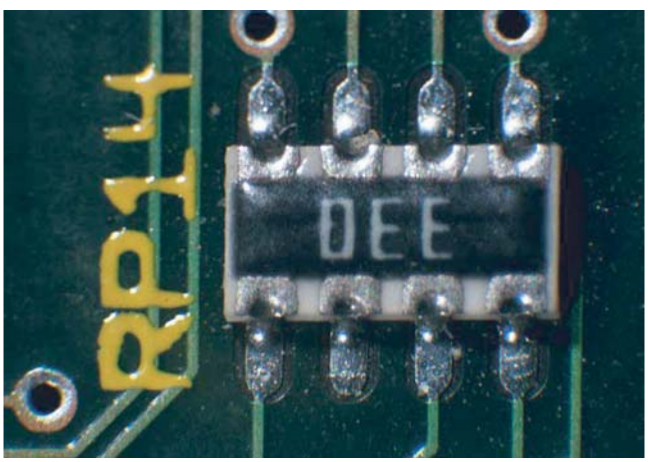

Figure 8-65

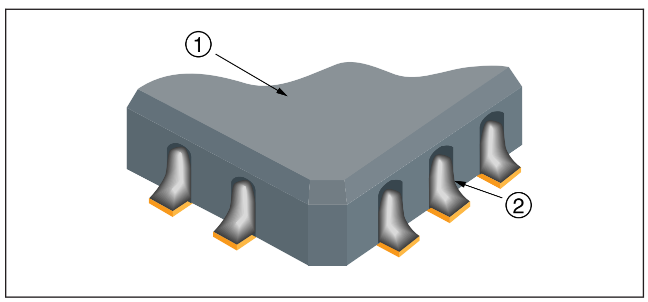

Figure 8-66
1. **Leadless chip carrier**
2. **Castellations (Terminations)**

8.3.4.1 Castellated Terminations – Side Overhang (A)

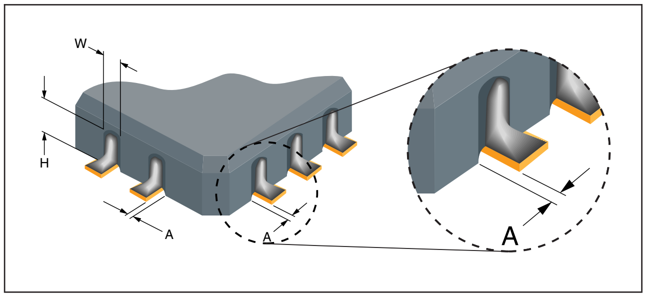

Figure 8-67

Acceptable – Class 1,2

- Maximum side overhang (A) is 50% castellation width (W).

Acceptable – Class 3

- Maximum side overhang (A) is 25% castellation width (W).

Defect – Class 1,2

- Side overhang (A) exceeds 50% castellation width (W).

Defect – Class 3

- Side overhang (A) exceeds 25% castellation width (W).

8.3.4.2 Castellated Terminations – End Overhang (B)

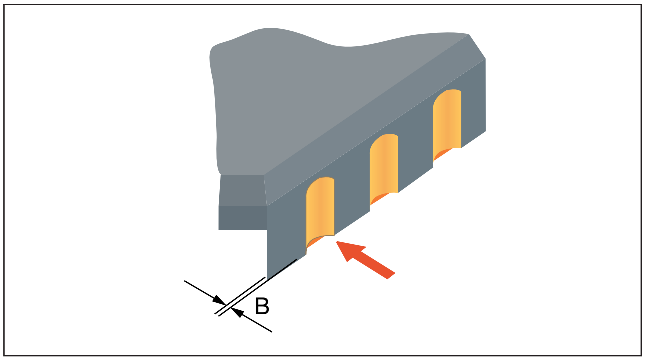

Figure 8-68

Acceptable – Class 1,2,3

• No end overhang.

Defect – Class 1,2,3

• End overhang (B).

8.3.4.3 Castellated Terminations – Minimum End Joint Width (C)

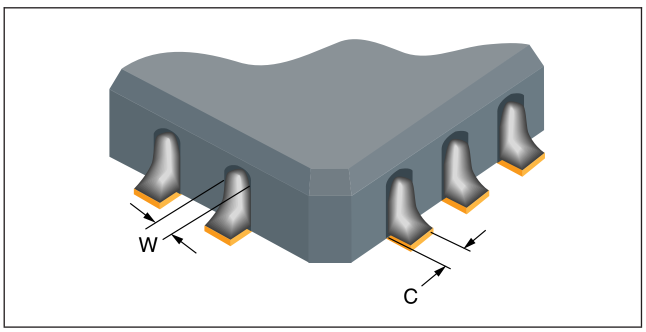

Figure 8-69

Acceptable – Class 1,2

• Minimum end joint width (C) is 50% castellation width (W).

Acceptable – Class 3

• Minimum end joint width (C) is 75% castellation width (W).

Defect – Class 1,2

• End joint width (C) is less than 50% castellation width (W).

Defect – Class 3

• End joint width (C) is less than 75% castellation width (W).

8.3.4.4 Castellated Terminations – Minimum Side Joint Length (D)

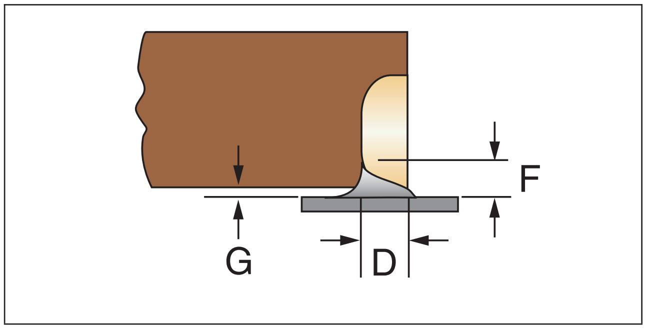

Figure 8-70

Acceptable – Class 1

- Wetted fillet evident.

Acceptable – Class 1,2,3

- Solder extends from the back of the castellation onto the land at or beyond the edge of the component.

Defect – Class 1,2,3

- Wetted fillet not evident.
- Solder does not extend from the back of the castellation onto the land at or beyond the edge of the component.

8.3.4.5 Castellated Terminations – Maximum Fillet Height (E)

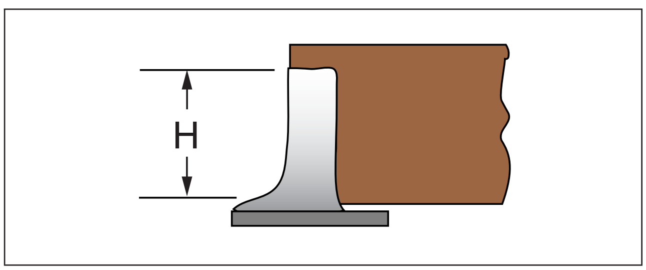

Figure 8-71

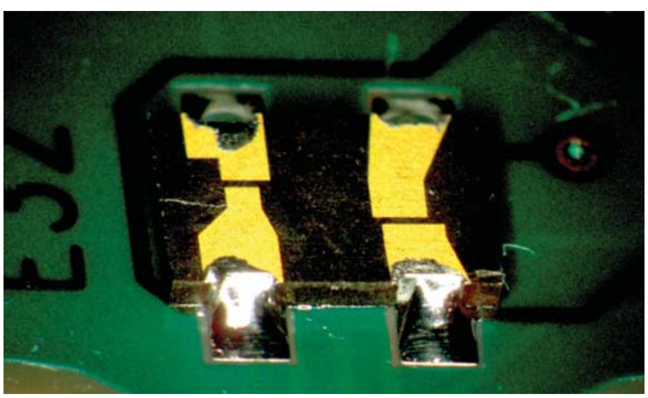

Figure 8-72

Acceptable – Class 1,2,3

- The maximum fillet may extend past the top of the castellation provided it does not extend onto the component body.

8.3.4.6 Castellated Terminations – Minimum Fillet Height (F)

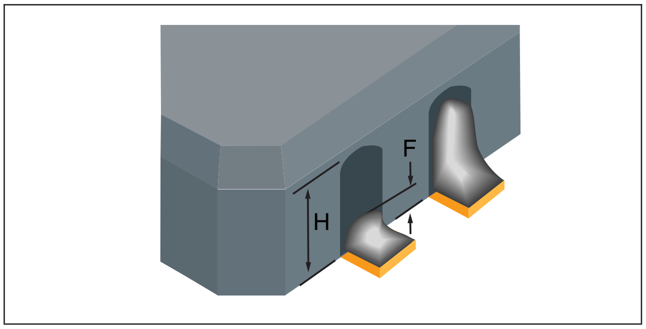

Figure 8-73

Acceptable – Class 1

- A wetted fillet is evident.

Acceptable – Class 2

- Minimum fillet height (F) is the solder thickness (G) (not shown) plus 25% castellation height (H).

Acceptable – Class 3

- Minimum fillet height (F) is the solder thickness (G) (not shown) plus 50% castellation height (H).

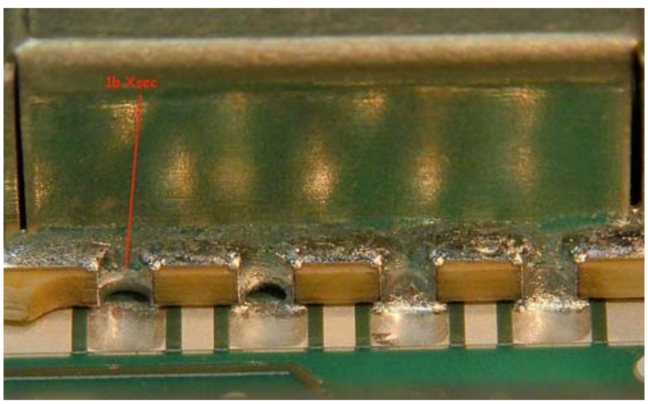

Figure 8-74

Defect – Class 1

- A wetted fillet is not evident.

Defect – Class 2

- Minimum fillet height (F) is less than solder thickness (G) (not shown) plus 25% castellation height (H).

Defect – Class 3

- Minimum fillet height (F) is less than solder thickness (G) (not shown) plus 50% castellation height (H).

8.3.4.7 Castellated Terminations – Solder Thickness (G)

Acceptable – Class 1,2,3

- Wetted fillet evident.

Defect – Class 1,2,3

- No wetted fillet.

8.3.5 Flat Gull Wing Leads

Connections formed to flat gull wing leads **shall** meet dimensional and solder fillet requirements in Table 8-5 and 8.3.5.1 through 8.3.5.8.

Toe Down Configuration is the formed conditions 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 8-75.

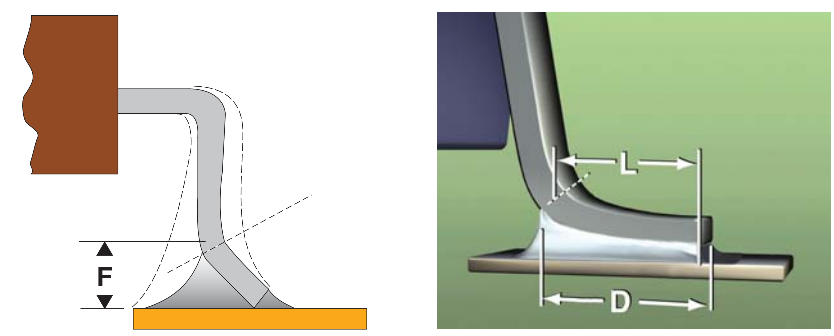

Figure 8-75 Toe Down Configuration

Table 8-5 Dimensional Criteria – Flat Gull Wing Leads

Feature		Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang		A	50% (W) or 0.5 mm [0.02 in], whichever is less, Note 1		25% (W) or 0.5 mm [0.02 in], whichever is less, Note 1
Maximum Toe Overhang	when (L) is ≥ 3 (W)	B	Note 1	Not permitted when (L) is less than 3 (W), Note 1	
	when (L) is < 3 (W)			Not permitted when (L) is less than 1 (W), Note 1	
Minimum End Joint Width		C	50% (W), Note 6		75% (W), Note 6
Minimum Side Joint Length	when (L) is ≥ 3 (W)	D	1 (W) or 0.5 mm [0.02 in], whichever is less, Note 7	3 (W) or 75% (L), whichever is longer, Note 7	
	when (L) is < 3 (W)			100% (L), Note 7	
Maximum Heel Fillet Height		E	Note 4		
Minimum Heel Fillet Height		F	Note 3	(G) + 50% (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 dimension, or variable in size as determined by design.
Note 3. Wetting is evident.
Note 4. Solder does not touch package body or end seal, see 8.2.1 Surface Mount Assemblies – SMT Leads – Plastic Components.
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 is not inspectable.

8.3.5.1 Flat Gull Wing Leads – Side Overhang (A)

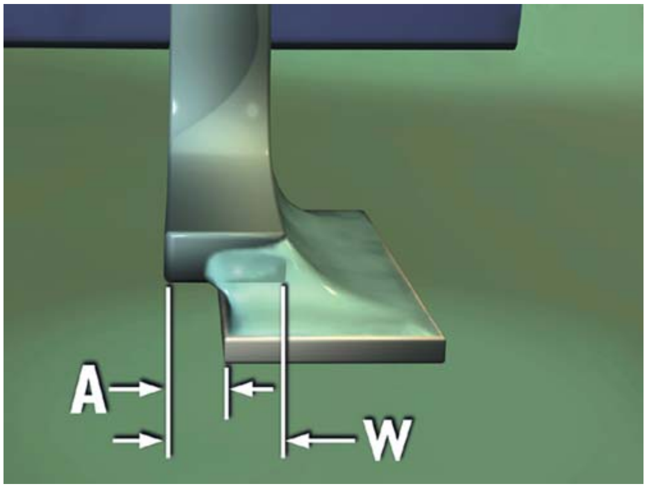

Figure 8-76

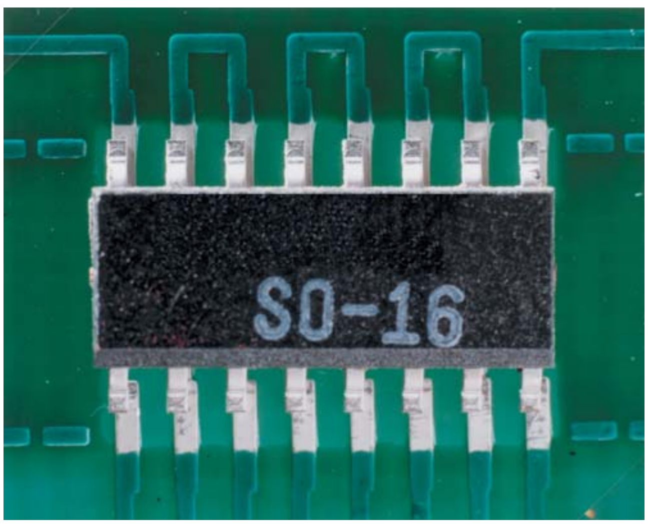

Figure 8-77

Acceptable – Class 1,2

- Maximum overhang (A) is not greater than 50% lead width (W) or 0.5 mm [0.02 in], whichever is less.

8.3.5.1 Flat Gull Wing Leads – Side Overhang (A) (cont.)

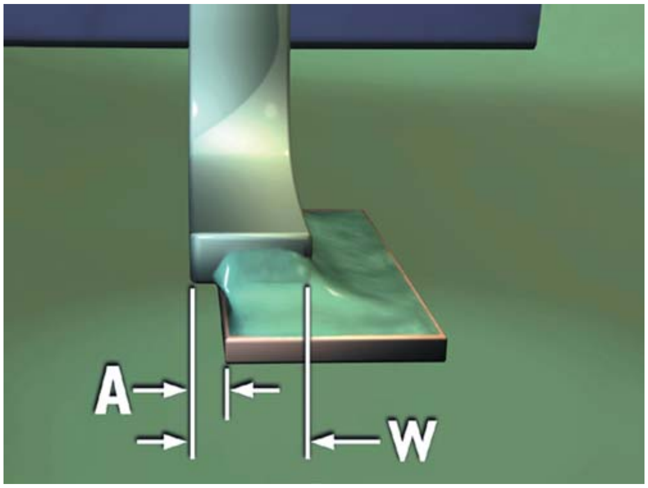

Figure 8-78

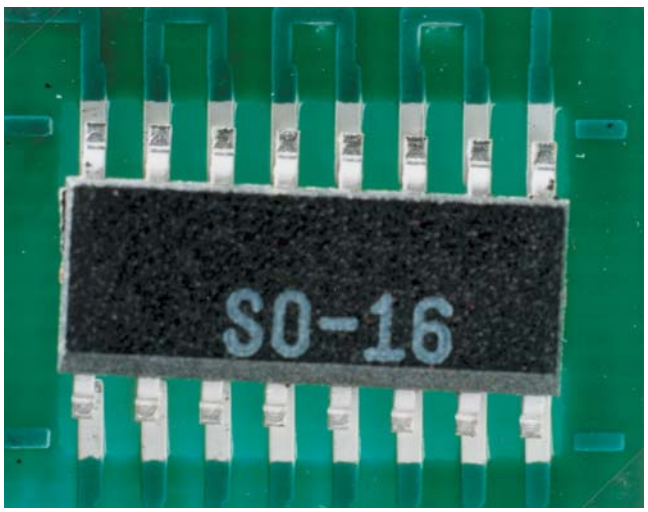

Figure 8-79

Acceptable – Class 3

- Maximum overhang (A) is not greater than 25% lead width (W) or 0.5 mm [0.02 in], whichever is less.

8.3.5.1 Flat Gull Wing Leads – Side Overhang (A) (cont.)

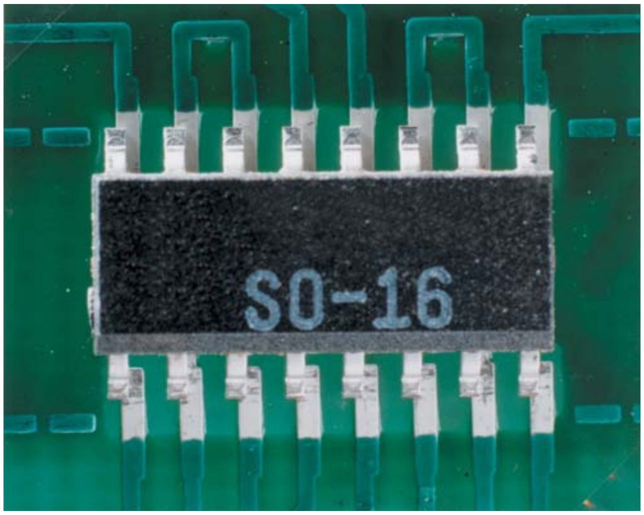

Figure 8-80

Defect – Class 1,2

- Side overhang (A) is greater than 50% lead width (W) or 0.5 mm [0.02 in], whichever is less.

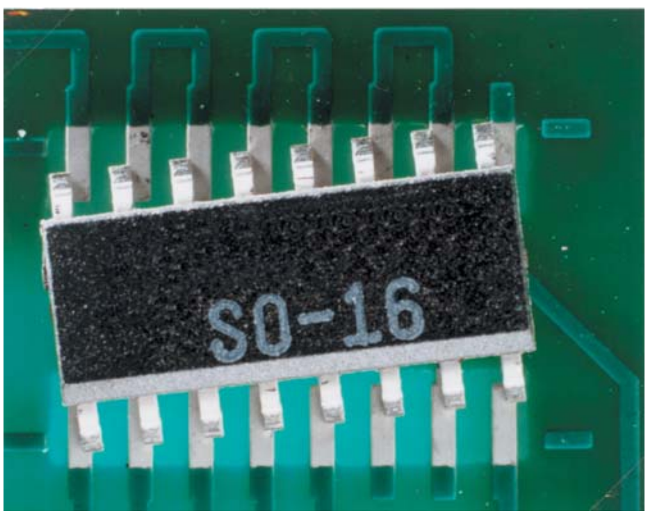

Figure 8-81

Defect – Class 3

- Side overhang (A) is greater than 25% lead width (W) or 0.5 mm [0.02 in], whichever is less.

8.3.5.2 Flat Gull Wing Leads – Toe Overhang (B)

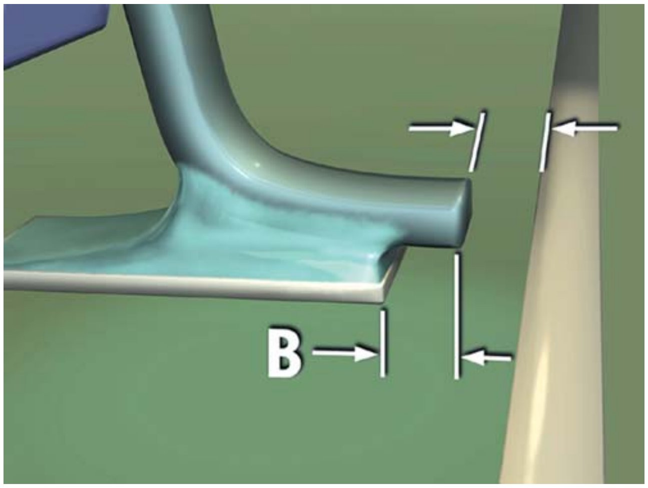

Figure 8-82

Acceptable – Class 1,2,3

- Toe overhang does not violate minimum electrical clearance.

Acceptable – Class 2,3

- When (L) is greater than or equal to 3 (W), formed foot length (L) is greater than three lead widths (W) and toe overhang (B) does not violate minimum electrical clearance.
- When (L) is less than 3 (W), formed foot length (L) is greater than one lead width (W) and toe overhang (B) does not violate minimum electrical clearance.

Defect – Class 2,3

- Toe overhang, when (L) is less than (W).

Defect – Class 1,2,3

- Toe overhang violates minimum electrical clearance.

8.3.5.3 Flat Gull Wing Leads – Minimum End Joint Width (C)

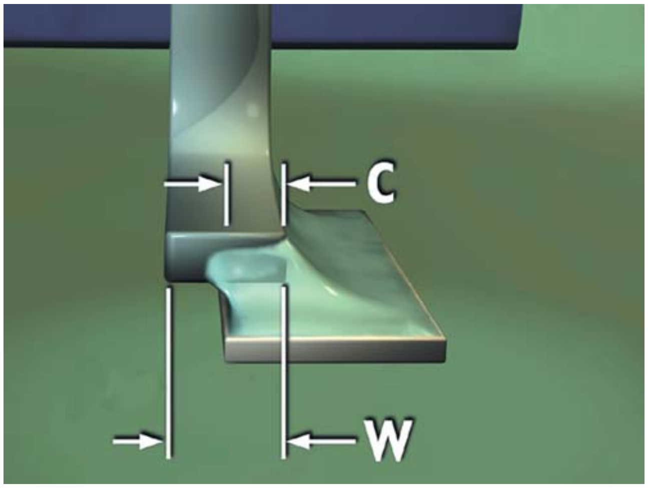

Figure 8-83

Acceptable – Class 1,2

• Minimum end joint width (C) is 50% lead width (W).

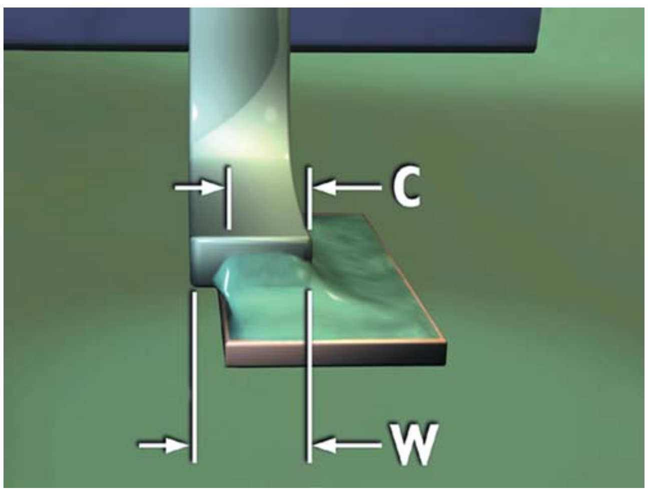

Figure 8-84

Acceptable – Class 3

• Minimum end joint width (C) is 75% lead width (W).

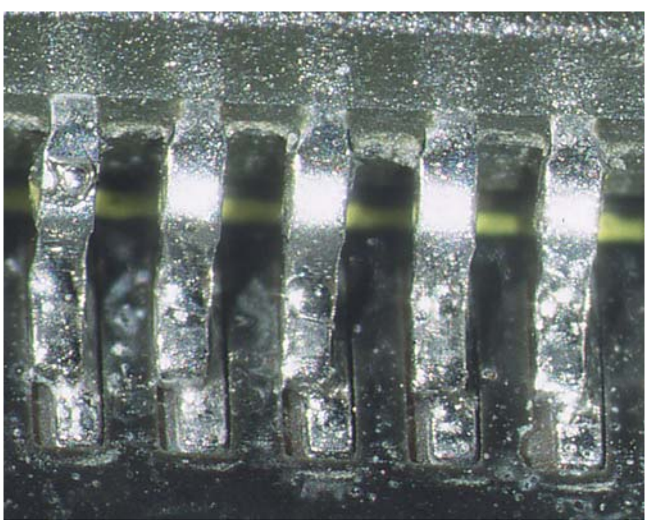

Figure 8-85

Defect – Class 1,2

• Minimum end joint width (C) is less than 50% lead width (W).

Defect – Class 3

• Minimum end joint width (C) is less than 75% lead width (W).

8.3.5.4 Flat Gull Wing Leads – Minimum Side Joint Length (D)

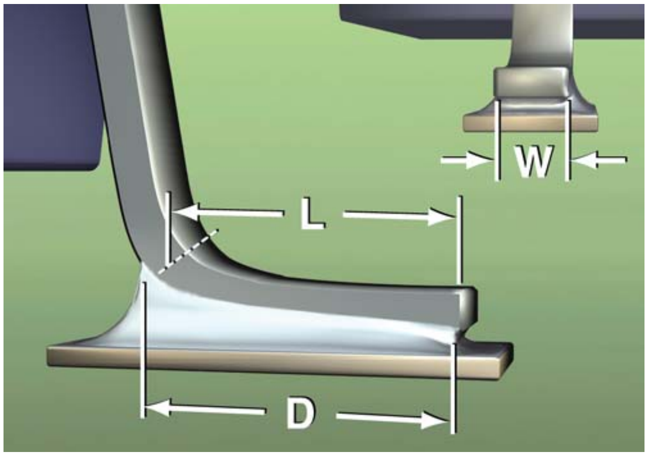

Figure 8-86

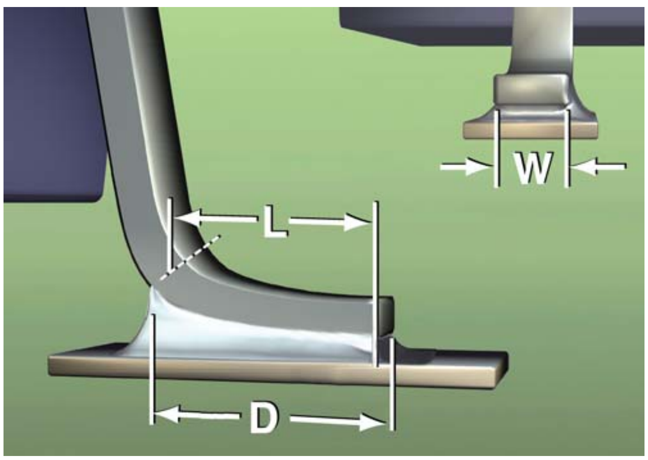

Figure 8-87

Acceptable – Class 1

- Minimum side joint length (D) is equal to lead width (W) or 0.5 mm [0.02 in], whichever is less (not shown).

Acceptable – Class 2,3

- When foot length (L) is greater than or equal to three lead widths (W), minimum side joint length (D) is equal to or greater than three lead widths (W) or 75% (L), whichever is longer, see Figure 8-86.
- When foot length (L) is less than three lead widths (W), minimum side joint length (D) is equal to 100% (L), see Figure 8-87.

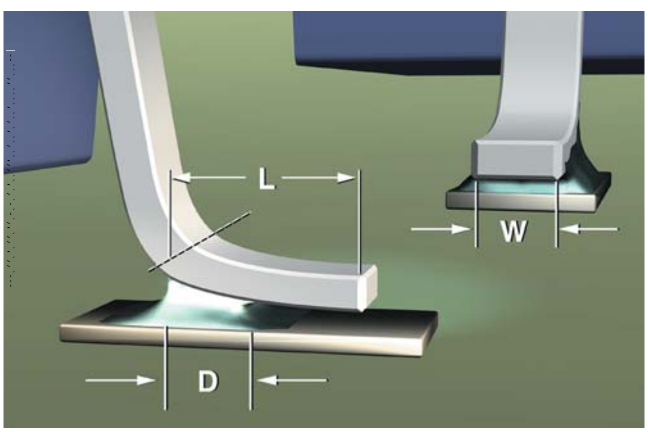

Figure 8-88

Defect – Class 1

- Minimum side joint length (D) is less than the lead width (W) or 0.5 mm [0.02 in], whichever is less.

Defect – Class 2,3

- When foot length (L) is greater than or equal to three lead widths (W), minimum side joint length (D) is less than three lead widths (W) or 75% (L), whichever is longer.
- When foot length (L) is less than three lead widths (W), minimum side joint length (D) is less than 100% (L).

8.3.5.5 Flat Gull Wing Leads – Maximum Heel Fillet Height (E)

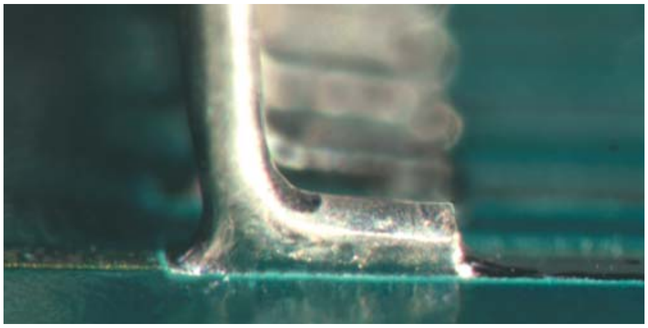

Figure 8-89

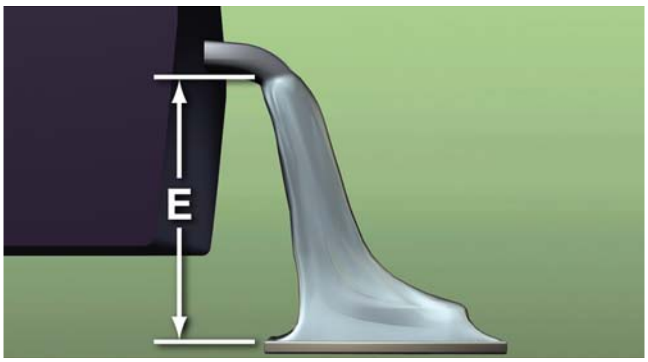

Figure 8-90

Acceptable – Class 1,2,3

- Solder does not contact the component body.

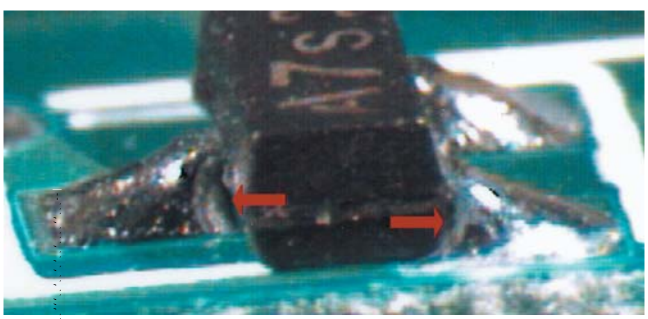

Figure 8-91

Acceptable – Class 1,2,3

- Solder touches a plastic SOIC family of components (small outline packages such as SOT, SOD), see Figure 8-91.
- Solder does not touch ceramic or metal component.

Defect – Class 1,2,3

- Solder touches the body of a plastic component, except for SOIC family of components (small outline packages such as SOT, SOD).
- Solder touches the body of a ceramic or metal component.

8.3.5.6 Flat Gull Wing Leads – Minimum Heel Fillet Height (F)

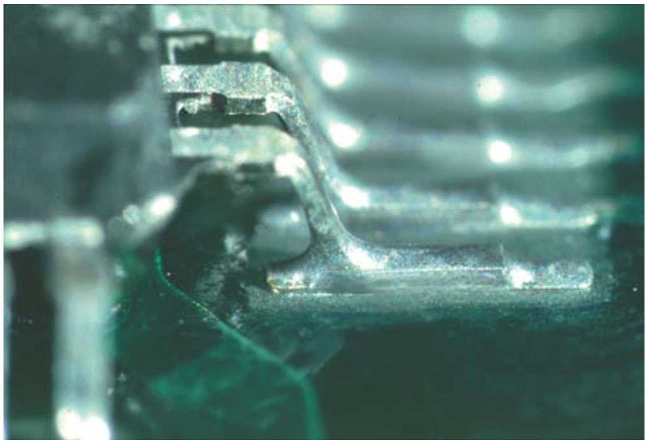

Figure 8-92

Acceptable – Class 1,2,3

- Heel fillet height (F) is greater than solder thickness (G) plus lead thickness (T) but does not extend into knee bend radius.

Acceptable – Class 1

- A wetted fillet is evident.

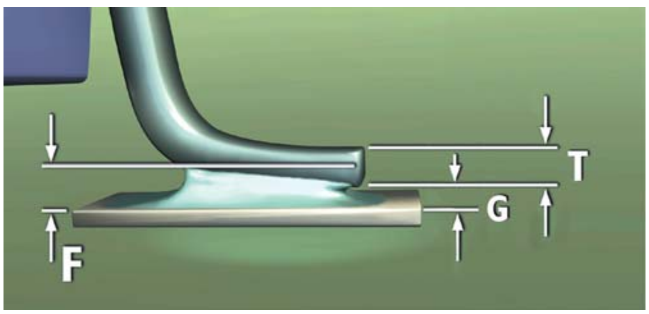

Figure 8-93

Acceptable – Class 2,3

- The minimum heel fillet is solder thickness (G) + 50% lead thickness (T).

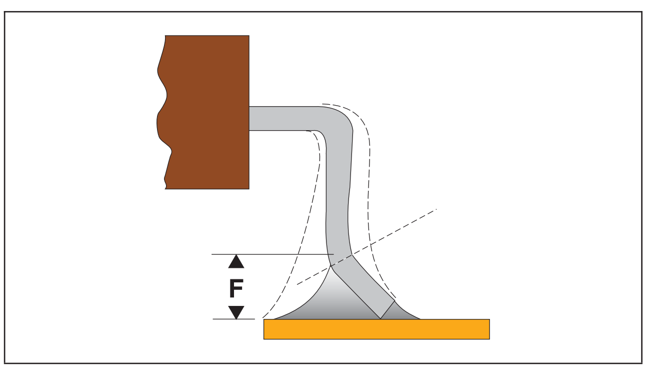

Figure 8-94

Acceptable – Class 1,2,3

- In the case of a toe-down configuration, see Figure 8-94, the minimum heel fillet height (F) extends at least to the mid-point of the outside lead bend.

8.3.5.6 Flat Gull Wing Leads – Minimum Heel Fillet Height (F) (cont.)

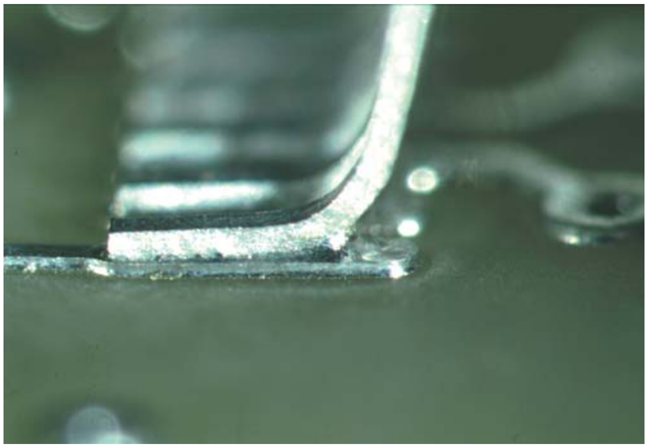

Figure 8-95

Defect – Class 1

- A wetted fillet is not evident.

Defect – Class 2,3

- The minimum heel fillet is less than solder thickness (G) + 50% lead thickness (T).

Defect – Class 1,2,3

- In the case of a toe-down configuration, the minimum heel fillet height (F) does not extend at least to the mid-point of the outside lead bend.

8.3.5.7 Flat Gull Wing Leads – Solder Thickness (G)

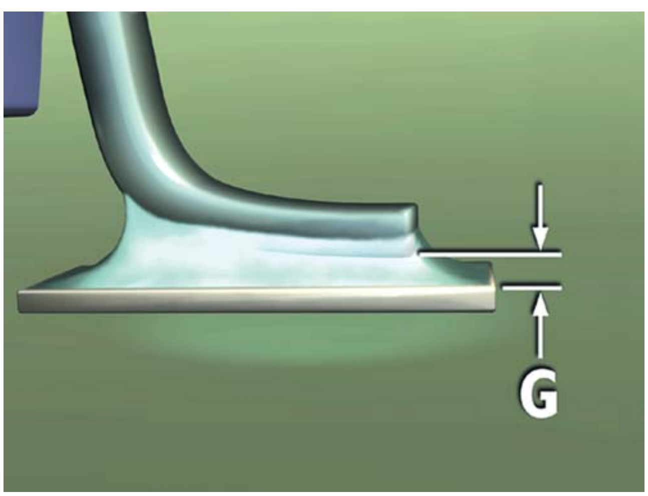

Figure 8-96

Acceptable – Class 1,2,3

- Wetted fillet evident.

Defect – Class 1,2,3

- No wetted fillet.

8.3.5.8 Flat Gull Wing Leads – Coplanarity

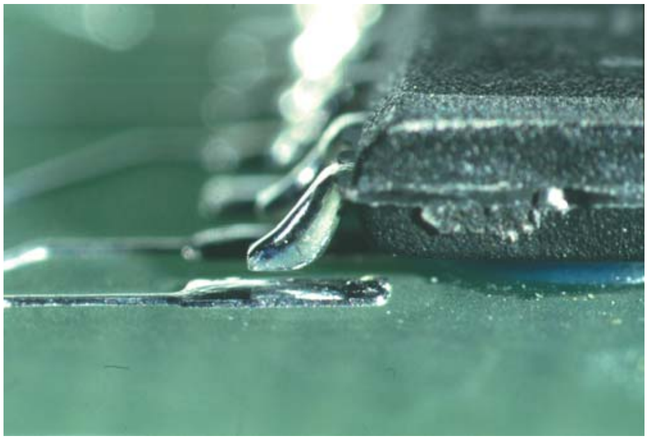

Figure 8-97

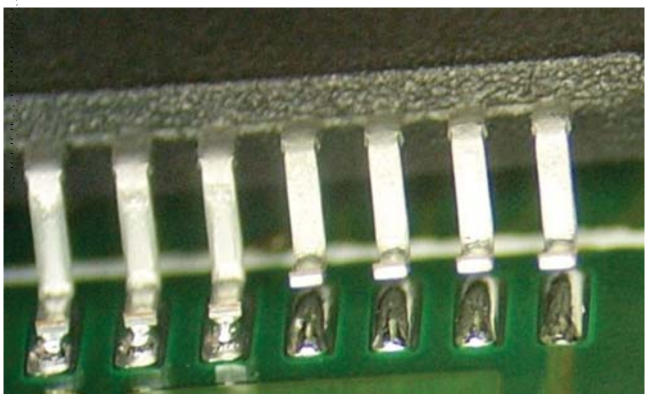

Figure 8-98

Defect – Class 1,2,3

- Component lead(s) out of alignment (coplanarity) preventing the formation of an acceptable solder connection.

8.3.6 Round or Flattened (Coined) Gull Wing Leads

Connections formed to round or flattened (coined) leads **shall** meet the dimensional and fillet requirements of Table 8-6 and 8.3.6.1 through 8.3.6.9.

Table 8-6 Dimensional Criteria – Round or Flattened (Coined) Gull Wing Lead Features

Feature	Dim	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W) or 0.5 mm [0.02 in], whichever is less, Note 1		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 (W), Note 1		Not permitted when (L) is less than 1.5 (W), Note 1
Minimum End Joint Width	C	Note 3		75% (W)
Minimum Side Joint Length	D	100% (W), Note 6		150% (W), Note 6
Maximum Heel Fillet Height	E	Note 4		
Minimum Heel Fillet Height	F	Note 3	(G) + 50% (T), Note 5	
Solder Thickness	G	Note 3		
Formed Foot Length	L	Note 2		
Minimum Side Joint Height	Q	Notes 3, 6	(G) + 50% (T), Note 6	
Thickness of Lead at Joint Side	T	Note 2		
Flattened Lead Width or Diameter of Round Lead	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. Solder does not touch package body or end seal, see 8.2.1 Surface Mount Assemblies – SMT Leads – Plastic Components.
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. Side fillet (and corresponding Dimensions (D) & (Q)) would not form and therefore is not required on a side where acceptable side overhang (A) is present.

8.3.6.1 Round or Flattened (Coined) Gull Wing Leads – Side Overhang (A)

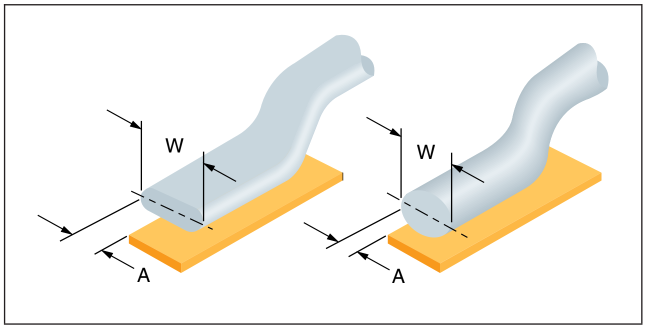

Figure 8-99

Acceptable – Class 1,2

- Side overhang (A) is not greater than 50% lead width/diameter (W) or 0.5 mm [0.02 in], whichever is less.

Acceptable – Class 3

- Side overhang (A) is not greater than 25% lead width/diameter (W) or 0.5 mm [0.02 in], whichever is less.

Defect – Class 1,2

- Side overhang (A) is greater than 50% lead width/diameter (W) or 0.5 mm [0.02 in], whichever is less.

Defect – Class 3

- Side overhang (A) is greater than 25% lead width/diameter (W) or 0.5 mm [0.02 in], whichever is less.

8.3.6.2 Round or Flattened (Coined) Gull Wing Leads – Toe Overhang (B)

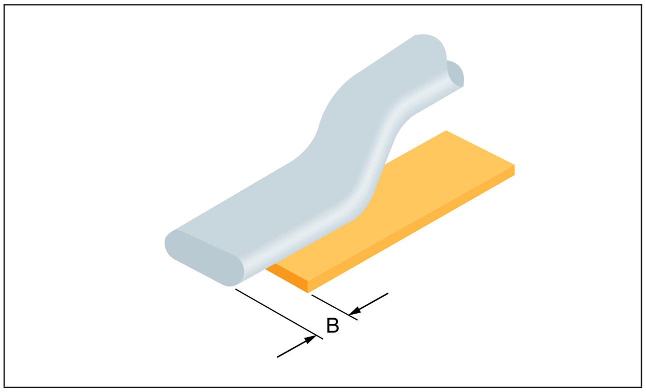

Figure 8-100

Acceptable – Class 1,2

- Formed foot length (L) is greater than or equal to lead/width diameter (W) and toe overhang (B) does not violate minimum electrical clearance.

Acceptable – Class 3

- Formed foot length (L) is greater than or equal to 1.5 lead/width diameter (W) and toe overhang (B) does not violate minimum electrical clearance.

Defect – Class 1,2

- Toe overhang (B) when formed foot length (L) is less than lead/width diameter (W).

Defect – Class 3

- Toe overhang (B) when formed foot length (L) is less than 1.5 lead/width diameter (W).

Defect – Class 1,2,3

- Toe overhang violates minimum electrical clearance.

8.3.6.3 Round or Flattened (Coined) Gull Wing Leads – Minimum End Joint Width (C)

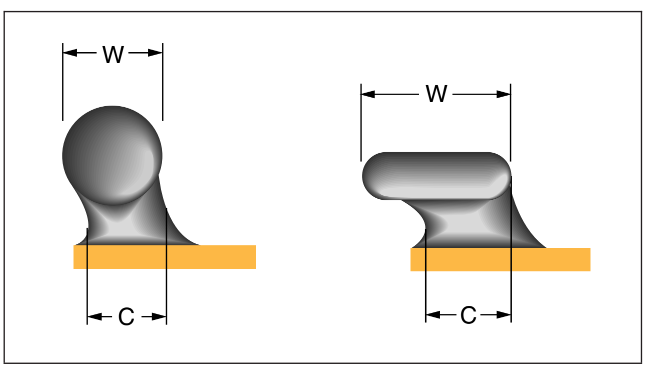

Figure 8-101

Acceptable – Class 1,2

- Wetted fillet is evident.

Acceptable – Class 3

- End joint width (C) is minimum 75% lead width/diameter (W).

Defect – Class 1,2

- No evidence of wetted fillet.

Defect – Class 3

- Minimum end joint width (C) is less than 75% lead width/diameter (W).

8.3.6.4 Round or Flattened (Coined) Gull Wing Leads – Minimum Side Joint Length (D)

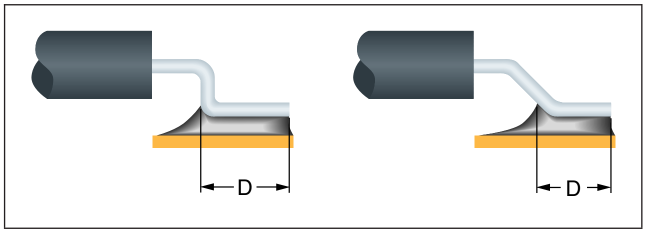

Figure 8-102

Acceptable – Class 1,2

- Side joint length (D) is equal to lead width/diameter (W).

Acceptable – Class 3

- Minimum side joint length (D) is equal to 150% lead width/diameter (W).

Defect – Class 1,2

- Side joint length (D) is less than lead width/diameter (W).

Defect – Class 3

- Minimum side joint length (D) is less than 150% the lead width/diameter (W).

8.3.6.5 Round or Flattened (Coined) Gull Wing Leads – Maximum Heel Fillet Height (E)

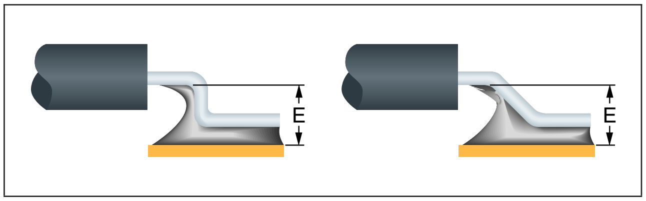

Figure 8-103

Acceptable – Class 1,2,3

- Solder does not contact the component body.
- Solder touches a plastic SOIC family of components (small outline packages such as SOT, SOD).
- Solder does not touch body of ceramic or metal component.

Defect – Class 1

- A wetted fillet is not evident.

Defect – Class 1,2,3

- Solder touches the body of a plastic component, except for SOIC family of components (small outline packages such as SOT, SOD).
- Solder touches the body of ceramic or metal component.
- Solder is excessive so that the minimum electrical clearance is violated.

8.3.6.6 Round or Flattened (Coined) Gull Wing Leads – Minimum Heel Fillet Height (F)

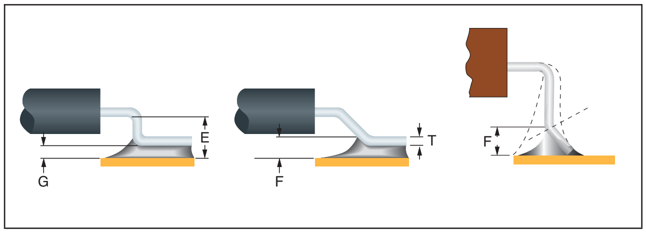

Figure 8-104

Acceptable – Class 1,2,3

- In the case of a toe-down configuration, the minimum heel fillet height (F) extends at least to the mid-point of the outside lead bend.

Acceptable – Class 1

- A wetted fillet is evident.

Acceptable – Class 2,3

- Minimum heel fillet height (F) is equal to solder thickness (G) plus 50% thickness of lead at joint side (T).

Defect – Class 1

- A wetted fillet is not evident.

Defect – Class 2,3

- Minimum heel fillet height (F) is less than solder thickness (G) plus 50% thickness of lead at joint side (T).

Defect – Class 2,3

- In the case of a toe-down configuration, the minimum heel fillet height (F) does not extend at least to the mid-point of the outside lead bend.

8.3.6.7 Round or Flattened (Coined) Gull Wing Leads – Solder Thickness (G)

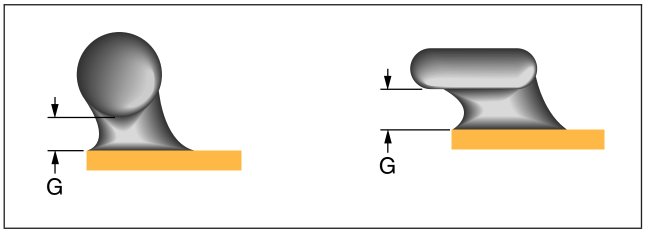

Figure 8-105

Acceptable – Class 1,2,3

• Wetted fillet evident.

Defect – Class 1,2,3

• No wetted fillet.

8.3.6.8 Round or Flattened (Coined) Gull Wing Leads – Minimum Side Joint Height (Q)

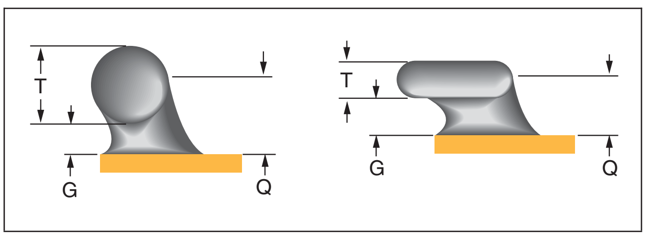

Figure 8-106

Acceptable – Class 1

• A wetted fillet is evident.

Acceptable – Class 2,3

• Minimum side joint height (Q) is equal to or greater than solder thickness (G) plus 50% lead thickness (T).

Defect – Class 1

• A wetted fillet is not evident.

Defect – Class 2,3

• Minimum side joint height (Q) is less than solder thickness (G) plus 50% lead thickness (T).

8.3.6.9 Round or Flattened (Coined) Gull Wing Leads – Coplanarity

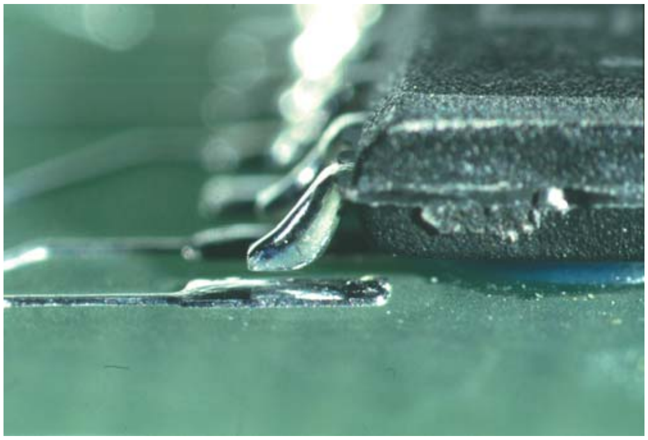

Figure 8-107

Defect – Class 1,2,3

- Component lead(s) out of alignment (coplanarity) preventing the formation of an acceptable solder connection.

8.3.7 J Leads

Connections formed to leads having a J shape **shall** meet the dimensional and fillet requirements in Table 8-7 and 8.3.7.1 through 8.3.7.8.

Table 8-7 Dimensional Criteria – J Leads

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W), Note 1		25% (W), Note 1
Maximum Toe Overhang	B	Note 1		
Minimum End Joint Width	C	50% (W), Note 5		75% (W), Note 5
Minimum Side Joint Length	D	Note 3	150% (W)	
Maximum Heel Fillet Height	E	Note 4		
Minimum Heel Fillet Height	F	(G) + 50% (T)		(G) + (T)
Solder Thickness	G	Note 3		
Lead Thickness	T	Note 2		
Lead Width	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. Solder does not touch package body or end seal, see 8.2.1 Surface Mount Assemblies – SMT Leads – Plastic Components.
Note 5. (C) is inspected at the narrowest point of the required fillet.

8.3.7.1 J Leads – Side Overhang (A)

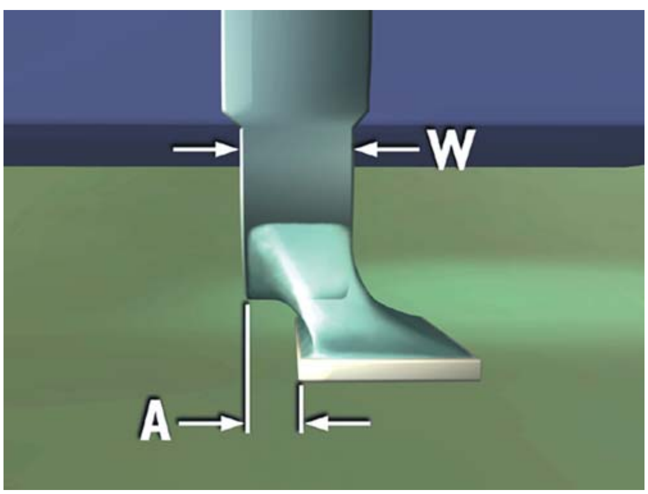

Figure 8-108

Acceptable – Class 1,2

- Side overhang (A) equal to or less than 50% lead width (W).

8.3.7.1 J Leads – Side Overhang (A) (cont.)

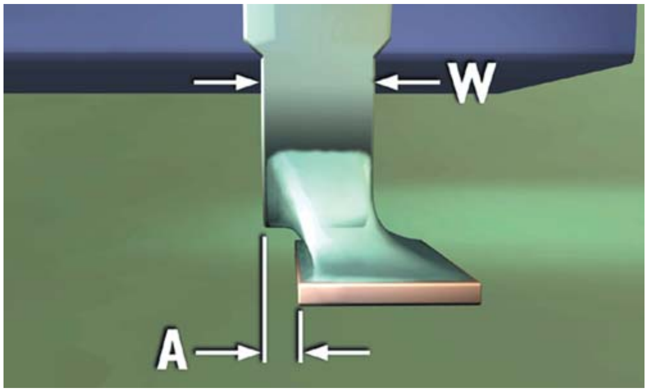

Figure 8-109

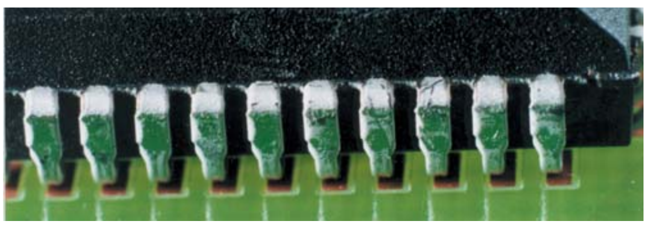

Figure 8-110

Acceptable – Class 3

- Side overhang (A) equal to or less than 25% lead width (W).

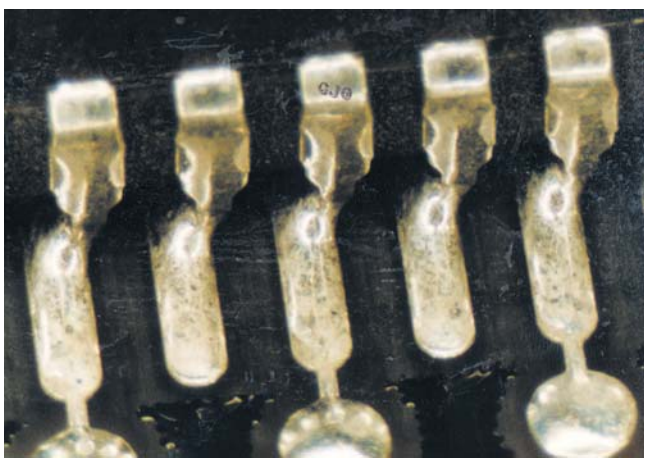

Figure 8-111

Defect – Class 1,2

- Side overhang exceeds 50% lead width (W).

Defect – Class 3

- Side overhang exceeds 25% lead width (W).

8.3.7.2 J Leads – Toe Overhang (B)

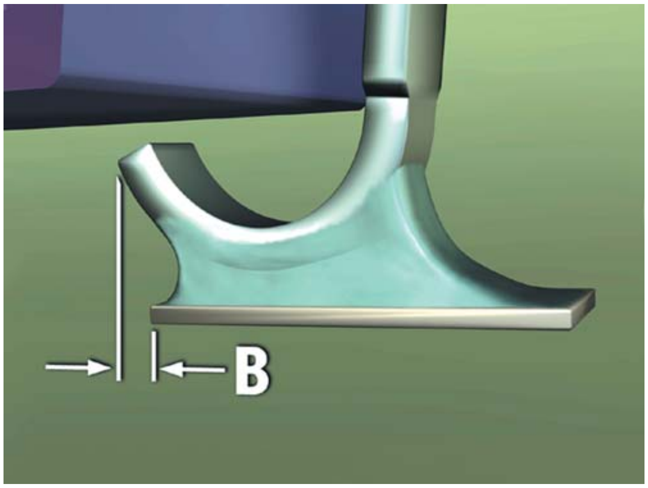

Figure 8-112

Acceptable – Class 1,2,3

- Toe overhang (B) is an unspecified parameter.

8.3.7.3 J Leads – End Joint Width (C)

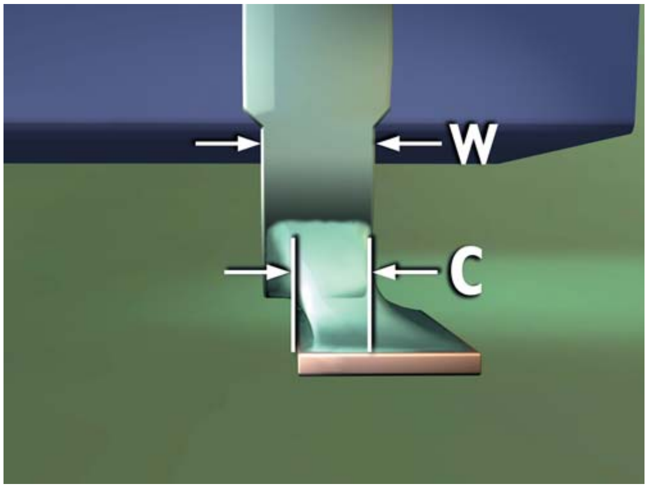

Figure 8-113

Acceptable – Class 1,2

- Minimum end joint width (C) is 50% lead width (W).

Acceptable – Class 3

- Minimum end joint width (C) is 75% lead width (W).

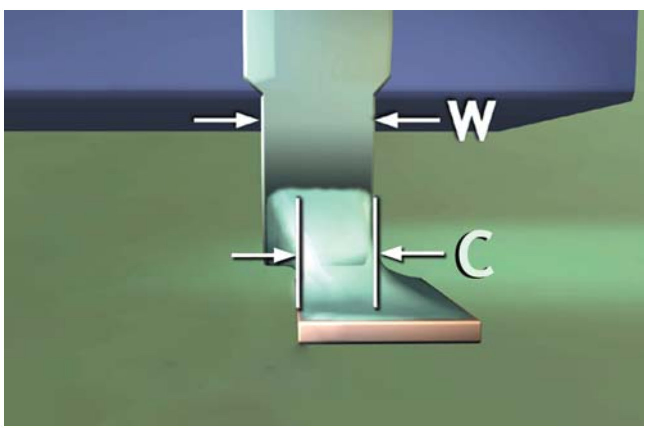

Figure 8-114

Defect – Class 1,2

- Minimum end joint width (C) is less than 50% lead width (W).

Defect – Class 3

- Minimum end joint width (C) is less than 75% lead width (W).

8.3.7.4 J Leads – Side Joint Length (D)

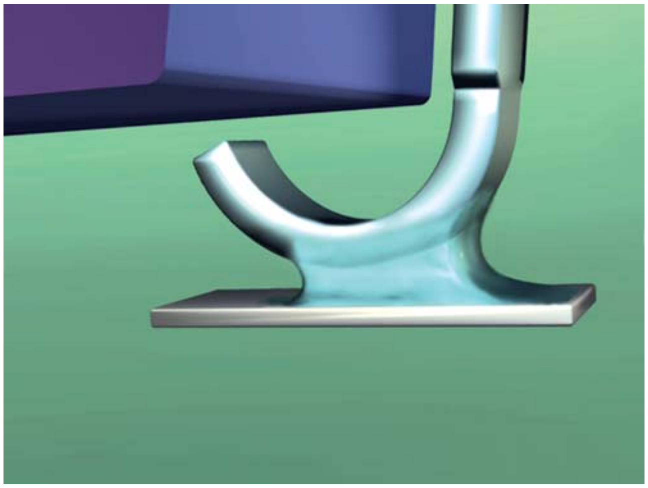

Figure 8-115

Acceptable – Class 1

- Wetted fillet.

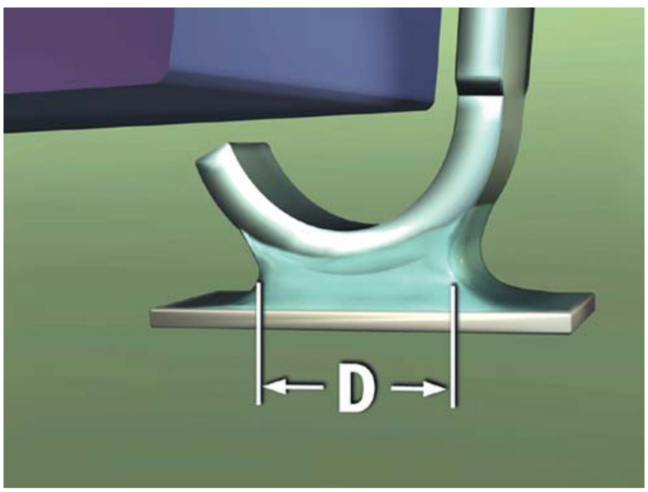

Figure 8-116

Acceptable – Class 2,3

- Side joint length (D) greater than or equal to 150% lead width (W).

Defect – Class 2,3

- Side joint fillet (D) less than 150% lead width (W).

Defect – Class 1,2,3

- A wetted fillet is not evident.

8.3.7.5 J Leads – Maximum Heel Fillet Height (E)

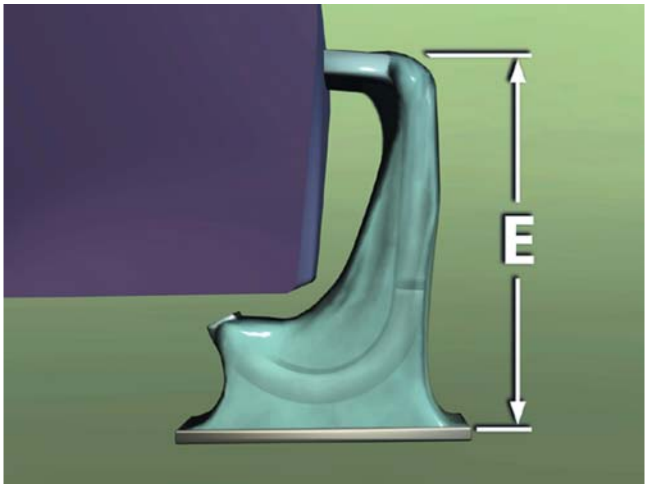

Figure 8-117

Acceptable – Class 1,2,3

- Solder fillet does not touch package body.

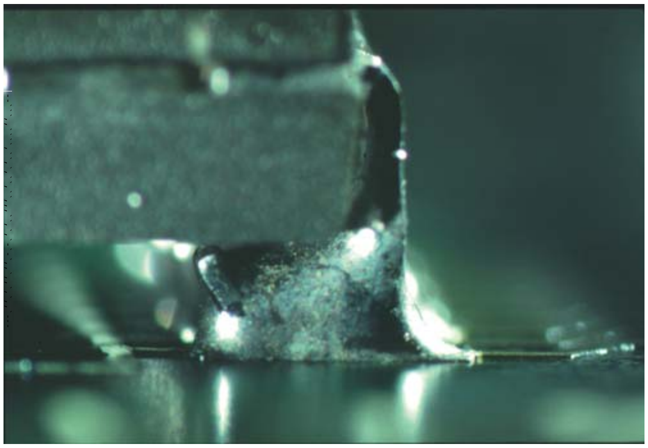

Figure 8-118

Defect – Class 1,2,3

- Solder fillet touches package body, see 8.2.1 Surface Mount Assemblies – SMT Leads – Plastic Components.

8.3.7.6 J Leads – Minimum Heel Fillet Height (F)

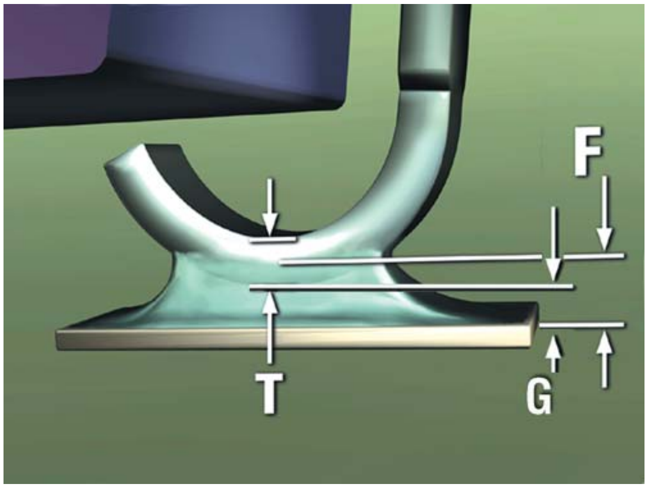

Figure 8-119

Acceptable – Class 1,2

- Heel fillet height (F) is minimum solder thickness (G) plus 50% lead thickness (T).

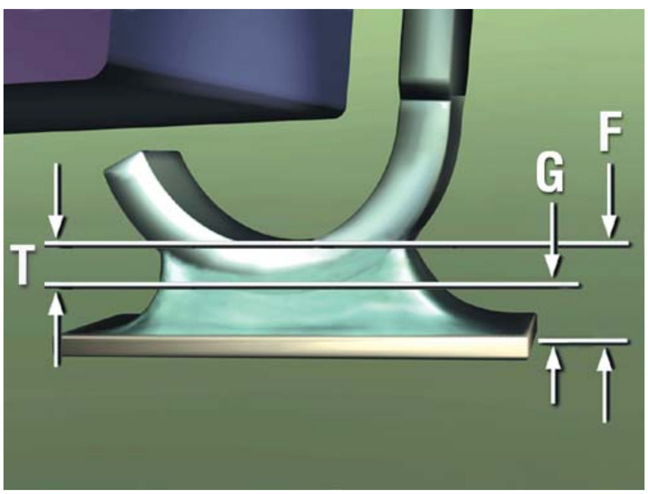

Figure 8-120

Acceptable – Class 3

- Heel fillet height (F) is at least lead thickness (T) plus solder thickness (G).

8.3.7.6 J Leads – Minimum Heel Fillet Height (F) (cont.)

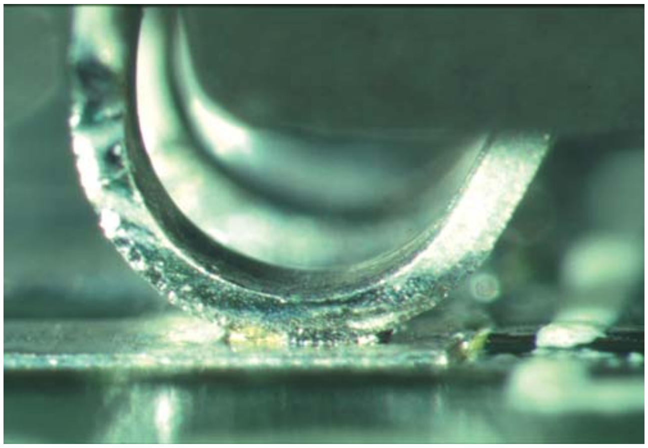

Figure 8-121

Defect – Class 1,2,3

- Heel fillet not wetted.

Defect – Class 1,2

- Heel fillet height (F) less than solder thickness (G) plus 50% lead thickness (T).

Defect – Class 3

- Heel fillet height (F) less than solder thickness (G) plus lead thickness (T).

8.3.7.7 J Leads – Solder Thickness (G)

Figure 8-122

Acceptable – Class 1,2,3

- Wetted fillet evident.

Defect – Class 1,2,3

- No wetted fillet.

8.3.7.8 J Leads – Coplanarity

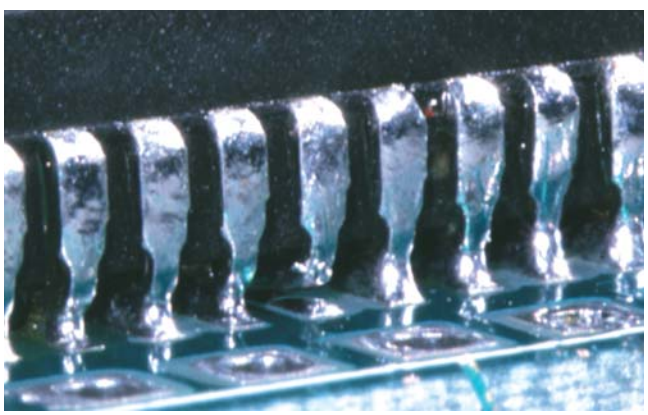

Figure 8-123

Defect – Class 1,2,3

- Component lead(s) out of alignment (coplanarity) preventing the formation of an acceptable solder connection.

8.3.8 Butt/I Connections

Connections formed with leads configured for butt mounting **shall** meet dimensional and solder fillet requirements in Tables 8-8 or 8.9 and 8.3.8.1.1 through 8.3.8.2.4 as applicable.

8.3.8.1 Butt/I Connections – Modified Through-Hole Terminations

Components designed for pin-in-hole application and modified for butt connection attachment, or stiff-leaded dual-inline packages, e.g., Alloy 42, brazed or tempered leads, etc., may be modified for use on Class 1 and 2 products. Butt connections with modified through-hole leads are not permitted for Class 3 products.

Post assembly acceptability evaluations should consider the inherent limitation of this component mounting technique to survive operational environments when compared to footed leads or through-hole mounting.

For Class 1 and 2 product, leads not having wettable sides by design (such as leads stamped or sheared from preplated stock) are not required to have side fillets. However the design should permit easy inspection of wetting to the wettable surfaces.

Table 8-8 Dimensional Criteria – Butt/I Connections – Modified Through-Hole Leads

Feature	Dim.	Class 1	Class 2
Maximum Side Overhang	A	25% (W), Note 1	Not permitted
Toe Overhang	B	Not permitted	
Minimum End Joint Width	C	75% (W), Note 5	
Minimum Side Joint Length	D	Note 3	
Maximum Fillet Height	E	Note 4	
Minimum Fillet Height	F	0.5 mm [0.02 in]	
Solder Thickness	G	Note 3	
Lead Thickness	T	Note 2	
Lead Width	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. Solder does not touch package body.
Note 5. (C) is inspected at the narrowest point of the required fillet.

8.3.8.1.1 Butt/I Connections – Modified Through-Hole Terminations – Maximum Side Overhang (A)

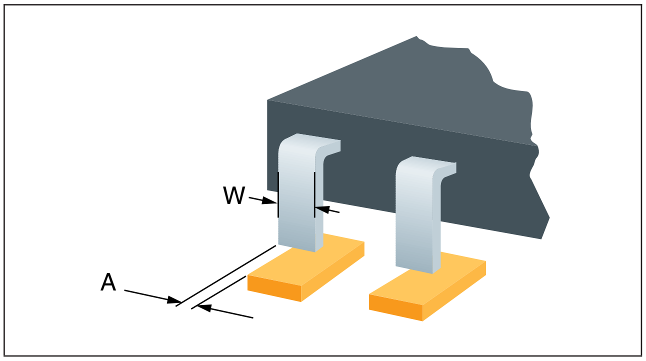

Figure 8-124

Acceptable – Class 1

- Overhang (A) less than 25% lead width (W), see Figure 8-124.

Defect – Class 1

- Overhang (A) exceeds 25% lead width (W).

Defect – Class 2

- Any side overhang (A).

8.3.8.1.2 Butt/I Connections – Modified Through-Hole Terminations – Toe Overhang (B)

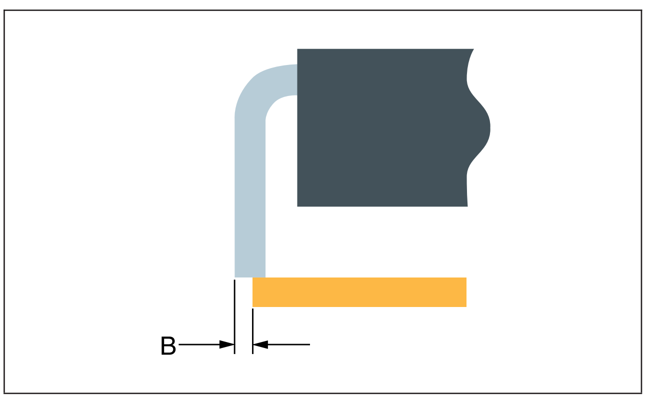

Figure 8-125

Defect – Class 1,2

- Any toe overhang (B).

8.3.8.1.3 Butt/I Connections – Modified Through-Hole Terminations – Minimum End Joint Width (C)

Acceptable – Class 1, 2

- End joint width (C) is minimum 75% lead width (W).

Defect – Class 1, 2

- End joint width (C) is less than 75% lead width (W).

8.3.8.1.4 Butt/I Connections – Modified Through-Hole Terminations – Minimum Side Joint Length (D)

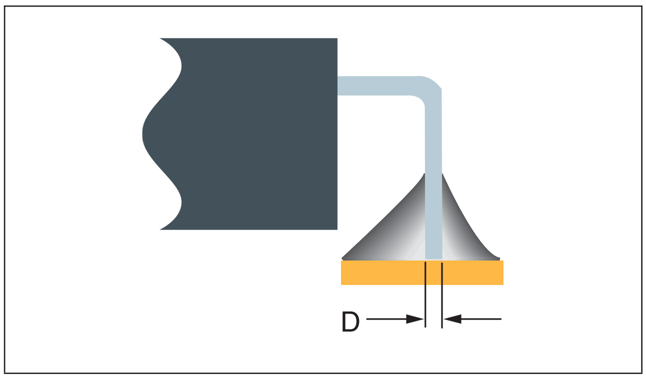

Figure 8-126

Acceptable – Class 1,2

- Wetting is evident.

8.3.8.1.5 Butt/I Connections – Modified Through-Hole Terminations – Maximum Fillet Height (E)

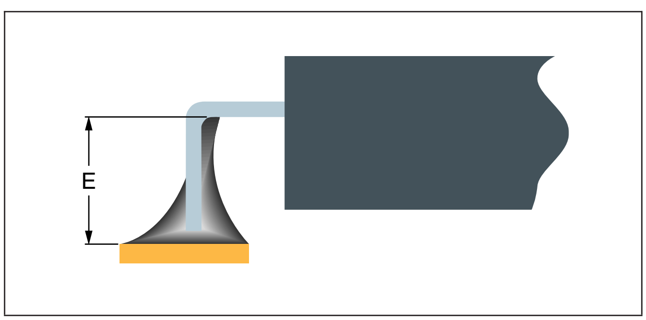

Figure 8-127

Acceptable – Class 1,2

- Wetted fillet evident.

Defect – Class 1,2

- No wetted fillet.
- Solder touches package body.

8.3.8.1.6 Butt/I Connections – Modified Through-Hole Terminations – Minimum Fillet Height (F)

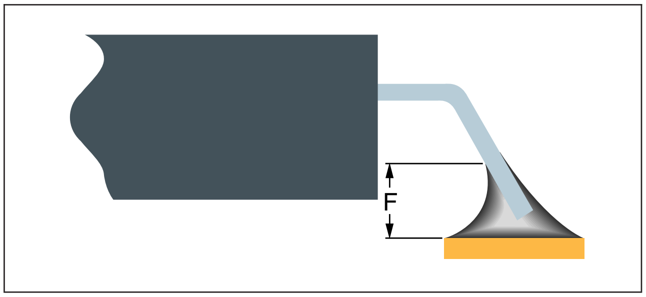

Figure 8-128

Acceptable – Class 1,2

- Fillet height (F) is minimum 0.5 mm [0.02 in].

Defect – Class 1,2

- Fillet height (F) is less than 0.5 mm [0.02 in].

8.3.8.1.7 Butt/I Connections – Modified Through-Hole Terminations – Solder Thickness (G)

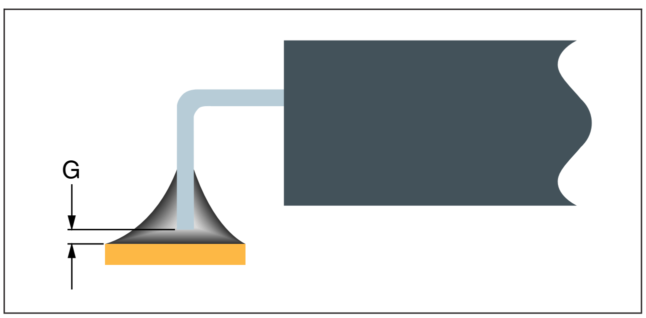

Figure 8-129

Acceptable – Class 1,2

- Wetted fillet evident.

Defect – Class 1,2

- No wetted fillet.

8.3.8.2 Butt/I Connections – Solder Charged Terminations

These criteria are for components designed with a hole or holes in the lead, a bump on the bottom to assure a good (G) fillet thickness across most of the bottom, and an attached solder slug to control the amount of solder, and are applicable to terminations on oval or round land patterns.

The top hole of a solder charged termination with two holes is not required to be filled.

Table 8-9 Dimensional Criteria – Butt/I Connections – Solder Charged Terminations

Feature	Dim.	Class1	Class 2	Class 3
Maximum Side Overhang	A	Not permitted		
Maximum Toe Overhang	B	Not permitted		
Minimum End Joint Width	C	100% of W, Note 2		
Minimum Fillet Height	F	Completely fills bottom hole on the termination		
Lead Width	W	Note 1		
Land Width	P	Note 1		

Note 1. Unspecified parameter or variable in size as determined by design.
Note 2. (C) is inspected at the narrowest point of the required fillet.

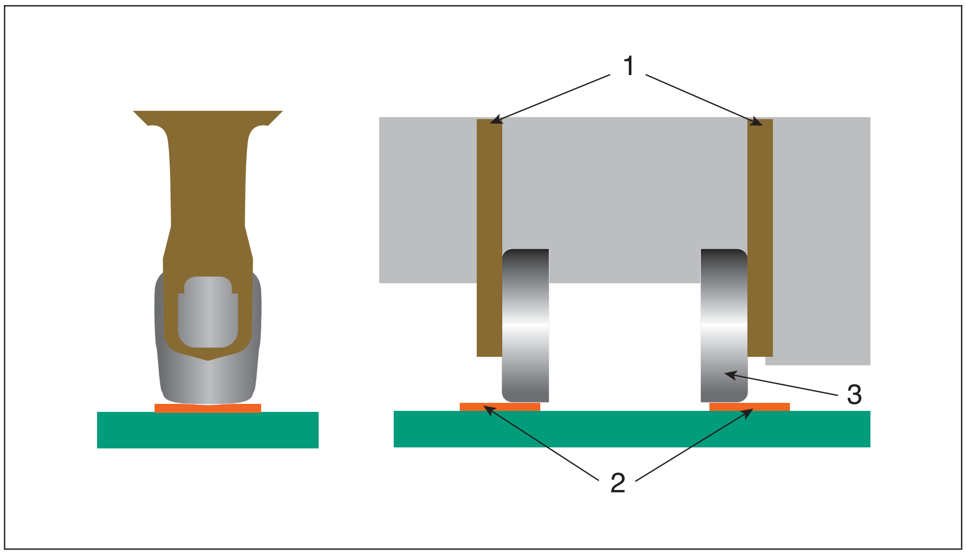

Figure 8-130
1. **Connector lead**
2. **Land**
3. **Solder charge**

8.3.8.2.1 Butt/I Connections – Solder Charged Terminations – Maximum Side Overhang (A)

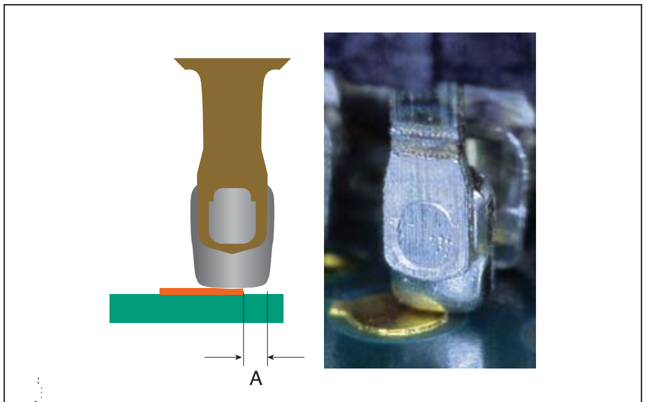

Figure 8-131

Defect – Class 1, 2,3

- Any side overhang (A).

8.3.8.2.2 Butt/I Connections – Solder Charged Terminations – Maximum Toe Overhang (B)

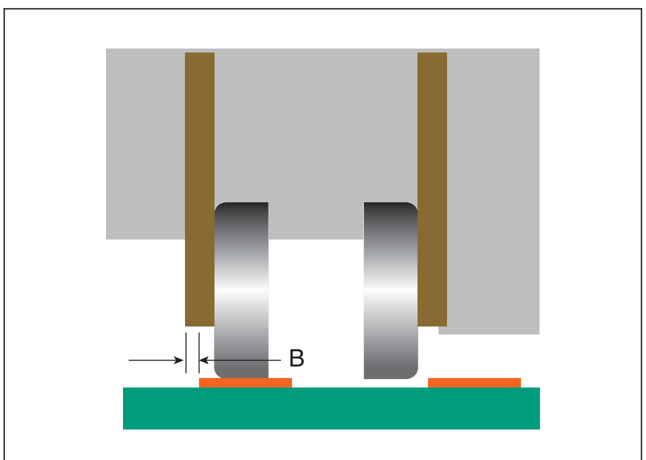

Figure 8-132

Defect – Class 1,2,3

- Any toe overhang (B).

8.3.8.2.3 Butt/I Connections – Solder Charged Terminations – Minimum End Joint Width (C)

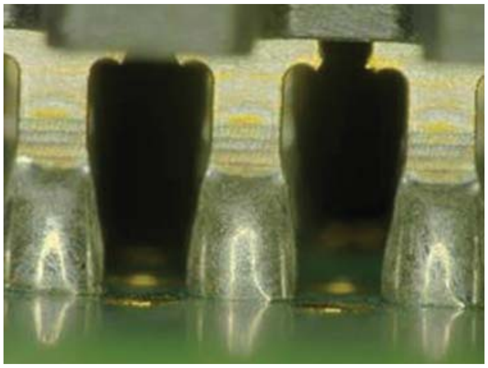

Figure 8-133
1. Lead
2. Land

Acceptable – Class 1,2,3

- End joint width (C) is 100% lead width (W).

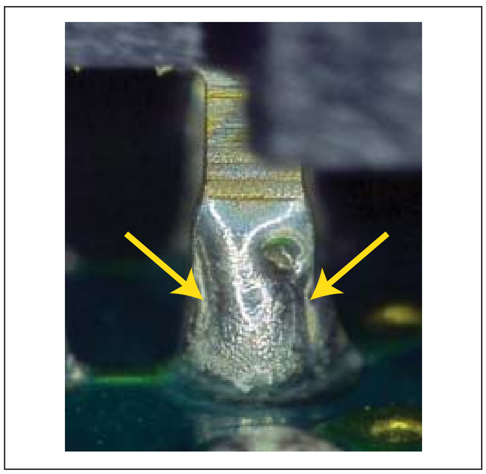

Figure 8-134

Defect – Class 1, 2, 3

- End joint width (C) is less than 100% lead width (W).

8.3.8.2.4 Butt/I Connections – Solder Charged Terminations – Minimum Fillet Height (F)

Acceptable – Class 1,2,3

- For solder charged terminations, the bottom hole is completely filled with solder.

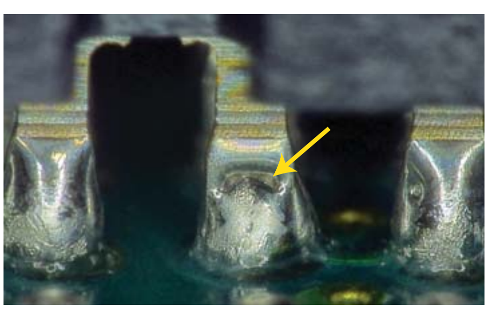

Figure 8-135

Defect – Class 1,2,3

- The bottom hole is not completely filled with solder.

8.3.9 Flat Lug Leads

Connections formed to the leads of components with flat lug leads **shall** meet the dimensional requirements of Table 8-10, see Figures 8-136, 8-137, 8-138 and 8-139. The design should permit easy inspection of wetting to the wettable surfaces.

Criteria for unformed flat lug lead connections, e.g., flexible circuitry terminations, are defined in Table 8-21. These criteria would also be used for non-power dissipating components.

Table 8-10 Dimensional Criteria – Flat Lug Leads[5]

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W), Note 1	25% (W), Note 1	Not permitted
Maximum Toe Overhang	B	Note 1	Not permitted	
Minimum End Joint Width	C	50% (W), Note 6	75% (W), Note 6	100% (W), Note 6
Minimum Side Joint Length	D	Note 3	(L)-(M), Note 4	
Maximum Fillet Height	E	Note 2		(G) + (T) + 1 mm [0.04 in]
Minimum Fillet Height	F	Note 3		(G) + (T)
Solder Thickness	G	Note 3		
Lead Length	L	Note 2		
Gap	M	Notes 1, 2		
Land Width	P	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. Wetted fillet is evident.
Note 4. Where the lug is intended to be soldered beneath the component body and the land is designed for the purpose, the lead shows evidence of wetting in the gap (M).
Note 5. Solder does not touch package body or end seal, see 8.2.1 Surface Mount Assemblies – SMT Leads – Plastic Components.
Note 6. (C) is inspected at the narrowest point of the required fillet.

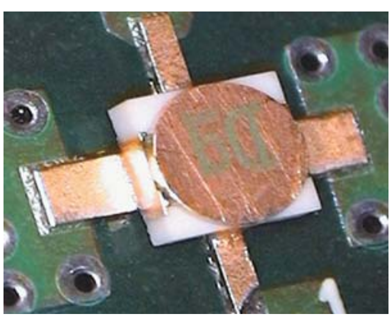

Figure 8-136

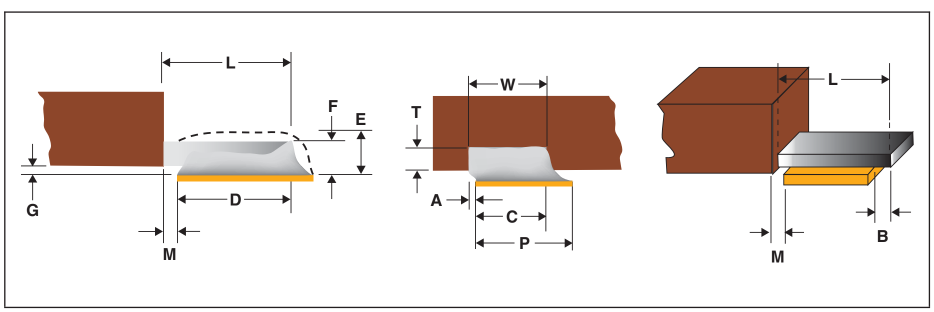

Figure 8-137

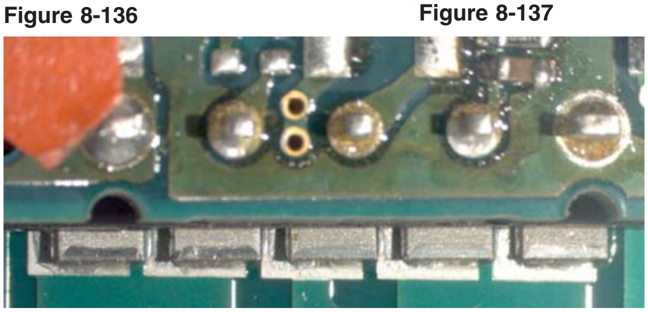

Figure 8-138

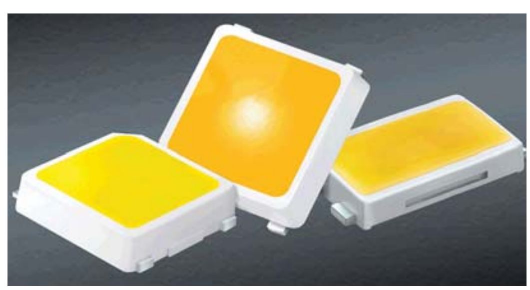

Figure 8-139 SMD-4 LED

8.3.10 Tall Profile Components Having Bottom Only Terminations

Connections formed to the termination areas of tall profile components (component height is more than twice width or thickness, whichever is less) having bottom only terminations **shall** meet the dimensional requirements of Table 8-11, see Figure 8-140.

Table 8-11 Dimensional Criteria – Tall Profile Components Having Bottom Only Terminations

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W), Notes 1, 4	25% (W), Notes 1, 4	Not permitted, Notes 1, 4
Maximum End Overhang	B	Notes 1, 4	Not permitted, Note 4	
Minimum End Joint Width	C	50% (W), Note 5	75% (W), Note 5	(W), Note 5
Minimum Side Joint Length	D	Note 3	50% (R)	75% (R)
Solder Thickness	G	Note 3		
Termination/Plating Length	R	Note 2		
Land Length	S	Note 2		
Termination 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. As a function of the component design, the termination may not extend to the component edge, and the component body may overhang the printed board land area. It is the component solderable termination area that is not allowed to overhang the printed board land area, except as noted in the table above.
Note 5. (C) is inspected at the narrowest point of the required fillet.

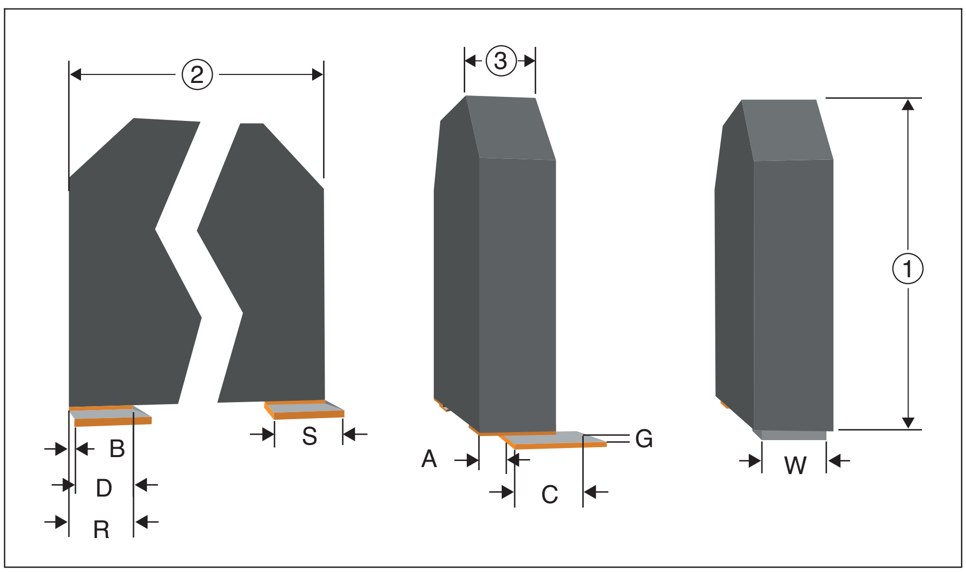

Figure 8-140
1. **Component height**
2. **Component width**
3. **Component thickness**

8.3.11 Inward Formed L-Shaped Ribbon Leads

Connections formed to components having inward formed L-shaped lead terminations **shall** meet the dimensional and solder fillet requirements of Table 8-12, see Figure 8-141. The design should permit easy inspection of wetting to the wettable surfaces.

Table 8-12 Dimensional Criteria – Inward Formed L-Shaped Ribbon Leads[5]

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W), Note 1		25% (W) or 25% (P), whichever is less, Note 1
Maximum Toe Overhang	B	Note 1		
Minimum End Joint Width	C	50% (W), Note 7		75% (W) or 75% (P), whichever is less, Note 7
Minimum Side Joint Length	D	Notes 3, 6	50% (L), Note 6	75% (L), Note 6
Maximum Fillet Height	E	(H) + (G), Note 4		
Minimum Fillet Height	F	Wetting is evident on the vertical surface(s) of the component termination.	(G) + 25% (H) or (G) + 0.5 mm [0.02 in], whichever is less	
Solder Thickness	G	Note 3		
Lead Height	H	Note 2		
Lead Length	L	Note 2		
Land Width	P	Note 2		
Land Length	S	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 contact the component body, see 8.2.1 Surface Mount Assemblies – SMT Leads – Plastic Components.
Note 5. Where a lead has two prongs, the joint to each prong is to meet all the specified requirements.
Note 6. Not always a visually inspectable attribute.
Note 7. (C) is inspected at the narrowest point of the required fillet.

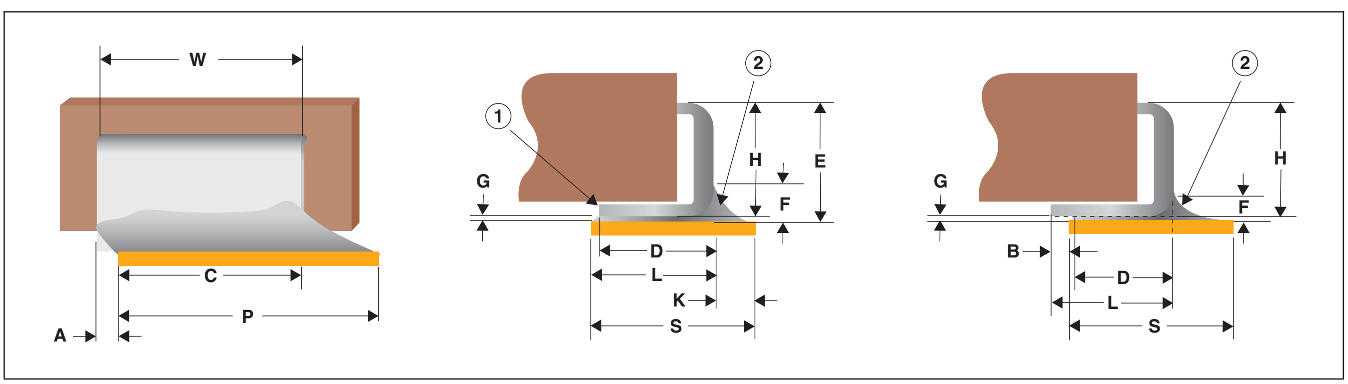

Figure 8-141
1. Toe
2. Heel

8.3.11 Inward Formed L-Shaped Ribbon Leads (cont.)

Figure 8-142

Examples of inward formed L-shaped ribbon lead components.

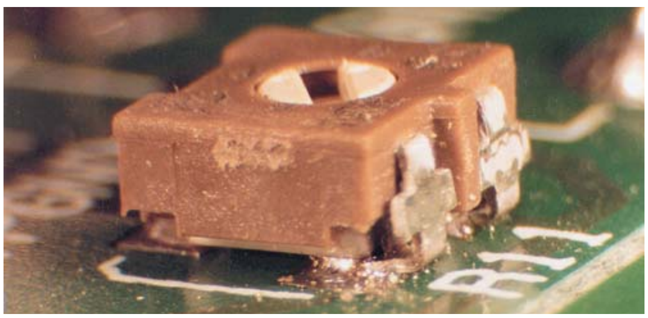

Figure 8-143

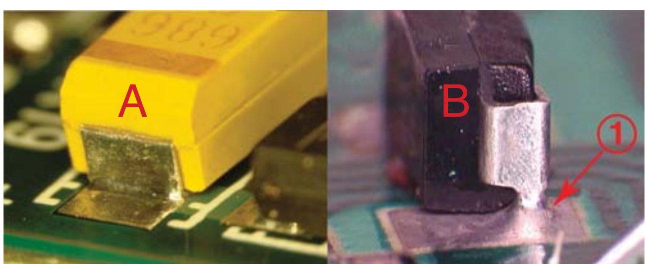

Figure 8-144

Defect – Class 1,2,3

- Insufficient fillet height, see Figure 8-144-A.
- Insufficient end joint width, see Figure 8-144-B, also showing component turned on side preventing formation of required end joint width.

8.3.12 Surface Mount Area Array

Some examples of area array components are BGA, Micro-BGA and Column Grid Array.

Area array criteria defined herein assumes an inspection process is established to determine compliance for both x-ray and 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.

Nonconformance to the requirements of Tables 8-13, 8-14 and 8-15 are defects when visual inspection or x-ray inspection is performed to verify product acceptance.

Visual inspection of the solder terminations on the outside row (perimeter) of the area array component should be performed whenever practical.

Solder balls or columns **shall not** be absent unless specified by design.

Voiding criteria for components with noncollapsing balls are not established, see 1.5.1 Acceptance Criteria.

Alternative criteria for voiding may be developed between Manufacturer and User, see 1.2 Purpose.

Table 8-13 Dimensional Criteria – Ball Grid Array Components with Collapsing Balls

Feature	Clause	Classes 1,2,3
Alignment	8.3.12.1	Solder ball offset does not violate minimum electrical clearance.
Solder Ball Clearance (C), see Figure 8-146	8.3.12.2	Solder ball does not violate minimum electrical clearance.
Soldered Connection	8.3.12.3	No solder bridging; BGA solder balls contact and wet to the land forming a continuous elliptical round connection.
Voids	8.3.12.4	30% or less voiding of any ball in the x-ray image area. Notes 1 and 2.

Note 1. Design induced voids, e.g., microvia in land, are excluded from this criteria. In such cases acceptance criteria should be established between the Manufacturer and User.

Note 2. Plating process induced voids, e.g., champagne voids, are excluded from this criteria. In such cases, the acceptance of the voids will need to be established between the Manufacturer and User.

Table 8-14 Ball Grid Array Components with Noncollapsing Balls

Feature	Classes 1,2,3
Alignment	Solder ball offset does not violate minimum electrical clearance.
Soldered Connections	a. Solder connections meet the criteria of 8.3.12.3. b. Solder is wetted to the solder balls and land terminations.
Voids	Voiding criteria are not established.

Table 8-15 Column Grid Array

Feature	Class 1	Classes 2,3
Alignment	Column offset does not violate minimum electrical clearance.	Column perimeter does not extend beyond the perimeter of the land.
Solder connections	Meet the criteria of 8.3.12.3.	
	Minimum 270° circumferential wetting for the portions of the columns that are visible, see Figure 8-151.	

8.3.12.1 Surface Mount Area Array – Alignment

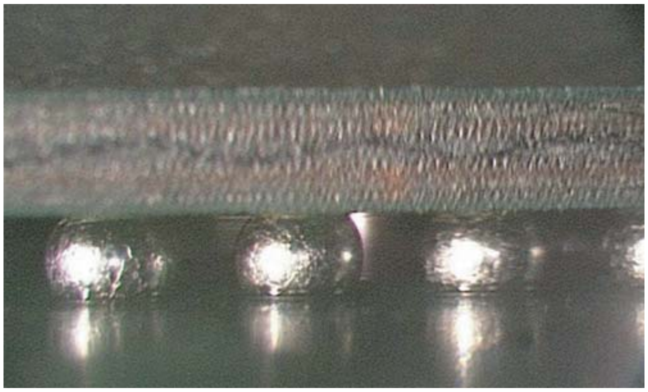

Figure 8-145

Acceptable – Class 1,2,3

- Placement of the BGA solder ball is centered and shows no offset of the ball to land centers.

Defect – Class 1,2,3

- Solder ball offset violates minimum electrical clearance.

8.3.12.2 Surface Mount Area Array – Solder Ball Spacing

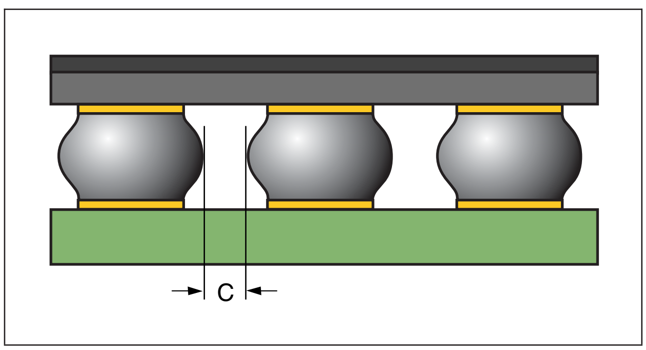

Figure 8-146

Acceptable – Class 1,2,3

- BGA solder balls do not violate minimum electrical clearance, see Figure 8-146-C.

Defect – Class 1,2,3

- BGA solder ball spacing violates minimum electrical clearance.

8.3.12.3 Surface Mount Area Array – Solder Connections

Acceptable – Class 1,2,3

- No solder bridging.
- BGA solder balls contact and wet to the land forming a continuous elliptical round connection, see Figure 8-145.

Process Indicator – Class 2,3

- BGA solder ball terminations are not uniform in size, shape, coloration, and color contrast.

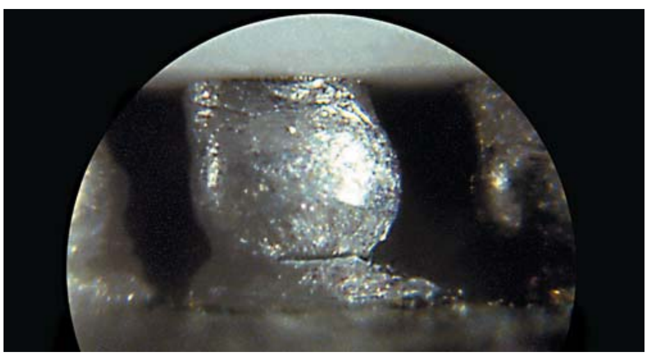

Figure 8-147

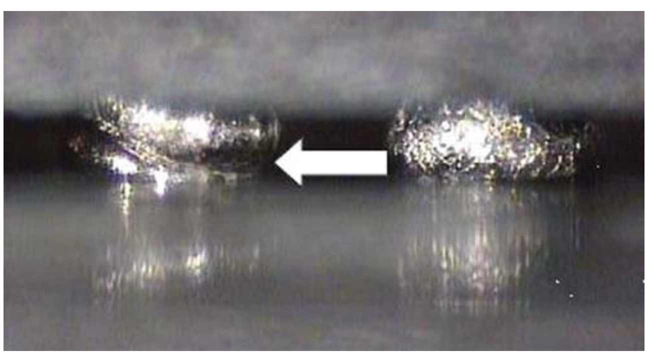

Figure 8-148

Defect – Class 1,2,3

- Fractured solder connection, see Figure 8-147.
- Ball is not wetted to solder (head in pillow/head on pillow), see Figure 8-148.
- Visual or x-ray evidence of solder bridging, see Figure 8-148.
- A ''waist'' in the solder connection indicating that the solder ball and the attaching solder paste did not flow together, see Figure 8-150.
- Incomplete wetting to the land, see Figures 8-150 and 8-151.
- Solder terminations have incomplete reflow of the solder paste, see Figure 8-152.

8.3.12.3 Surface Mount Area Array – Solder Connections (cont.)

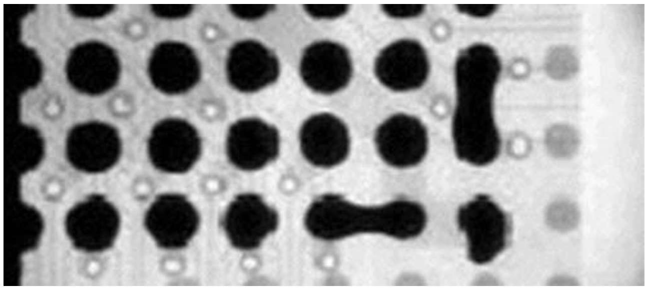

Figure 8-149

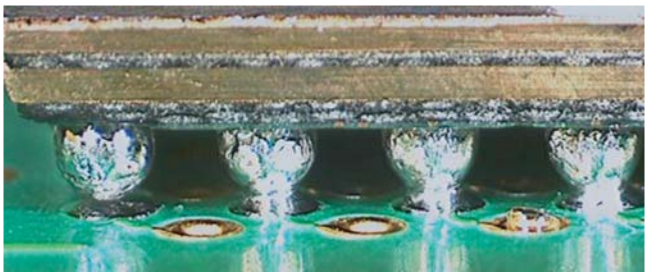

Figure 8-150

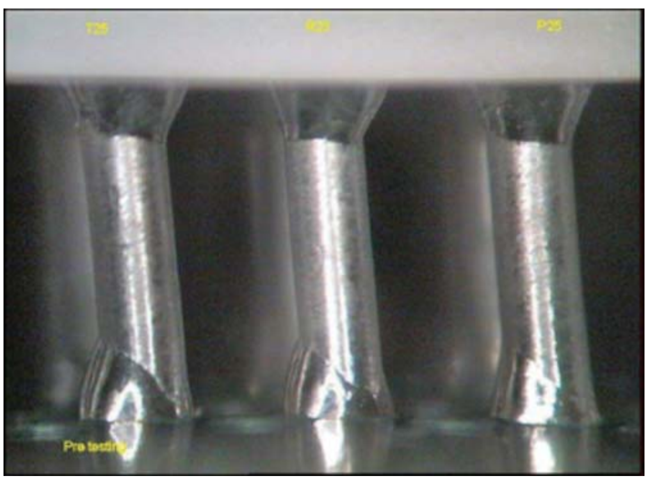

Figure 8-151

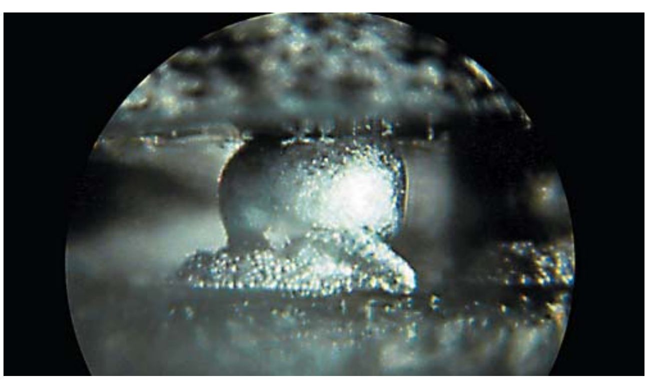

Figure 8-152

8.3.12.4 Surface Mount Area Array – Voids

Design induced voids, e.g., microvia in land, are excluded from this criteria. In such cases acceptance criteria **shall** be established between the Manufacturer and User.

Acceptable – Class 1,2,3

- 30% or less voiding of any ball in the x-ray image area.

Defect – Class 1,2,3

- More than 30% voiding of any ball in the x-ray image area.

8.3.12.5 Surface Mount Area Array – Underfill/Staking

Acceptable – Class 1,2,3

- When specified, underfill or staking material is present.
- Excess underfill or staking material does not interfere with form, fit or function of the assembly.
- Underfill or staking material completely cured.

Defect – Class 1,2,3

- When specified, underfill or staking material is not present.
- Excess underfill or staking material interferes with form, fit or function of the assembly.
- Underfill or staking material not fully cured.

8.3.12.6 Surface Mount Area Array – Package on Package

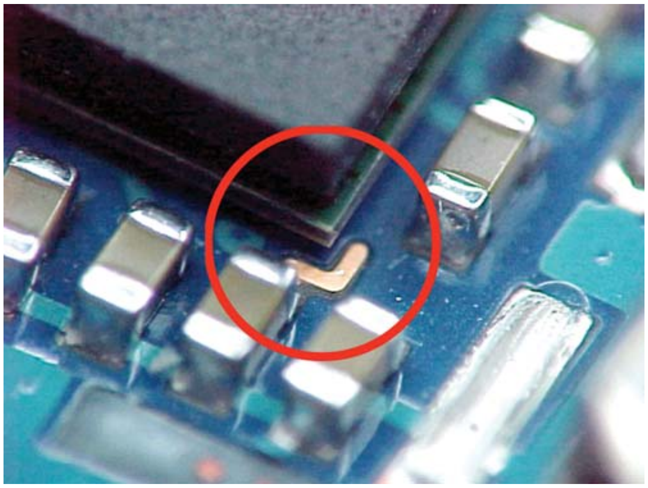

Figure 8-153

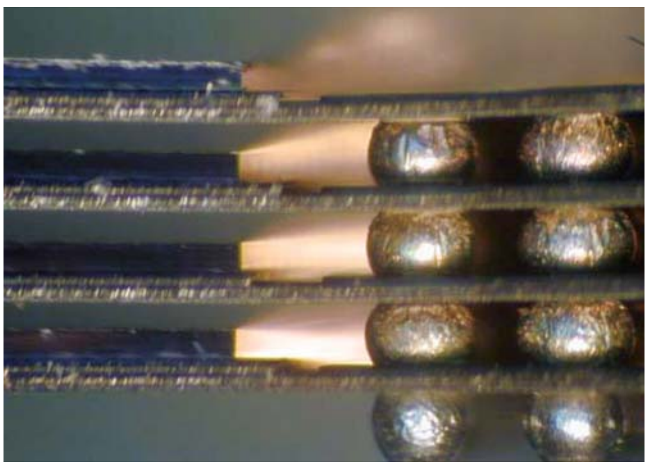

Figure 8-154

Acceptable – Class 1,2,3

- Components aligned to markings on the printed board if provided, see Figure 8-153.
- Ball to land alignment conforms to 8.3.12.1 Surface Mount Assemblies – SMT Connections – Surface Mount Area Array – Alignment.
- Solder connections conform to 8.3.12.3 Surface Mount Assemblies – SMT Connections – Surface Mount Area Array – Solder Connections, see Figure 8-154, and have reflowed showing wetting to the lands on all package levels.
- Package warping or distortion does not interfere with alignment or the formation of solder connections.

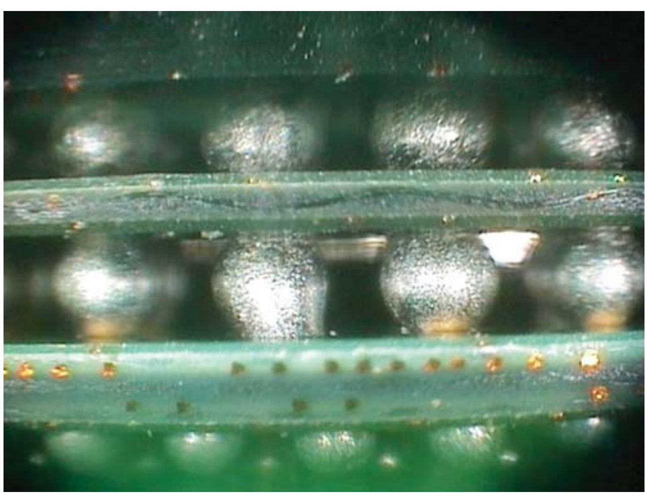

Figure 8-155

Defect – Class 1,2,3

- Ball to land alignment does not conform to 8.3.12.1 Surface Mount Assemblies – SMT Connections – Surface Mount Area Array – Alignment.
- Solder connections do not conform to 8.3.12.3 Surface Mount Assemblies – SMT Connections – Surface Mount Area Array – Solder Connections. Figure 8-155 shows wetting only to middle ball.
- Missing solder ball(s), see Figure 8-156.
- Package warping or distortion interferes with alignment or the formation of solder connections, see Figures 8-157 and 8-158.

8.3.12.6 Surface Mount Area Array – Package on Package (cont.)

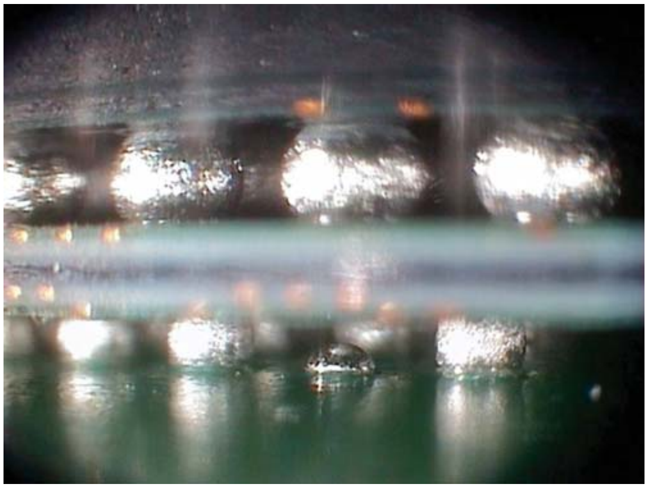

Figure 8-156

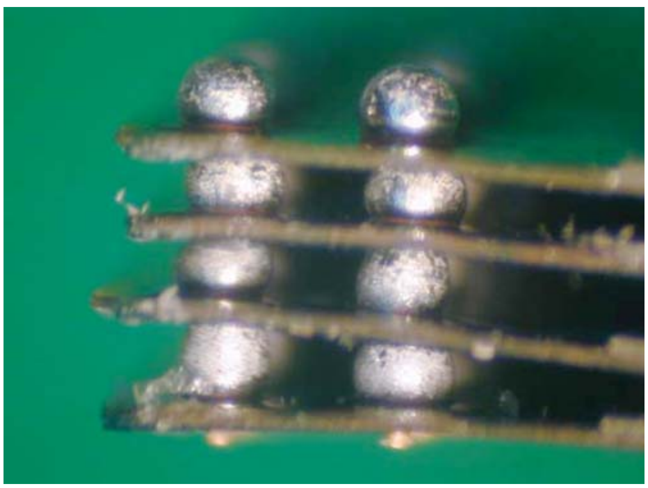

Figure 8-157

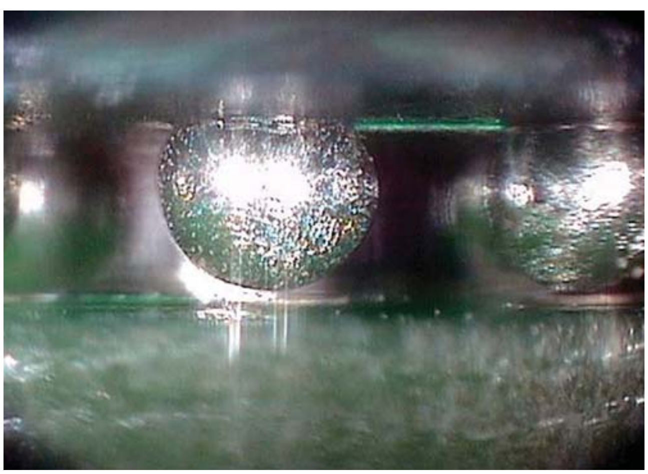

Figure 8-158

8.3.13 Bottom Termination Components (BTC)

Some other names for these devices are Land Grid Array (LGA), Quad Flat No-Lead (QFN), Plastic Quad Flat No-Lead (PQFN), Microlead Frame Packages (MLF), Leadless Plastic Chip Carriers (LPCC), and Quad Flat No-Lead Exposed Pad (QFN-EP). Connections formed to bottom termination components (BTC) **shall** meet dimensional and solder fillet requirements in Table 8-16, see Figures 8-159 and 8-160.

See IPC-7093 for further definition of the thermal pad wettable area.

Table 8-16 Dimensional Criteria – BTC

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W), Note 1	25% (W), Note 1	
Toe Overhang (outside edge of component termination)	B	Not permitted		
Minimum End Joint Width	C	50% (W), Note 6	75% (W), Note 6	
Minimum Side Joint Length	D	Note 4		
Solder Thickness	G	Note 3		
Minimum Toe (End) Fillet Height	F	Notes 2, 5		
Termination Height	H	Note 5		
Land Width	P	Note 2		
Termination 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. Not a visually inspectable attribute.
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 inspected at the narrowest point of the required fillet.

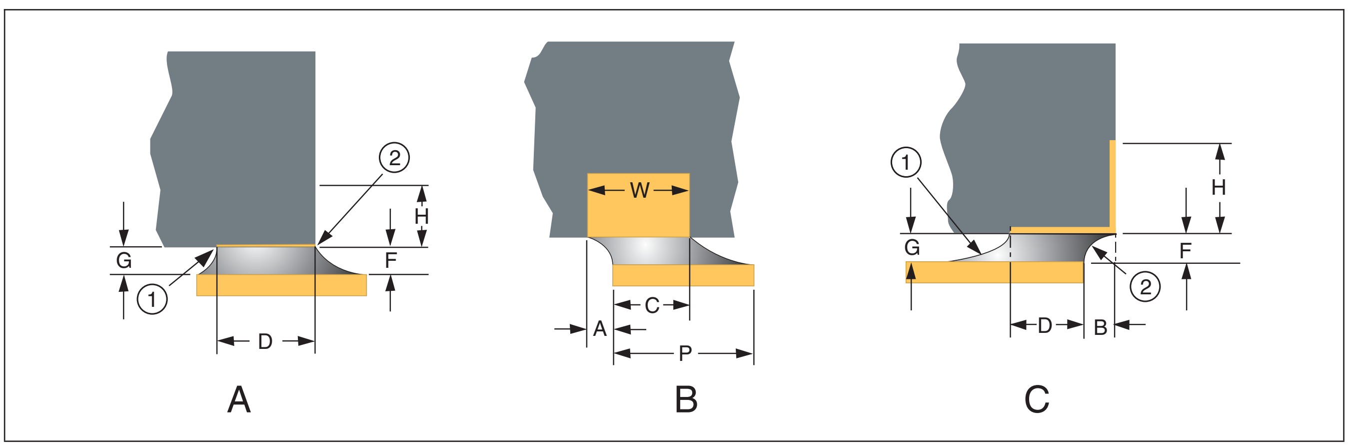

Figure 8-159
1. Heel
2. Toe

A. Side View
B. End View
C. Additional Side View

8.3.13 Bottom Termination Components (BTC) (cont.)

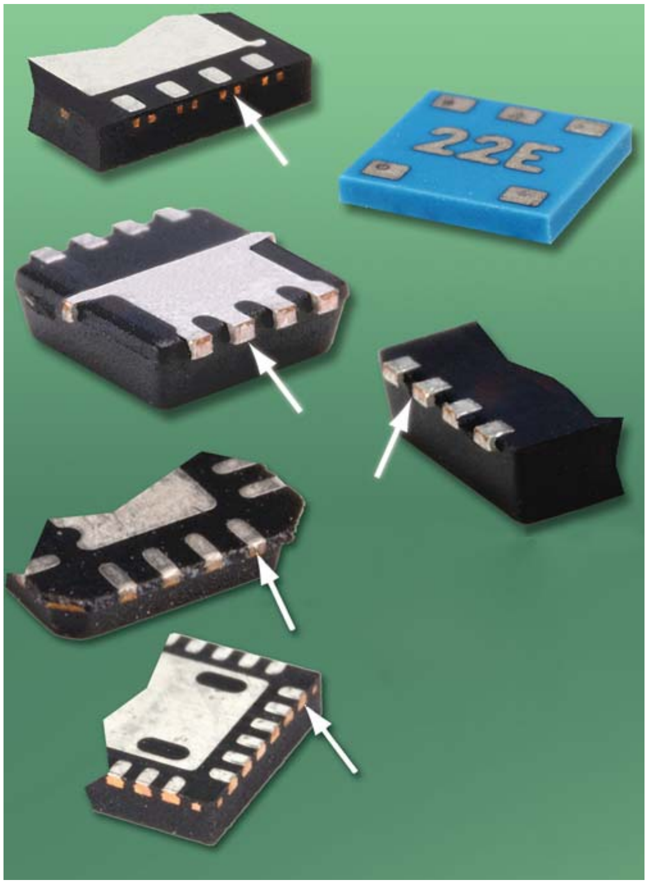

Figure 8-160

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, see Figure 8-160 arrows, and a toe fillet will not form, see Figures 8-161 and 8-162.

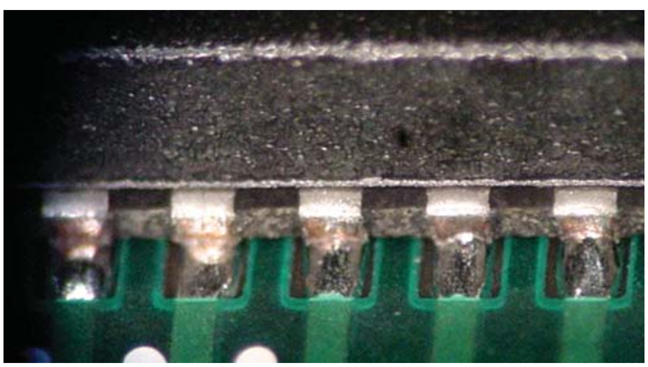

Figure 8-161

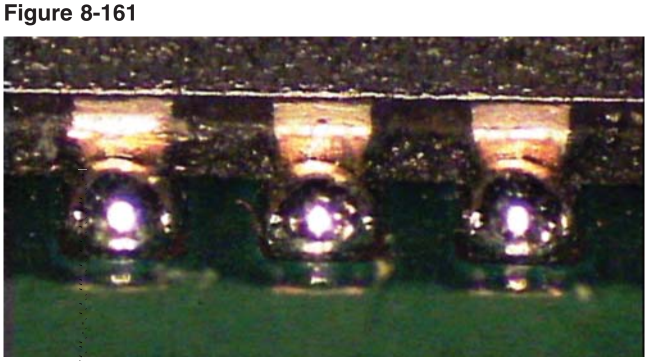

Figure 8-162

Acceptable – Class 1,2,3

- When voiding criteria have not been established, the voiding is 50% or less of the thermal pad wettable area.

Not Established – Class 1
Process Indicator – Class 2,3

- When voiding criteria have not been established, the voiding is more than 50% of the thermal pad wettable area.

8.3.14 Components with Bottom Thermal Plane Terminations (D-Pak)

Connections formed to components with bottom thermal-plane terminations **shall** meet dimensional and solder fillet requirements in Table 8-17.

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

Criteria for nonvisible thermal plane solder connections are not described in this document and **shall** be established by agreement between the User and the Manufacturer. The thermal transfer plane acceptance criteria are design and process related. Issues to consider include but are not limited to component manufacturer's application notes, solder coverage, voids, solder height, etc. When soldering these types of components voiding in the thermal plane is common.

Table 8-17 Dimensional Criteria – Bottom Thermal Plane Terminations (D-Pak)

Feature (all connections except thermal plane)	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	Criteria for the type of lead termination being used.		
Toe Overhang	B			
Minimum End Joint Width	C			
Minimum Side Joint Length	D			
Maximum Heel Fillet Height	E			
Minimum Heel Fillet Height	F			
Solder Thickness	G			
Lead Thickness	T			
Feature (only for the thermal plane connection)		**Class 1,2,3**		
Thermal Plane Side Overhang		Not greater than 25% of termination width.		
Thermal Plane End Overhang (not shown)		Overhang permitted. Note 4		
Thermal Plane End Joint Width, Notes 2, 4 (not shown)		100% wetting to land in the end-joint contact area.		
Thermal Plane Side Joint Length	D	Note 1		
Thermal Plane Solder Thickness	G	Wetting is evident when a fillet is present.		
Thermal Plane Voids		Note 1		
Thermal Plane Termination Width	W	Note 2		
Thermal Plane Land Width	P	Note 3		

Note 1. Acceptance criteria will need to be 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. End overhang is permitted provided all other soldering and positional requirements are met and minimum electrical clearances are not violated.

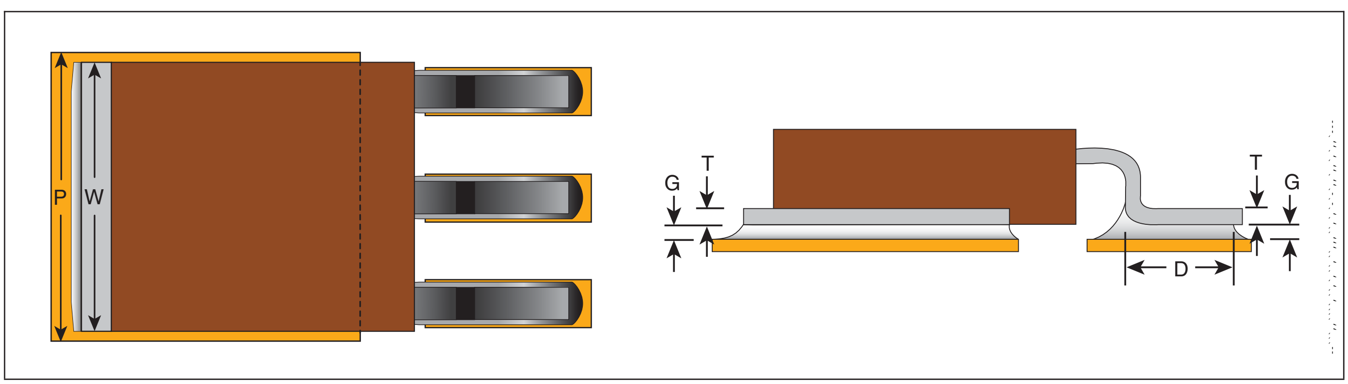

Figure 8-163

8.3.14 Components with Bottom Thermal Plane Terminations (D-Pak) (cont.)

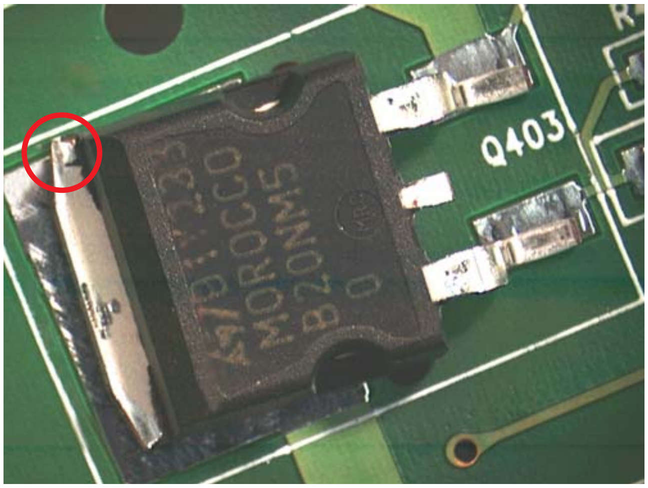

Figure 8-164

Acceptable – Class 1,2,3

- Thermal plane termination side overhang is not greater than 25% of termination width, see Figure 8-164.
- End joint width of the thermal plane end termination has 100% wetting to land in the contact area.

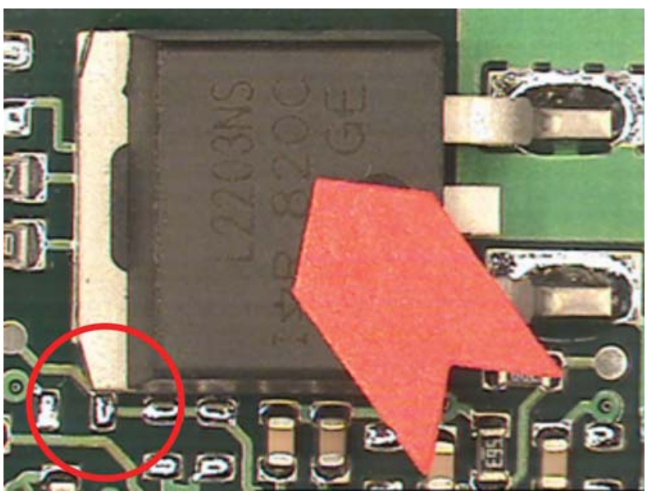

Figure 8-165

Defect – Class 1,2,3

- Side overhang of thermal plane termination is greater than 25% of termination width.
- End joint width of the thermal plane end termination has less than 100% wetting to land in the contact area.
- Thermal plane overhang violates minimum electrical clearance, see Figure 8-165.

8.3.15 Flattened Post Connections

This termination style is sometimes referred to as nail-head pin.

Criteria have not been established for Class 3 for this termination style. Connections formed to flattened post terminations **shall** meet dimensional and solder fillet requirements in Table 8-18 and 8.3.15.1 through 8.3.15.3.

Table 8-18 Dimensional Criteria Flattened Post Connections

<table>
<tr><th>Feature</th><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr>
<tr><td>Maximum Termination Overhang, Square Solder Land</td><td>75% Termination Width (W), Notes 1, 2</td><td>50% Termination Width (W), Notes 1, 2</td><td rowspan="4">Criteria not established</td></tr>
<tr><td>Maximum Termination Overhang, Round Solder Land</td><td>50% Termination Width (W), Notes 1, 2</td><td>25% Termination Width (W), Notes 1, 2</td></tr>
<tr><td>Maximum Fillet Height</td><td colspan="2">Note 4</td></tr>
<tr><td>Minimum Fillet Height</td><td colspan="2">Note 3</td></tr>
</table>

Note 1. Does not violate minimum electrical clearance.
Note 2. Lead diameter is less than diameter or side length of the solder land.
Note 3. Wetting is evident.
Note 4. Solder does not touch package body.

8.3.15.1 Flattened Post Connections – Maximum Termination Overhang – Square Solder Land

Acceptable – Class 1

- Overhang of 75% or less.

Acceptable – Class 2

- Overhang of 50% or less.

Defect – Class 1

- Overhang exceeds 75%.

Defect – Class 2

- Overhang exceeds 50%.

8.3.15.2 Flattened Post Connections – Maximum Termination Overhang – Round Solder Land

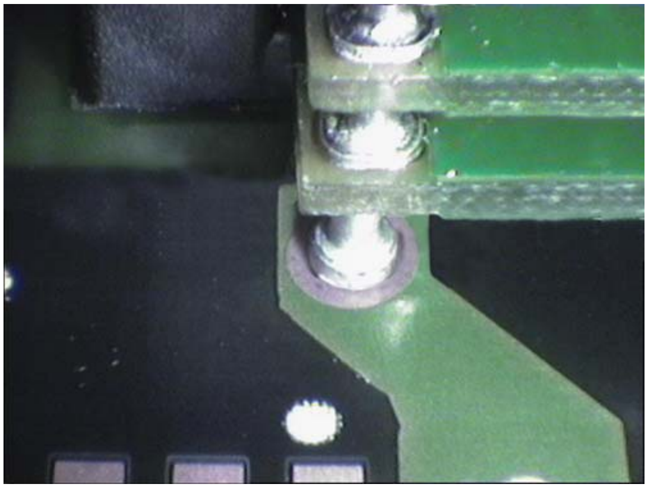

Figure 8-166

Acceptable – Class 1

• Overhang of 50% or less.

Acceptable – Class 2

• Overhang of 25% or less.

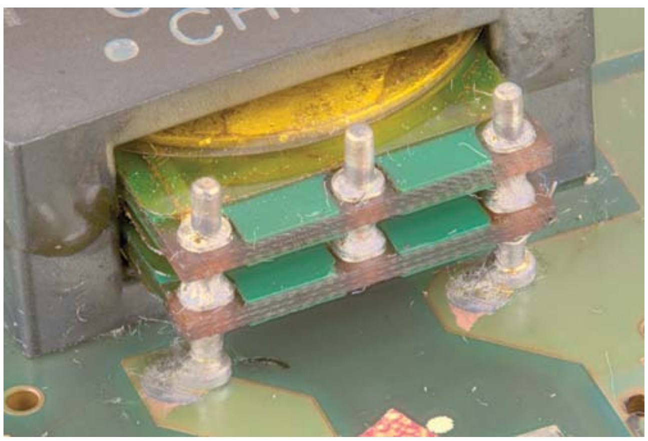

Figure 8-167

Defect – Class 1

• Overhang exceeds 50%.

Defect – Class 2

• Overhang exceeds 25%.

8.3.15.3 Flattened Post Connections – Maximum Fillet Height

Acceptable – Class 1,2

• Wetted fillet evident.

Defect – Class 1,2

• No wetted fillet.

• Solder touches package body.

8.3.16 P-Style Terminations

Connections formed to components having the P-Style termination, see Figure 8-168, **shall** meet the dimensional and solder fillet requirements of Table 8-19 and 8.3.16.1 through 8.3.16.5. This termination style is typically found on edge mounted connectors that will be soldered on both sides of the board.

Table 8-19 Dimensional Criteria – P-Style Terminations

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W)	25% (W)	Not permitted
Maximum Toe Overhang	B	Note 1		
Minimum End Joint Width	C	50% (W), Note 4	75% (W), Note 4	100% (W), Note 4
Minimum Side Joint Length	D	100% (W)	150% (W)	
Minimum Fillet Height – Heel and Toe	F	Note 2	G + 25% (H)	
Solder Thickness	G	Note 3		
Termination Height	H	Note 3		
Minimum Side Fillet Height	Q	Note 2		
Termination Length	L	Note 3		
Termination Width	W	Note 3		

Note 1. No part of the (L) portion of the termination extends beyond the land.
Note 2. Unspecified parameter or variable in size as determined by design.
Note 3. Wetting is evident.
Note 4. (C) is inspected at the narrowest point of the required fillet.

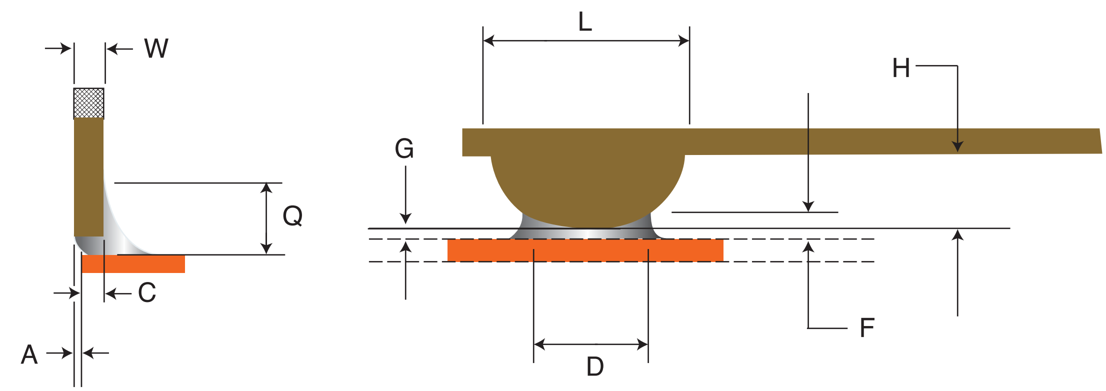

Figure 8-168 P-Style Termination

8.3.16.1 P-Style Terminations – Maximum Side Overhang (A)

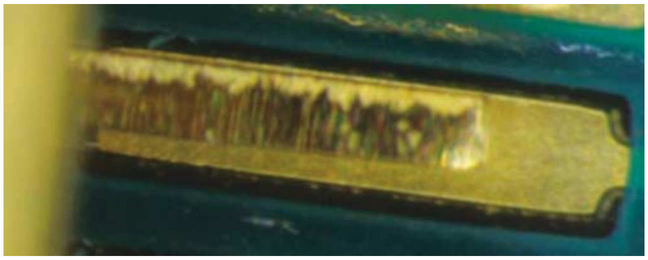

Figure 8-169

Acceptable – Class 1

- Overhang equal to or less than 50% termination width (W).

Acceptable – Class 2

- Overhang equal to or less than 25% termination width (W).

Acceptable – Class 3

- No side overhang.

Defect – Class 1

- Overhang exceeds 50% termination width (W).

Defect – Class 2

- Overhang exceeds 25% termination width (W).

Defect – Class 3

- Any side overhang.

8.3.16.2 P-Style Terminations – Maximum Toe Overhang (B)

Acceptable – Class 1,2,3

- No portion of the termination length (L) extends beyond the land length (S).

Defect – Class 1,2,3

- Any portion of the termination length (L) extends beyond the land length (S).

8.3.16.3 P-Style Terminations – Minimum End Joint Width (C)

Acceptable – Class 1

• End joint width (C) is 50% termination width (W).

Acceptable – Class 2

• End joint width (C) is 75% termination width (W).

Acceptable – Class 3

• End joint width (C) is 100% termination width (W).

Defect – Class 1

• End joint width (C) is less than 50% termination width (W).

Defect – Class 2

• End joint width (C) is less than 75% termination width (W).

Defect – Class 3

• End joint width (C) is less than 100% termination width (W).

8.3.16.4 P-Style Terminations – Minimum Side Joint Length (D)

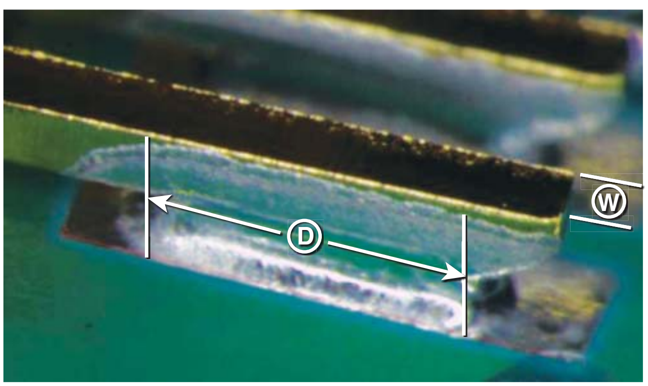

Figure 8-170

Acceptable – Class 1

• Side joint length (D) is 100% termination width (W).

Acceptable – Class 2,3

• Side joint length (D) is 150% termination width (W).

Defect – Class 1

• Side joint length (D) is less than 100% termination width (W).

Defect – Class 2,3

• Side joint length (D) is less than 150% termination width (W).

8.3.16.5 P-Style Terminations – Minimum Fillet Height (F)

These criteria are applicable to both the toe and heel regions of the connection.

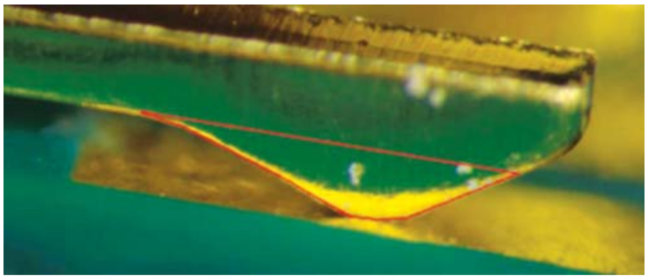

Figure 8-171

Acceptable – Class 1

• Wetting is evident.

Acceptable – Class 2,3

• Fillet height (F) is 25% termination height (H).

Acceptable – Class 1
Defect – Class 2,3

• Fillet height (F) is less than 25% termination height (H).

8.3.17 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.

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 8-20.

Connections formed to Vertical Cylindrical Cans with Outward L-Shaped lead terminations **shall** meet the dimensional and solder fillet requirements of Table 8-20, see Figures 7-172 and 7-173. This termination style is typically found on Aluminum Electrolytic Capacitors, or two-pin SMT Crystal Oscillators.

8.3.17 Vertical Cylindrical Cans with Outward L-Shaped Lead Terminations (cont.)

Table 8-20 Dimensional Criteria – Vertical Cylindrical Cans with Outward L-Shaped Lead Terminations

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W), Note 1	25% (W), Note 1	
Maximum Toe Overhang	B	Note 1	Not permitted	
Minimum End Joint Width	C	50% (W)	75% (W)	
Minimum Side Joint Length	D	Note 3	100% (L)	
Maximum Heel Fillet Height	E	Note 4		
Minimum Heel Fillet Height	F	Note 3	(G) + 50% (T)	(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.

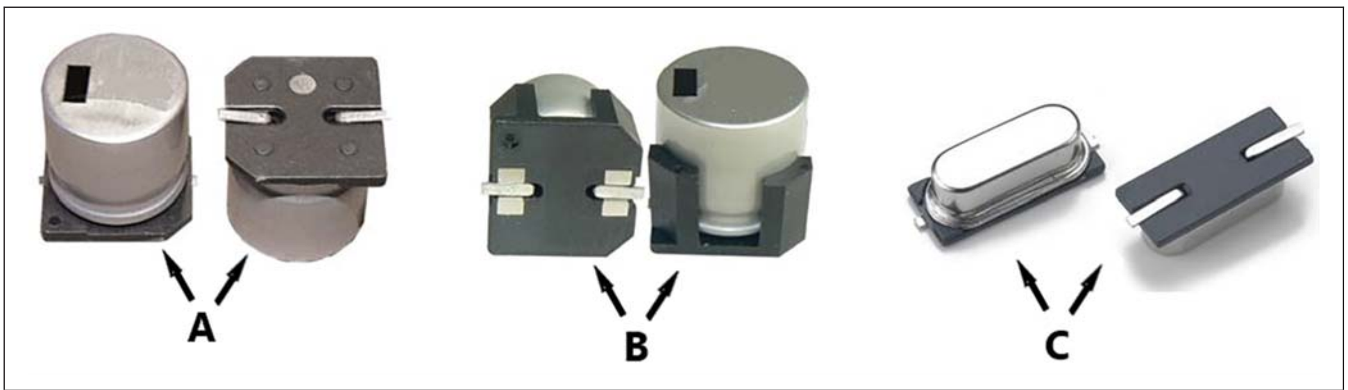

Figure 8-172
A. Standard Aluminum Electrolytic Capacitors
B. Vibration Resistant (Ruggedized) Aluminum Electrolytic Capacitors
C. SMT Two-Pin Oscillators

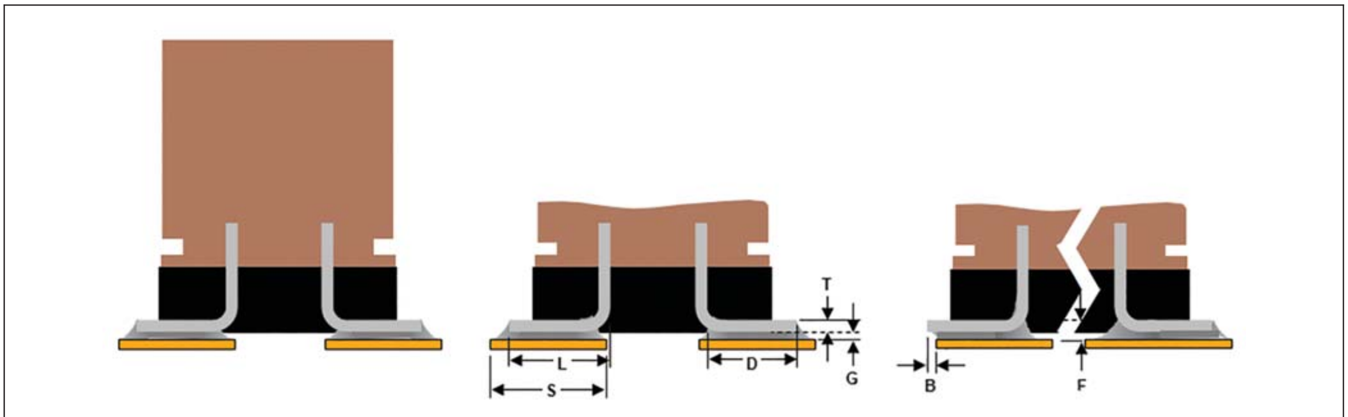

Figure 8-173

8.3.18 Flexible and Rigid Flex Printed Circuitry with Flat Unformed Leads

Connections formed to flexible and rigid-flex printed circuitry with flat unformed leads **shall** meet the dimensions and solder fillet requirements of Table 8-21, see Figure 8-174.

Table 8-21 Dimensional Criteria – Flexible and Rigid-Flex Circuitry with Flat Unformed Leads[5]

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W), Note 1	25% (W), Note 1	
Maximum Toe Overhang	B	Note 1	Not permitted	
Minimum End Joint Width	C	50% (W), Note 5	75% (W), Note 5	
Minimum Side Joint Length	D	Note 1	(L) – (M), Note 4	
Maximum Fillet Height	E	Note 2		(G) + (T) + 1.0 mm [0.04 in]
Minimum Fillet Height	F	Note 3		(G) + (T)
Solder Thickness	G	Note 3		
Lead Length	L	Note 2		
Gap	M	Notes 1, 2		
Land Width	P	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. Where the lead is intended to be soldered beneath the flex and the land is designed for the purpose, wetting is evident.
Note 5. (C) is inspected at the narrowest point of the solder fillet.

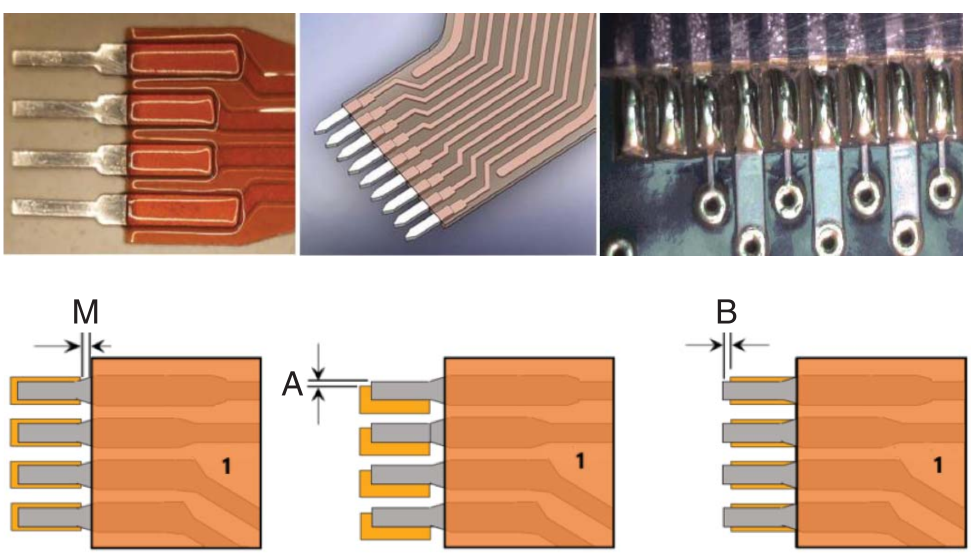

Figure 8-174 Flexible and Rigid-Flex Circuitry with Flat Unformed Leads
1. Top View

8.3.19 Wrapped Terminals

Wrapped terminals are made by a wire wrapped one or more times around a supporting element of the component. Connections formed to a wrapped terminal **shall** meet the requirements of Table 8-22, see Figures 8-175, 8-176, 8-177 and 8-178.

Table 8-22 Dimensional Criteria – Wrapped Terminals

Feature	Dim.	Class 1	Class 2	Class 3
Maximum Side Overhang	A	50% (W), Note 1		25% (W), Note 1
End Overhang	B	Not permitted		
Minimum End Joint Width	C	Note 3	150% (R)	
Minimum Side Joint Length	D	50% (R), Note 1		75% (R), Note 5
Maximum Heel Fillet Height	E	Note 1		
Minimum Heel Fillet Height	F	(G) + 50% (T), Note 4		(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 8-178.
Note 5. (C) is inspected at the narrowest point of the required fillet.

Figure 8-175

Figure 8-176

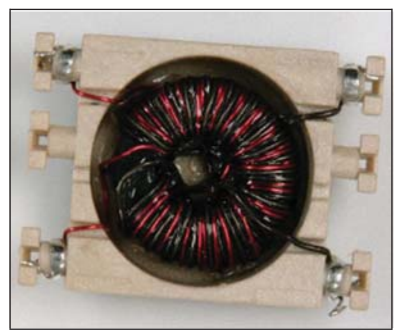

Figure 8-177

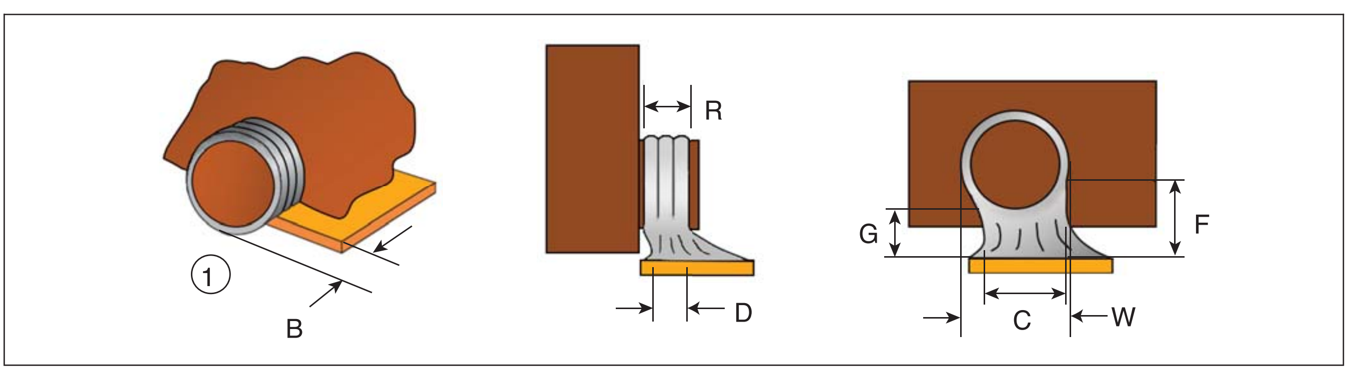

Figure 8-178

8.3.19.1 Wrapped Terminals – Side Overhang (A)

Defect – Class 1,2

- Side overhang exceeds 50% lead width (W).

Defect – Class 3

- Side overhang exceeds 25% lead width (W).

8.3.19.2 Wrapped Terminals – End Joint Width (C)

Defect – Class 2,3

- Minimum end joint width (C) less than 150% termination length (R).

Defect – Class 1,2,3

- Wetting is not evident.

8.3.19.3 Wrapped Terminals – Side Joint Length (D)

Defect – Class 1,2

- Minimum side joint length (D) is less than 50% termination length (R).

Defect – Class 3

- Minimum side joint length (D) is less than 75% termination length (R).

8.3.19.4 Wrapped Terminals – Maximum Heel Fillet Height (E)

Defect – Class 1,2,3

- Solder fillet violates minimum electrical clearance.

8.3.19.5 Wrapped Terminals – Minimum Heel Fillet Height (F)

Defect – Class 1,2,3

- Heel fillet not wetted.

Defect – Class 1,2

- Heel fillet height (F) less than solder thickness (G) plus 50% lead thickness (T).

Defect – Class 3

- Heel fillet height (F) less than solder thickness (G) plus lead thickness (T).

8.3.19.6 Wrapped Terminals – Solder Thickness (G)

Defect – Class 1,2,3

- Wetting is not evident.

8.4 Specialized SMT Terminations

The IPC committee that maintains this standard has received requests to include a number of specialized SMT termination styles such as shown in Figures 8-179, 8-180 and 8-181. Often these termination styles are unique to a particular component or are specially made for a limited number of users. Before acceptance criteria can be developed there needs to be significant use so that a history of failure data can be captured from multiple users. Clause 1.5.1.6 of this standard is repeated here.

> ***1.5.1.6 Specialized Designs*** *IPC-A-610, as an industry consensus document, cannot address all of the possible components and product design combinations. Where uncommon or specialized technologies are used, it may be necessary to develop unique acceptance criteria. However, where similar characteristics exist, this document may provide guidance for product acceptance criteria. Often, unique definition is necessary to consider the specialized characteristics while considering product performance criteria. The development should include User involvement or consent and for Classes 2 and 3 the criteria* ***shall*** *include agreed definition of product acceptance.*
>
> *Whenever possible these criteria should be submitted to the IPC Technical Committee to be considered for inclusion in upcoming revisions of this standard.*

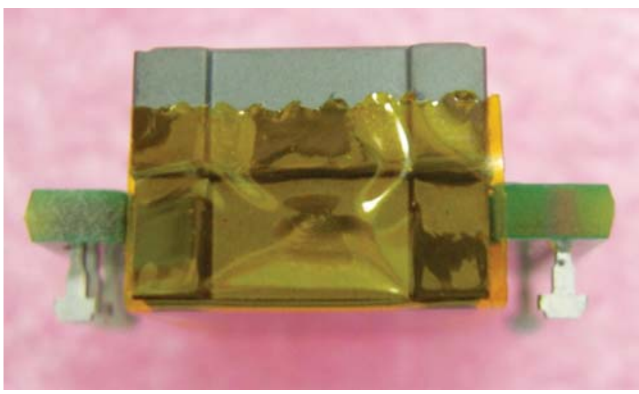

Figure 8-179

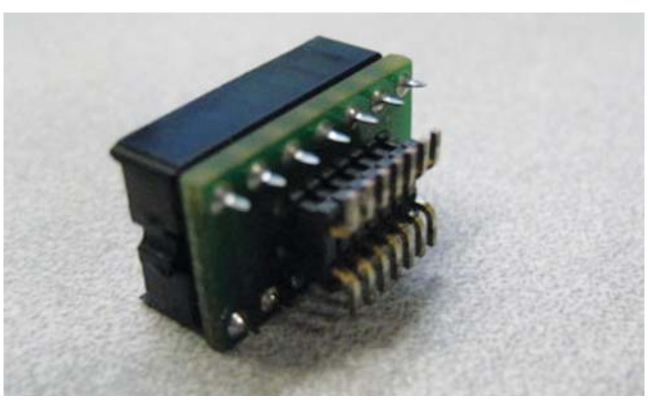

Figure 8-180

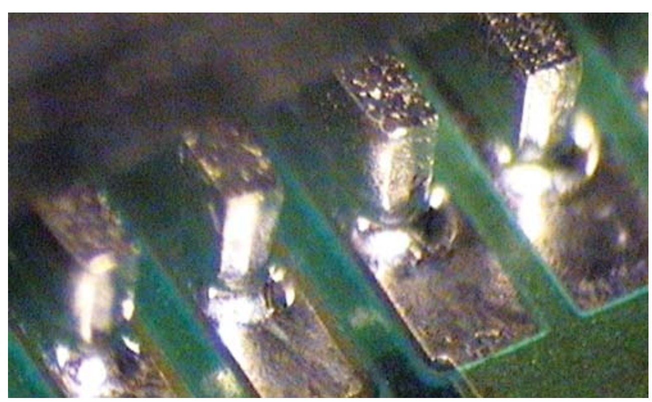

Figure 8-181

8.5 Surface Mount Connectors

These criteria apply to soldered connectors. For connector damage criteria see 9.5 Component Damage – Connectors. The mounting and solder requirements for SMT connectors **shall** meet the criteria for the type of lead termination being used. There are no illustrations for these criteria.

Acceptable – Class 1,2,3

- Back edge of connector is flush; entering edge of connector does not violate component height.
- Board lock is fully inserted/snapped through the board.
- Any tilt, provided:
  - Maximum height requirements are not exceeded.
  - Mates correctly.

Defect – Class 1,2,3

- Will not mate when used in application due to angle.
- Component violates height requirements.
- Boardlock is not fully inserted/snapped into board.

Note: Connectors need to meet form, fit and function requirements. A trial mating of connector to connector or to assembly may be required for final acceptance.

8.5.1 Surface Mount Connectors – Surface Mount Threaded Standoffs (SMTS) or Surface Mount Fasteners

These components are typically mounted with an intrusive soldering process.

These criteria apply to SMTS type of components that are soldered onto the printed board.

Table 8-23 SMTS/Surface Mount Fasteners – Minimum Acceptable Solder Conditions

Criteria	Class 1	Class 2	Class 3
Circumferential wetting of fastener and pad on primary side (solder source side), Note 2	180°	270°	Criteria Not Established
Circumferential wetting on fastener and barrel secondary side (solder destination side), Note 2	180°		
Minimum fillet height – primary side (solder source side)	Wetted fillet is evident		
Percentage of land area covered with wetted solder on secondary side (solder destination side)	0%		

Note 1. There is no requirement specified for wetted land area on the solder source side.
Note 2. These criteria are in relation to wetting of the barrel and are valid for supported holes only.

Figure 8-182 Solder Source Side

Figure 8-183 Solder Destination Side

8.5.1 Surface Mount Connectors – Surface Mount Threaded Standoffs (SMTS) or Surface Mount Fasteners (cont.)

Figure 8-184

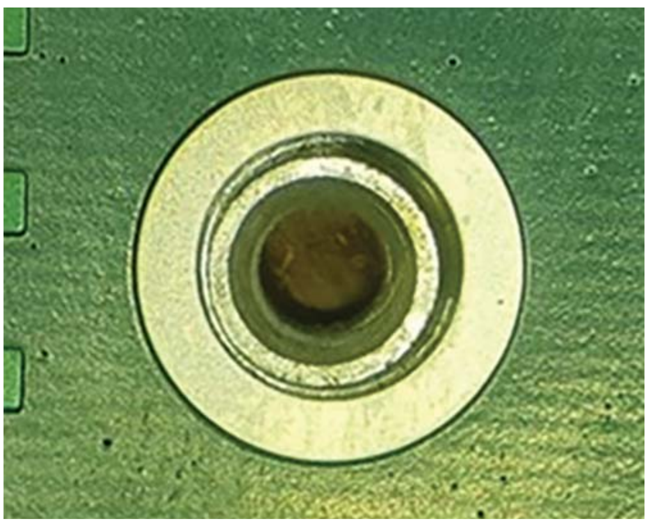

Figure 8-185

Acceptable – Class 1,2

- Minor chips, scratches that do not affect form, fit or function, see Figure 8-184.
- Criteria of Table 8-23 are met, see Figure 8-185.
- Component tilted/raised and does not:
  - Violate minimum electrical clearance.
  - Exceed maximum component height requirements.

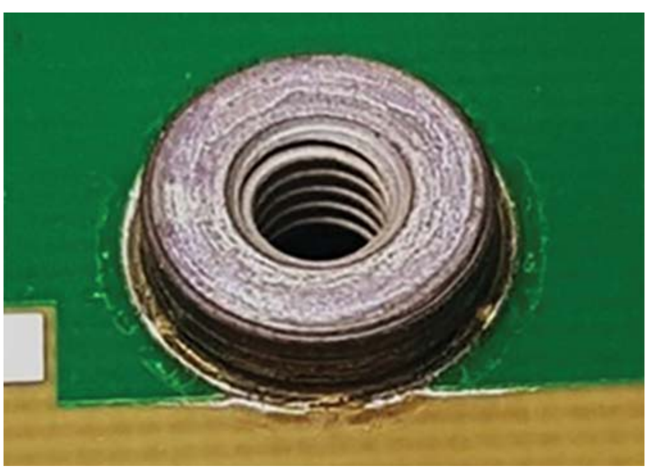

Figure 8-186

Not Established – Class 1
Process Indicator – Class 2

- Discoloration or any change in the coloration of fastener during reflow soldering, see Figure 8-186.

8.5.1 Surface Mount Connectors – Surface Mount Threaded Standoffs (SMTS) or Surface Mount Fasteners (cont.)

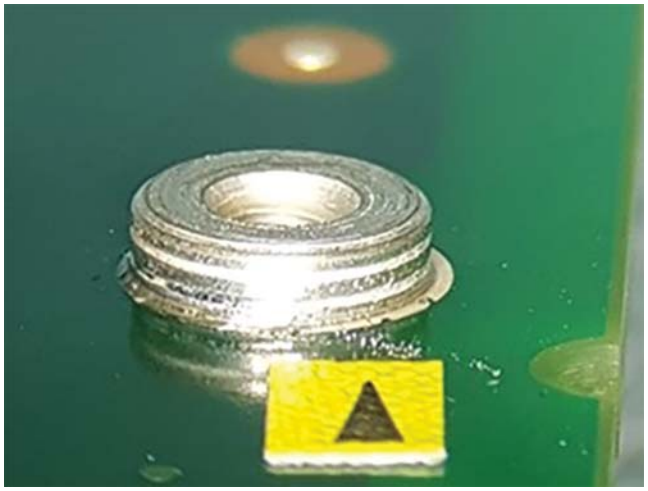

Figure 8-187

Figure 8-188

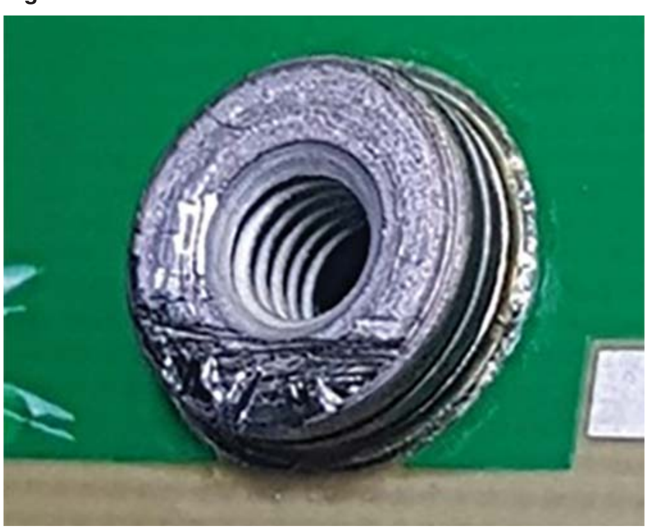

Figure 8-189

Defect – Class 1,2

- No evidence of wetting on primary side (solder source side), see Figure 8-187.
- Insufficient fillet height, regardless of the solder and wetting on the secondary side, see Figure 8-187.
- For supported holes, wetting on the secondary side (solder destination side) and barrel less than 180°, see Figure 8-188.
- Changes in shape, chips, scratches or other damage that affect form, fit or function, see Figure 8-190.
- Presence of solder inside the component, see Figures 8-190 and 8-191.
- Exceeds maximum component height requirements, see Figure 8-191.
- Unable to assemble the mating part.
- Component not fully inserted, see Figures 8-190 and 8-191.

Note: A trial mating of connector to connector or to assembly may be required to assure the connectors meet form, fit and function requirement.

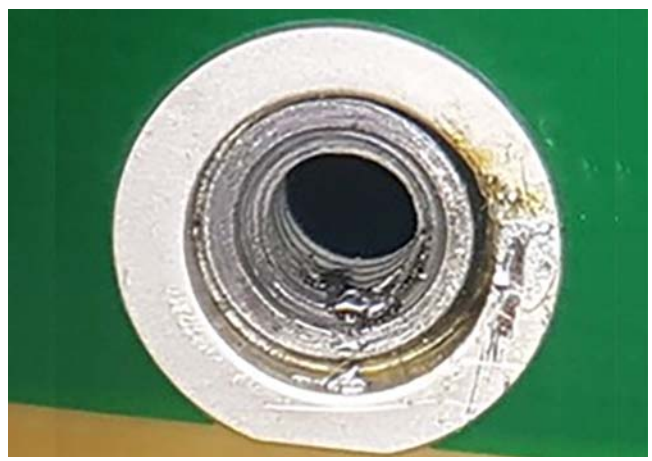

Figure 8-190

Figure 8-191

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9 Component Damage

This section provides some typical component damage criteria. It's recommended to refer to the component supplier documents or purchasing contract/specification.

The following topics are addressed in this section.

9.1 Loss of Metallization

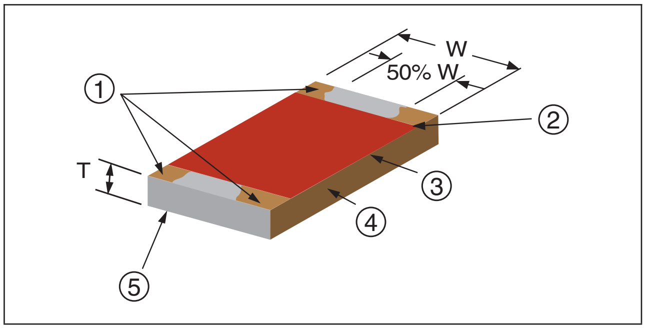

Figure 9-1
1. Metallization missing
2. Adhesive coating
3. Resistive element
4. Substrate (ceramic/alumina)
5. Terminal end

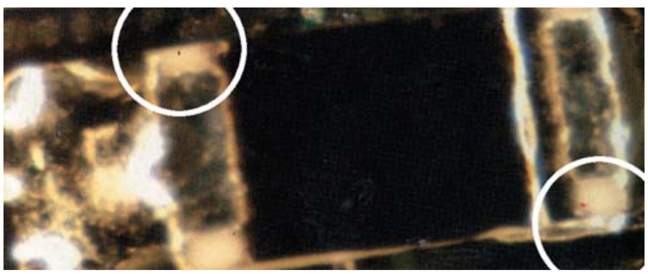

Figure 9-2

Acceptable – Class 1,2,3

- Metallization loss on any termination side (not the end face) of a five-sided termination component, up to 25% of the termination width or height (H).
- Maximum of 50% of metallization loss of top metallization area (for each terminal end) of a three-sided termination component, see Figures 9-1 and 9-2.

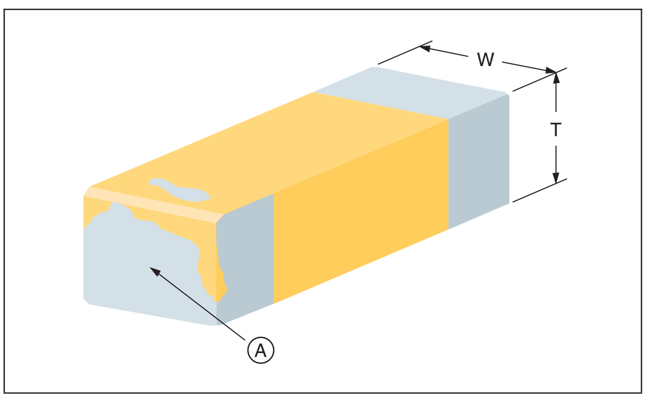

Figure 9-3

Defect – Class 1,2,3

- Metallization loss on the terminal end face exposing the ceramic, see Figure 9-3-A.
- Metallization loss on any termination side (not the end face) on a five-sided termination component greater than 25% of termination width or height, see Figures 9-4 and 9-5.
- Metallization loss greater than 50% of the top area on a three-sided termination component, see Figures 9-5 and 9-6.
- Irregular shapes exceeding maximum or minimum dimensions for that component type.

9.1 Loss of Metallization (cont.)

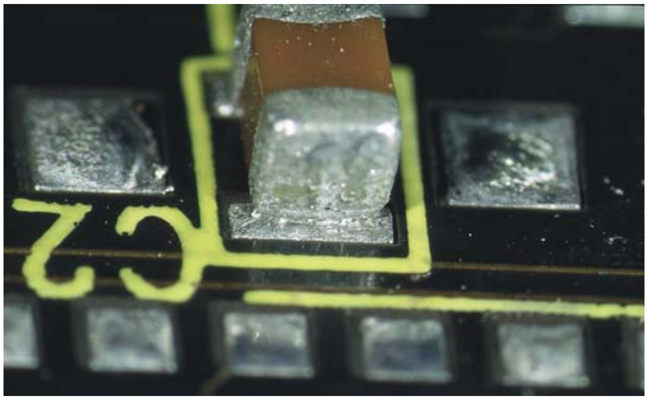

Figure 9-4

Figure 9-5

Figure 9-6

9.2 Chip Resistor Element

Figure 9-7

Acceptable – Class 1,2,3

- No damage to the resistive element or glass coating.
- No exposure of the resistive element.

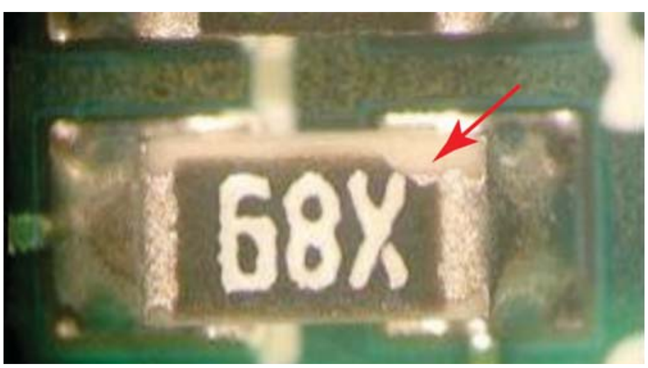

Figure 9-8

Defect – Class 1,2,3

- Damage to glass coating.
- Damage or exposure of the resistive element.

9.3 Leaded/Leadless Devices

These criteria are applicable to leaded and leadless devices.

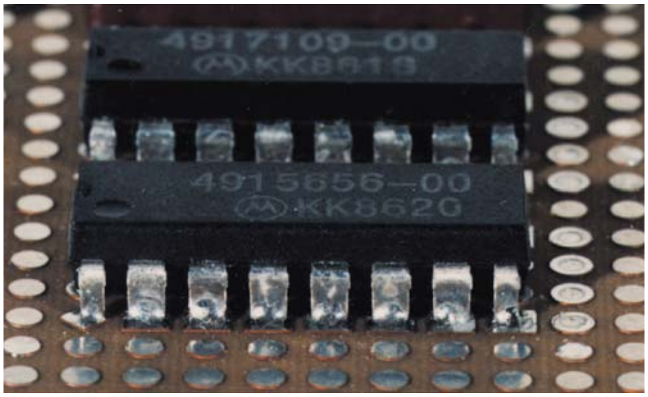

Figure 9-9

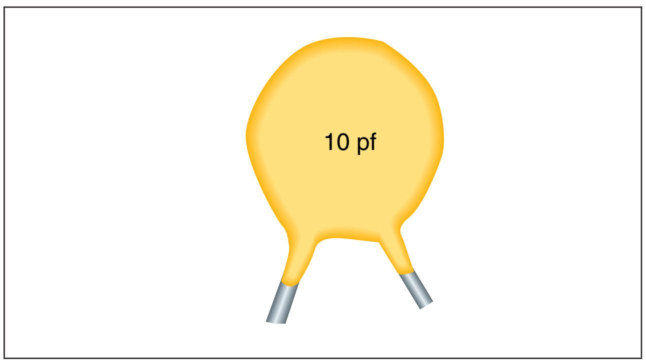

Figure 9-10

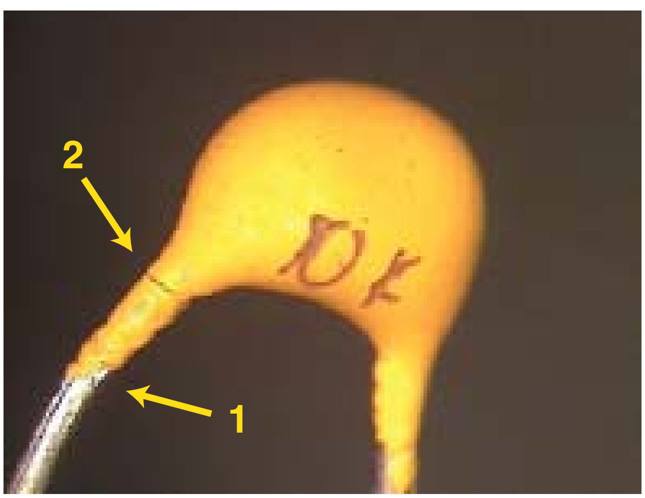

Figure 9-11
1. Chip
2. Crack

Acceptable – Class 1,2,3

- Chips or scratches that do not expose the component substrate or active element, or affect structural integrity, form, fit or function.
- Chips or cracks in component meniscus that do not expose the component substrate or active element, or affect structural integrity, form, fit or function.
- No evidence of cracks or damage to the lid or lead seals of a component.
- Dents, scratches do not affect form, fit and function and do not exceed manufacturer's specifications.
- No burned, charred components.

9.3 Leaded/Leadless Devices (cont.)

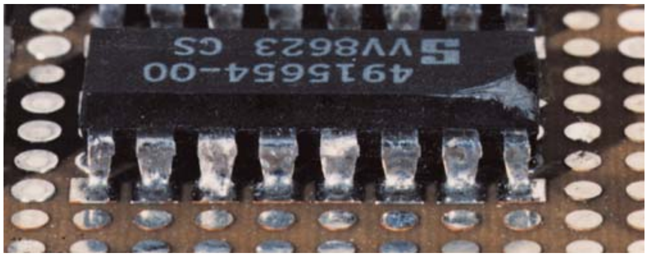

Figure 9-12

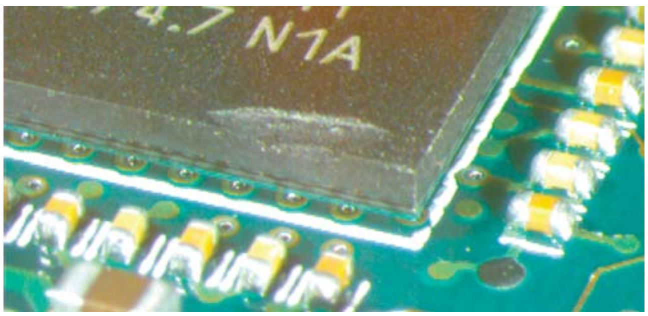

Figure 9-13

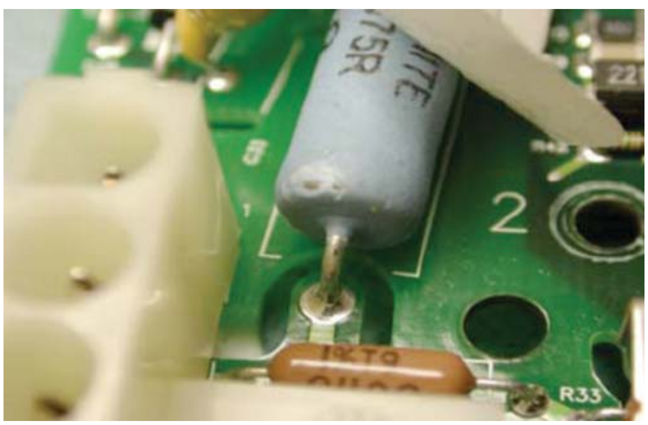

Figure 9-14

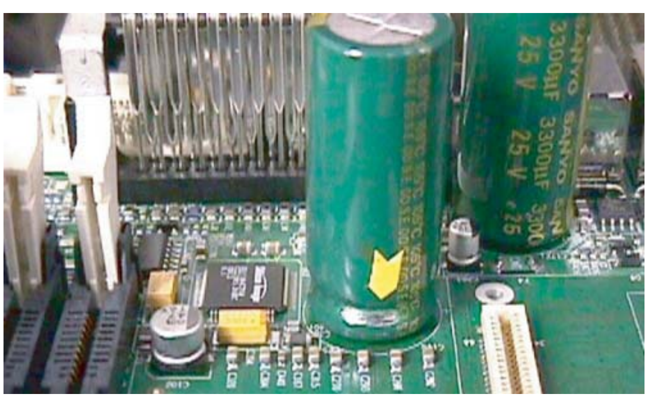

Figure 9-15

Acceptable – Class 1
Process Indicator – Class 2,3

- Indentations or chip-outs on plastic body components do not enter lead seal or lid seals or expose an internal functional element, see Figures 9-12, 9-13 and 9-14.
- Component damage has not removed required identification.
- Component insulation/sleeving has damage provided that:
  – Damaged area shows no evidence of increasing, e.g., rounded edges of the damage with no cracks, sharp corners or brittle material from heat damage, etc., see Figures 9-13 and 9-14.
  – Exposed component conductive surface provides no danger of shorting to adjacent components or circuitry, see Figure 9-15.

9.3 Leaded/Leadless Devices (cont.)

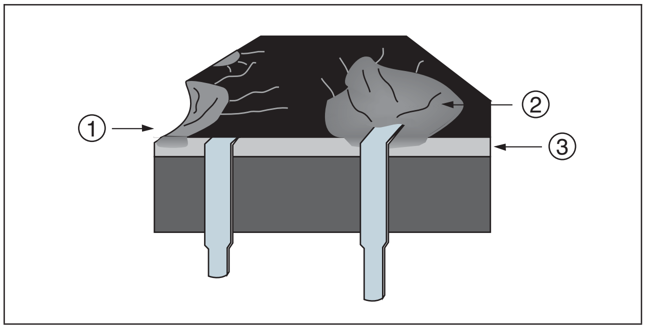

Figure 9-16
1. Chip enters seal
2. Exposed lead
3. Seal

Figure 9-17

Defect – Class 1,2,3

- Chip-out or crack that enters into the seal, see Figure 9-16.
- There are cracks leading from the chip-out on a ceramic body component, see Figure 9-16.
- Chip or crack that exposes the component substrate or active element, or affects hermeticity, integrity, form, fit or function, see Figure 9-17.
- Chips or cracks in glass body beyond the part specification, see Figure 9-18.
- Cracked or damaged glass bead beyond part specification (not shown).
- Required identification is missing due to component damage (not shown).
- The insulating coating is damaged to the extent that the internal functional element is exposed or the component shape is deformed (not shown).
- Damaged area shows evidence of increasing, for instance from cracks, sharp corners, brittle material from heat, etc., see Figure 9-19.
- Damage permits potential shorting to adjacent components or circuitry.
- Flaking, peeling, or blistering of plating.
- Burned, charred components (the charred surface on a component has black, dark brown appearance due to excessive heat), see Figure 9-20.
- Dents, scratches in the component body that affect form, fit and function or exceed component manufacturer's specifications, see Figure 9-21.
- Cracks in shield material, see Figure 9-22.
- Component body delaminates from substrate, see Figure 9-23.

9.3 Leaded/Leadless Devices (cont.)

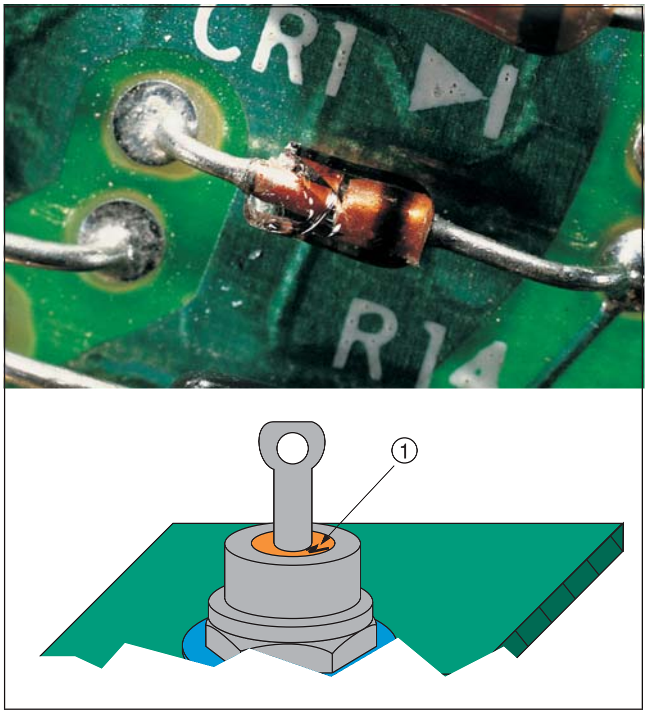

Figure 9-18

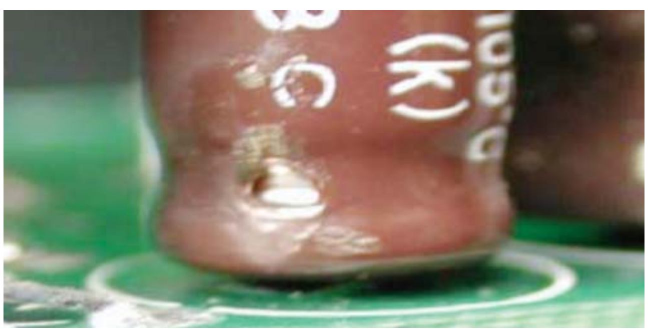

Figure 9-19

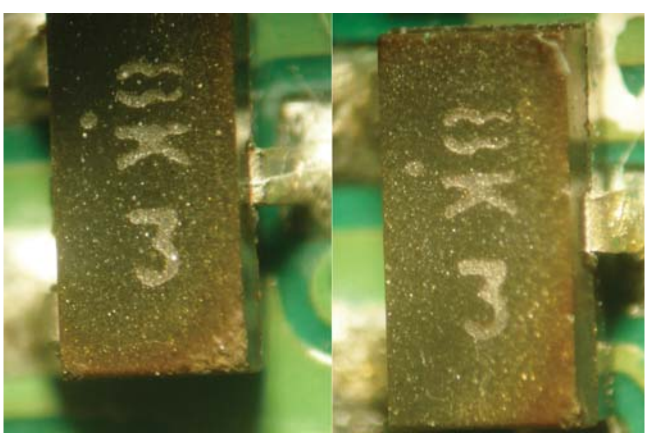

Figure 9-20

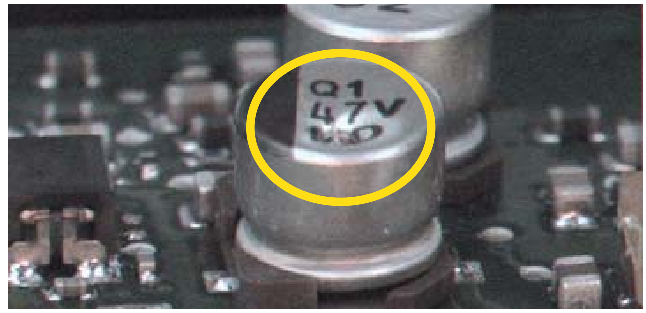

Figure 9-21

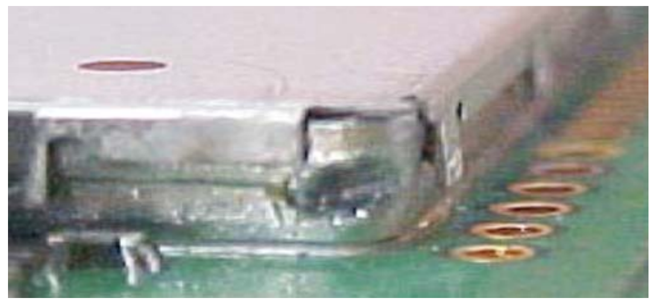

Figure 9-22

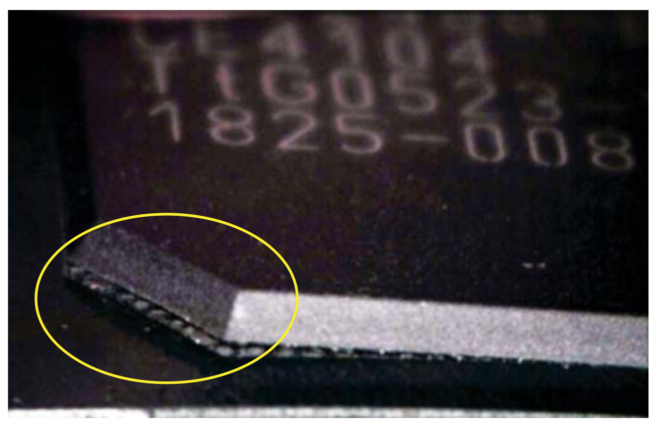

Figure 9-23

9.4 Ceramic Chip Capacitors

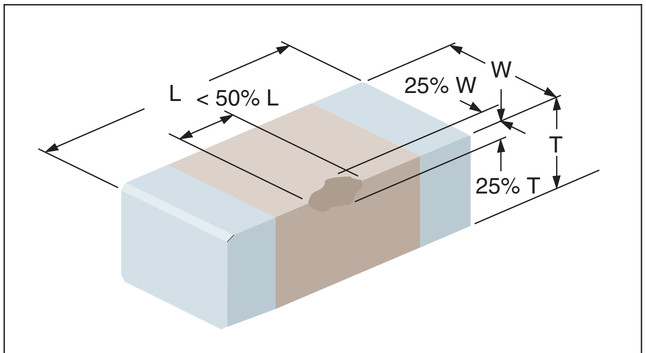

Figure 9-24

Acceptable – Class 1,2,3

- Nicks or chip-outs not greater than dimensions stated in Table 9-1, each considered separately.

Table 9-1 Chip-Out Criteria

(T)	25% of the thickness
(W)	25% of the width
(L)	50% of the length

Acceptable – Class 1,2,3

- Component color change due to thermal exposure in the reflow process.

9.4 Ceramic Chip Capacitors (cont.)

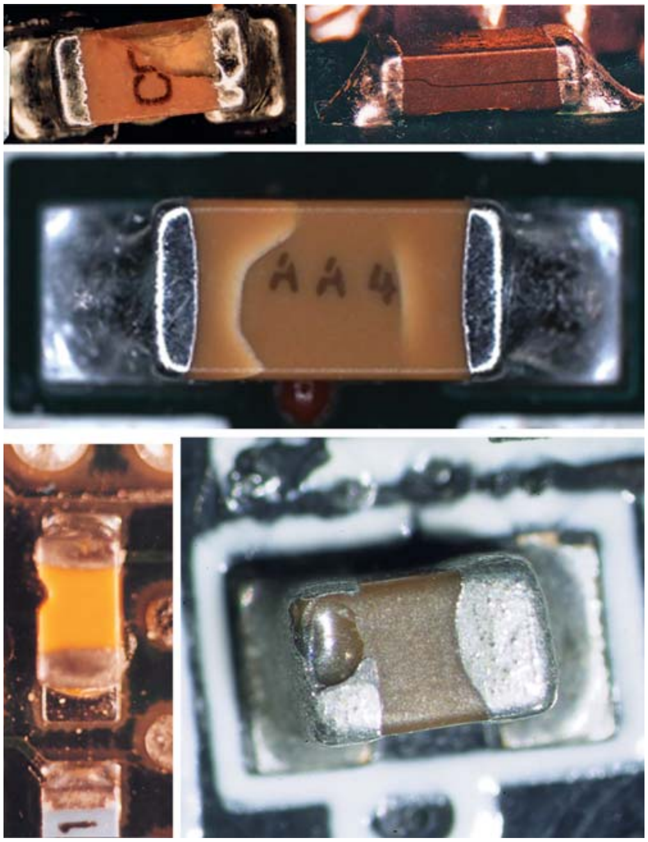

Figure 9-25

Defect – Class 1,2,3

- Any nick or chip-out in the termination area, or exposing an electrode.
- Any cracks or stress fractures.
- Damage in excess of Table 9-1.

9.5 Connectors

These criteria cover the plastic molded housings/shrouds which are used primarily as a guide for the mating connector. Connector pins are typically held by interference fit in a housing. Visual inspection of housings and shrouds includes physical damage such as cracks and deformation.

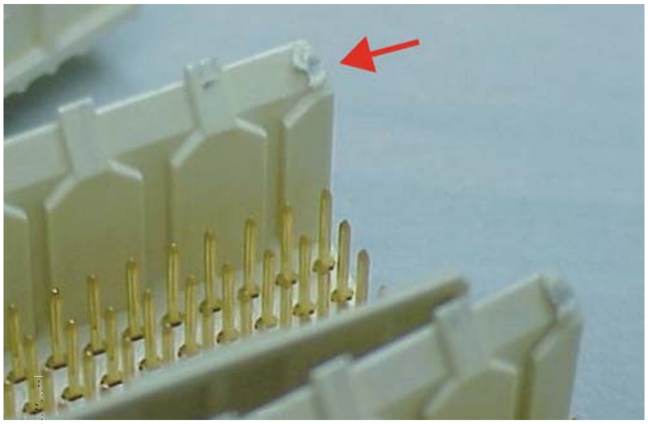

Figure 9-26

Acceptable – Class 1,2,3

- Burrs on housing but still attached (have not broken loose) and do not affect form, fit or function.
- Cracks in noncritical areas (do not impact integrity of the housing/shroud).
- Minor scratches, chips, or thermal deformation that do not compromise protection of the contacts or interfere with proper mating.
- Pins are bent off center by 25% pin thickness/diameter or less.

9.5 Connectors (cont.)

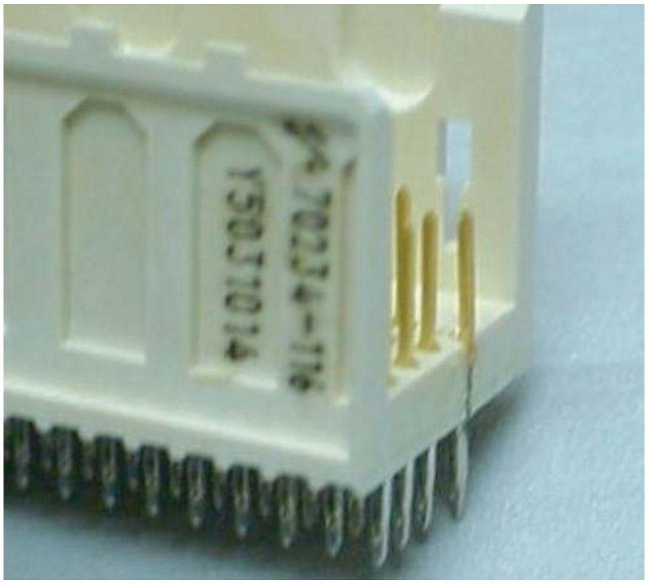

Figure 9-27

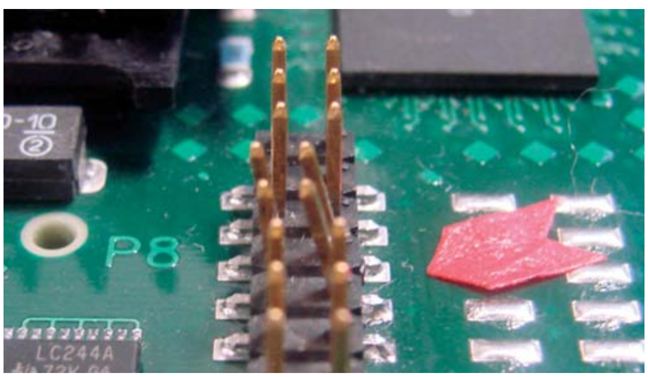

Figure 9-28

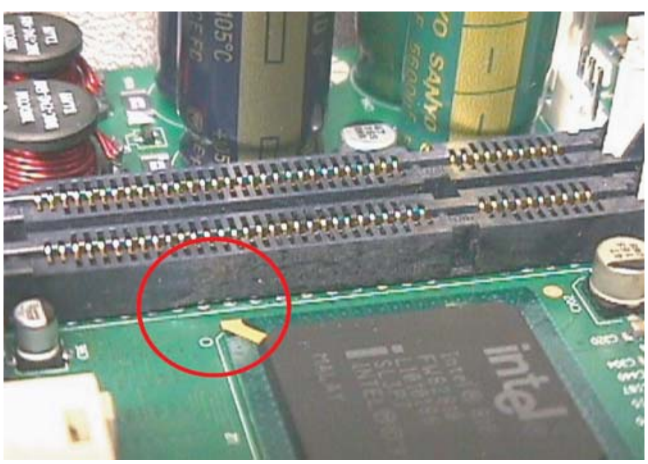

Figure 9-29

Defect – Class 1,2,3

- Burrs, cracks or other deformations that impact the mechanical integrity or functionality of the housing.
- Pins are bent off center by more than 25% pin thickness/diameter.

Acceptable – Class 1,2,3

- No evidence of burn or char.
- Slight discoloration.
- Minor chips, scrapes, scratches or melting that does not affect form, fit or function.

9.5 Connectors (cont.)

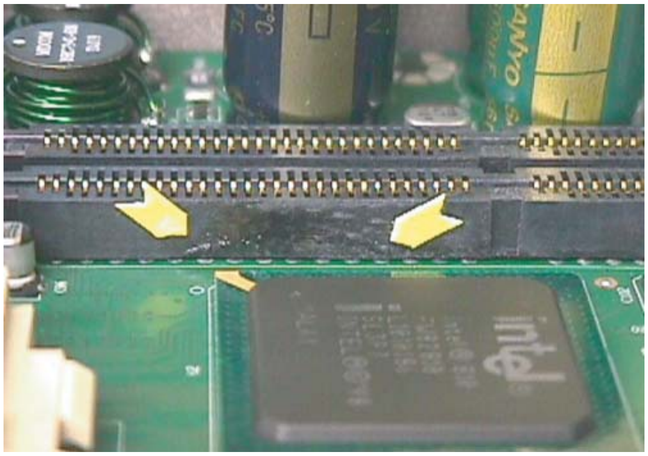

Figure 9-30

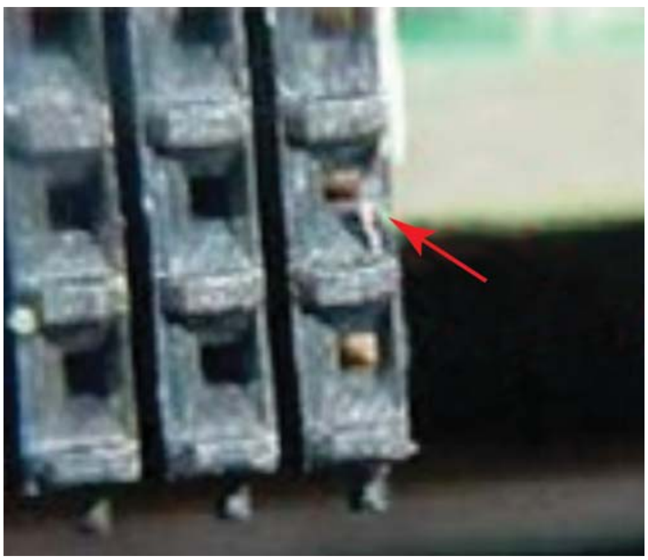

Figure 9-31

Defect – Class 1,2,3

- Evidence of burning or charring.
- Changes in shape, chips, scrapes, scratches, melting or other damage that affect form, fit or function.

9.6 Relays

Acceptable – Class 1,2,3

- Minor scratches, cuts, chips, or other imperfections that do not penetrate the case or affect the seal (not shown).

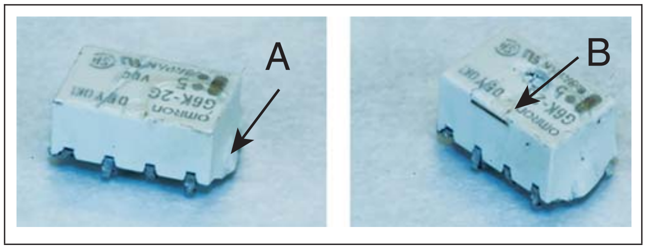

Figure 9-32

Defect – Class 1,2,3

- The case is bulging or swollen, see Figure 9-32-A.
- Scratches, cuts, chips, or other imperfections that penetrate the case or affect the seal, see Figure 9-32B.

9.7 Ferrite Core Components

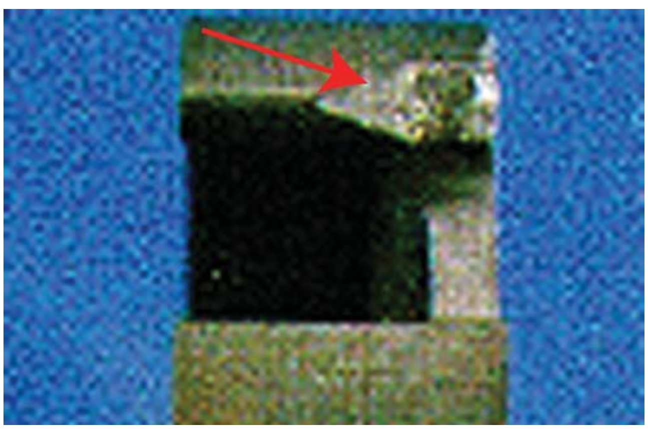

Figure 9-33

Acceptable – Class 1,2,3

- Chips and/or scratches on exterior edges of core are permissible, providing they do not extend into core mating surfaces and do not exceed 1/2 the thickness of the core.

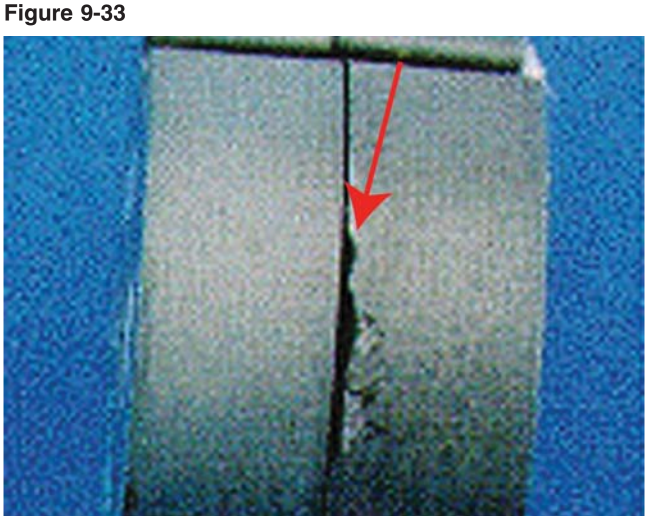

Figure 9-34

Defect – Class 1,2,3

- Chip in the core material is located on mating surface (arrow).
- Chip extending greater than 50% of the core thickness.
- Cracks in the core material.

9.8 Connectors, Handles, Extractors, Latches

This section shows some of the many different types of hardware mounted devices, e.g., connectors, handles, extractors and plastic molded parts.

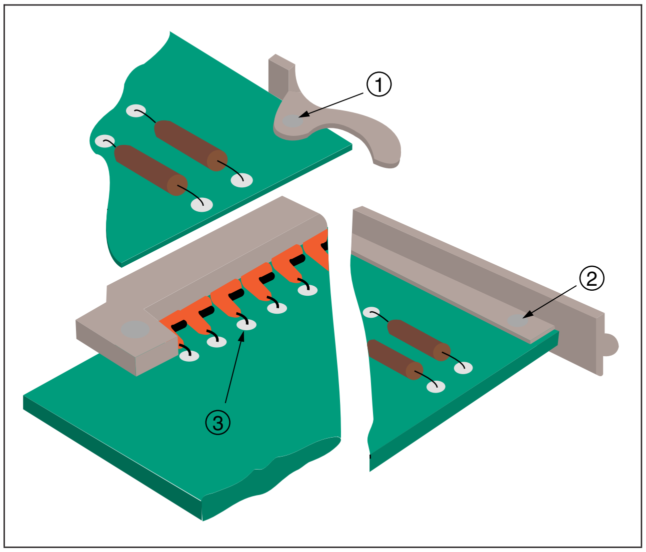

Figure 9-35
1. Extractor
2. Securing hardware
3. Component lead

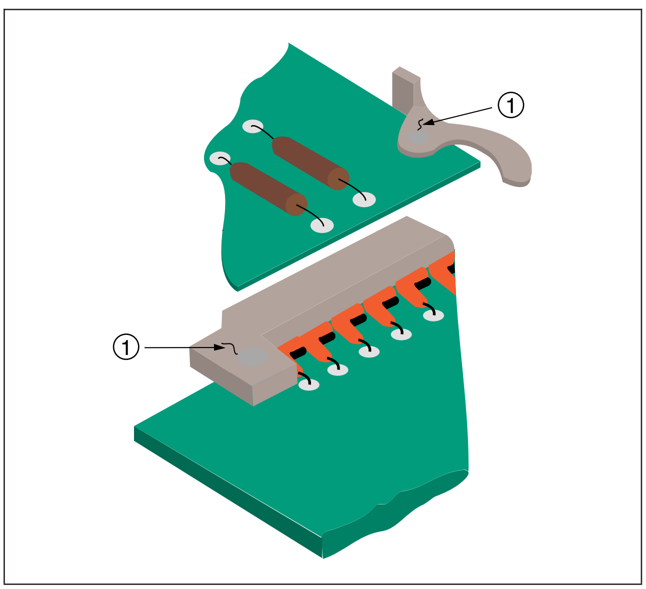

Figure 9-36
1. Crack

Acceptable – Class 1

- Cracks in the mounted part extend no more than 50% of the distance between a mounting hole and a formed edge.

Defect – Class 1

- Cracks in the mounted part extend more than 50% of the distance between a mounting hole and a formed edge.

Defect – Class 2,3

- Cracks in mounted part.

Defect – Class 1,2,3

- Crack connects a mounting hole to an edge.
- Damage/stress to connector lead pins.

9.9 Edge Connector Pins

Acceptable – Class 1,2,3

- Contact is not broken or twisted.

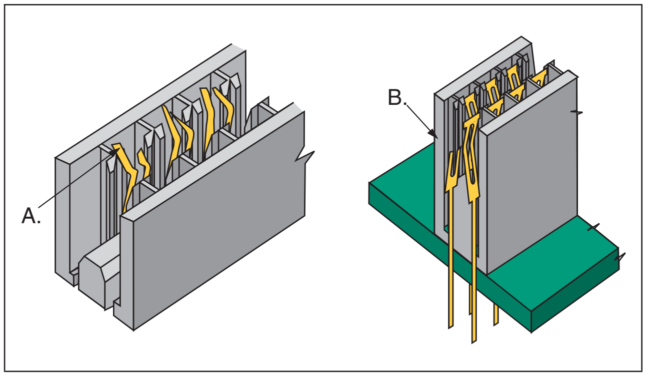

Figure 9-37

Defect – Class 1,2,3

- Contacts are twisted or otherwise deformed, see Figure 9-37-A.
- Contact is broken, see Figure 9-37-B.

9.10 Press Fit Pins

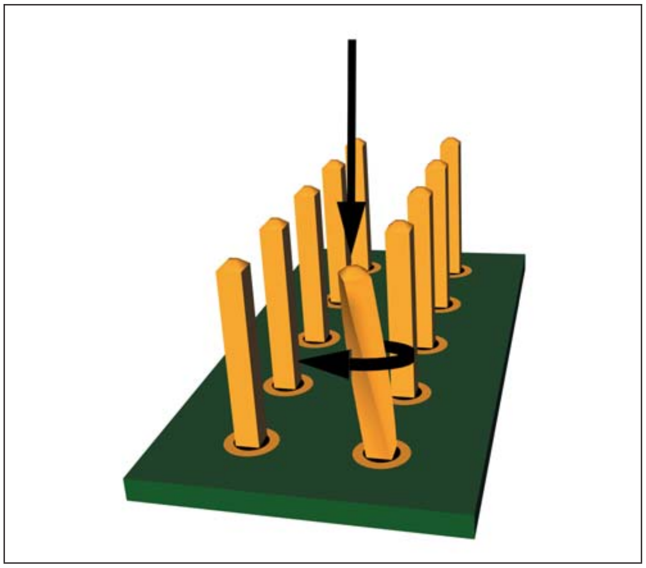

Figure 9-38

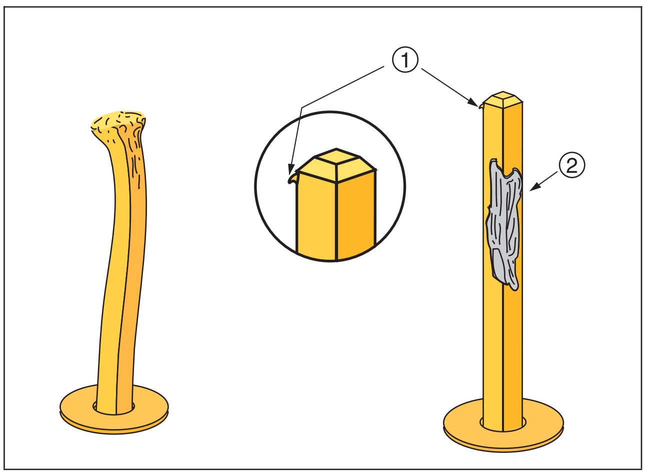

Figure 9-39
1. Burr
2. Plating missing

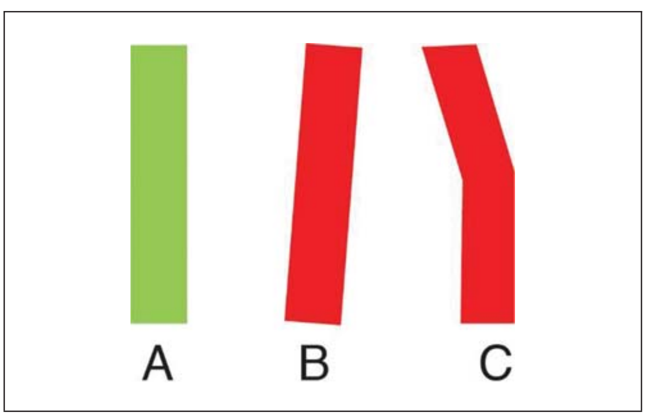

Figure 9-40
1. Aligned – Lateral View
2. Misaligned – Lateral View
3. Bent – Lateral View

Defect – Class 1,2,3

- Damaged pin as a result of handling or insertion.
  - Twisted
  - Mushroomed
  - Bent, see 4.3.2 Hardware – Connector Pins – Press Fit Pins
  - Exposed basis metal
  - Burr

9.11 Backplane Connector Pins

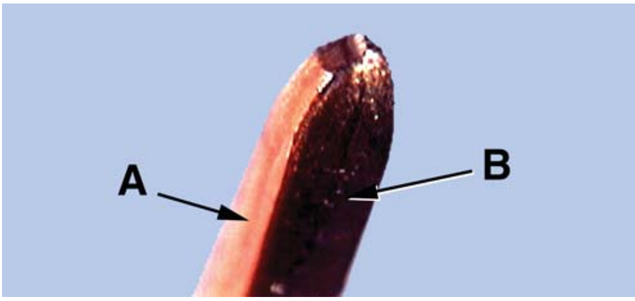

Figure 9-41
A. Sheared/non-mating surface of connector pin
B. Coined/mating surface of connector pin

Acceptable – Class 1,2,3

- Chip on non-mating surface of separable connector pin.
- Burnish on mating surface of separable connector pin, providing that plating has not been removed.
- Chip that encroaches the mating surface of separable connector pin which will not be in the mating connector contact wear path.

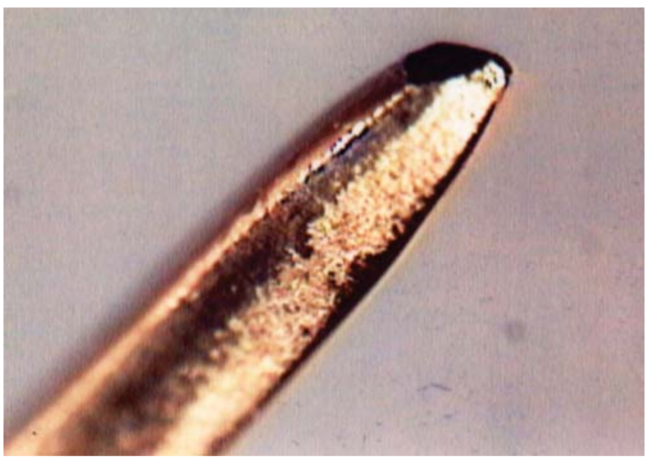

Figure 9-42

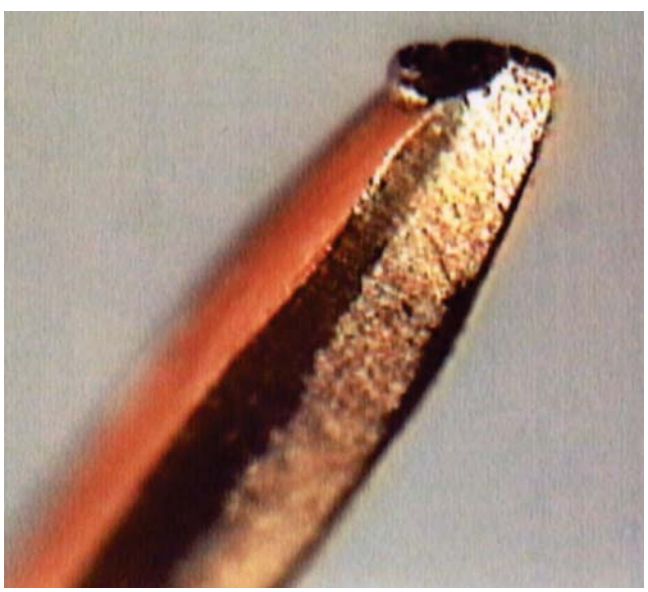

Figure 9-43

Defect – Class 1,2,3

- Chipped pin on mating surface of separable connector, see Figure 9-42.
- Scratched pin that exposes nonprecious plating or basis metal.
- Missing plating on required areas.
- Burr on pin, see Figure 9-43.
- Cracked printed board substrate.
- Pushed out barrel as indicated by copper protruding from bottom side of printed board.

9.12 Heatsink Hardware

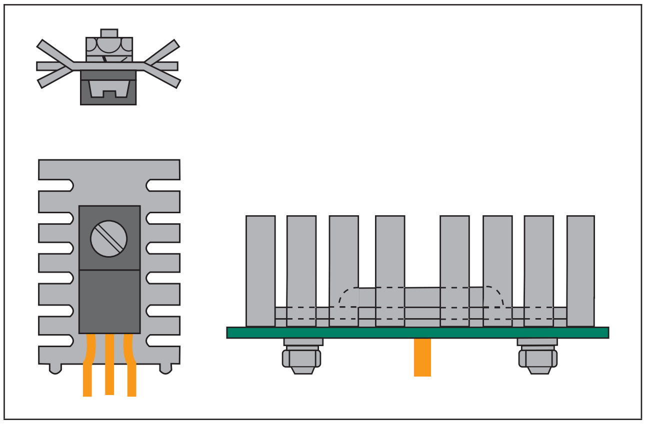

Figure 9-44
1. Heatsink

Acceptable – Class 1,2,3

- No damage or stress on heatsink hardware.

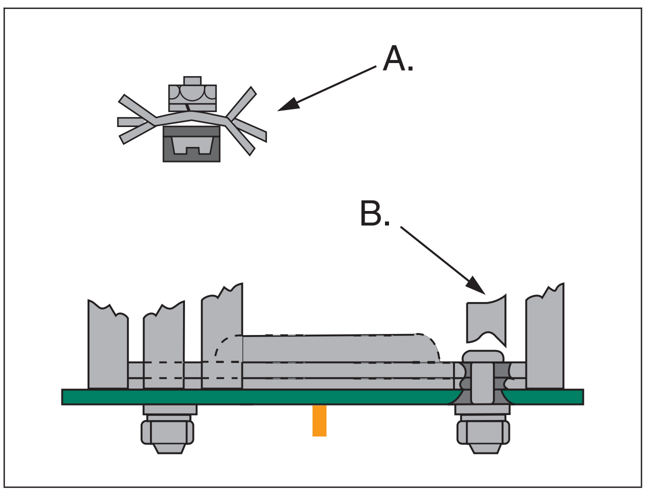

Figure 9-45

Defect – Class 1,2,3

- Bent heatsink, see Figure 9-45-A.
- Missing fins on heatsink, see Figure 9-45-B.
- Damage or stress to heatsink hardware.

9.13 Threaded Items and Hardware

Defect – Class 1,2,3

- Evidence of damage resulting from over-tightening of the threaded item.

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10 Printed Boards and Assemblies

For printed board anomalies not related to assembly caused damage refer to the applicable bare board specification criteria, e.g., IPC-6010-FAM, IPC-A-600, etc.

The following topics are addressed in this section.

10.1 Non-Soldered Contact Areas

These criteria are applicable to contacts that will mate in connectors.

See IPC-A-600 and IPC-6010-FAM for further criteria on gold fingers, gold pins or any gold surface contact area.

Inspection is typically accomplished without magnification or lighting aids. However, there may be instances where these aids are needed, e.g., pore corrosion, surface contamination.

Critical contact area (the portion that contacts the mating surface of the connector) is dependent upon the connector system scheme being used by the Manufacturer. The documentation should identify those particular dimensions.

10.1.1 Non-Soldered Contact Area – Contamination

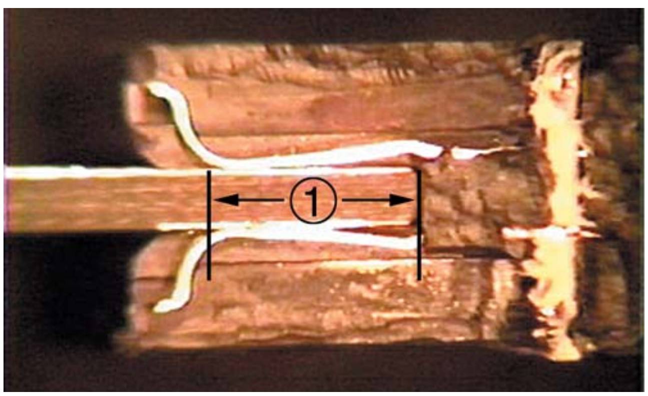

Figure 10-1
1. Critical contact area of edge fingers in contact with spring contact.

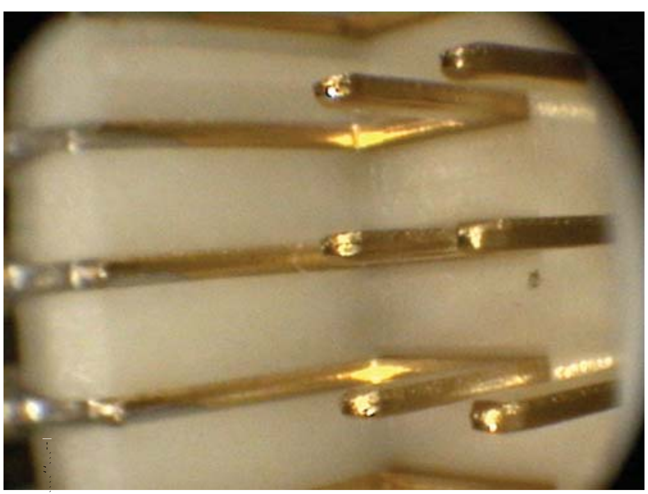

Figure 10-2

Acceptable – Class 1,2,3

• Solder is allowed in noncontact areas.

10.1.1 Non-Soldered Contact Area – Contamination (cont.)

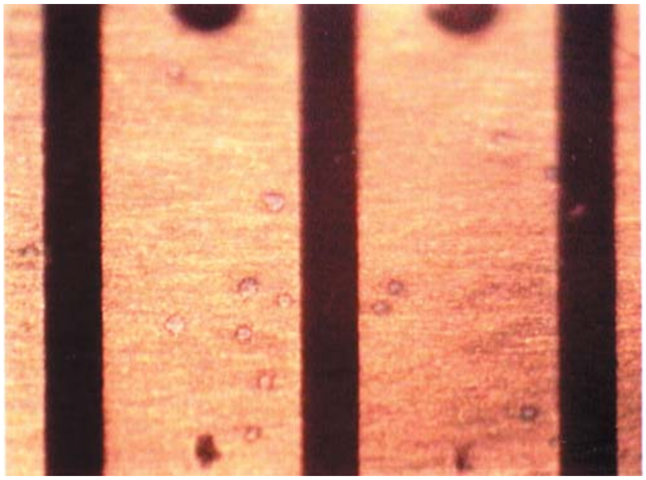

Figure 10-3

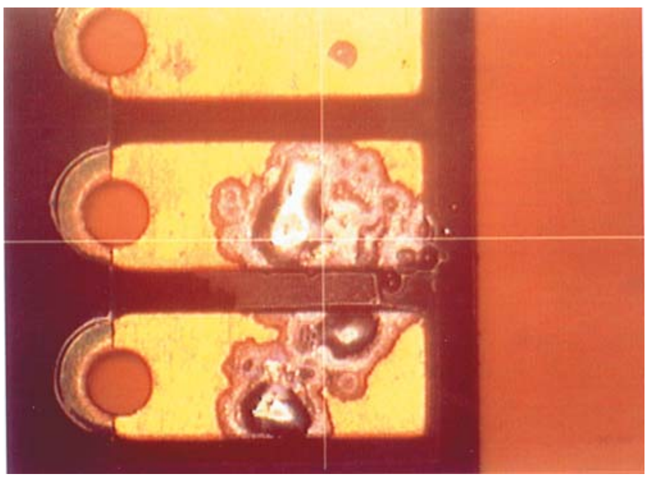

Figure 10-4

Defect – Class 1,2,3

- Solder or any other contamination in the critical contact area.

10.1.2 Non-Soldered Contact Area – Damage

Defect – Class 1,2,3

- Any surface defect in the critical contact area that exposes basis metal.

10.2 Laminate Conditions

The purpose of this section is to help the reader better understand the problem of recognizing laminate defects. In addition to providing detailed drawings and photographs to help identify common laminate defects, this section also provides acceptance criteria for the presence of measles on the board assembly.

The identification of laminate defects can be confusing. To help identify defect conditions, please refer to the following pages where definitions, illustrations and photographs have been provided that define and identify the following conditions and establish acceptance criteria:

- Measling
- Crazing
- Blistering
- Delamination
- Weave texture
- Weave exposure
- Haloing
- Edge nicks and crazing

It is important to note that laminate defect conditions may become apparent when the fabricator receives the material from the laminator, or during the fabrication or assembly of the printed board.

10.2.1 Laminate Conditions – Measling and Crazing

These are inherent conditions in the laminate caused during processing the board or assembly.

Measling or crazing that occurs as a result of an assembly process, e.g., use of press fit pins, reflow soldering, etc., will usually not increase.

Where measles are present that violate minimum electrical clearance, additional performance testing or dielectric resistance measurements may be required considering the product performance envelope, e.g., moisture environments, low atmosphere.

Where the substrate includes embedded components, additional criteria may need to be defined.

Measling – An internal condition occurring in laminated base material in which the glass fibers are separated from the resin at the weave intersection. This condition manifests itself in the form of discrete white spots or crosses below the surface of the base material, and is usually related to thermally induced stress.

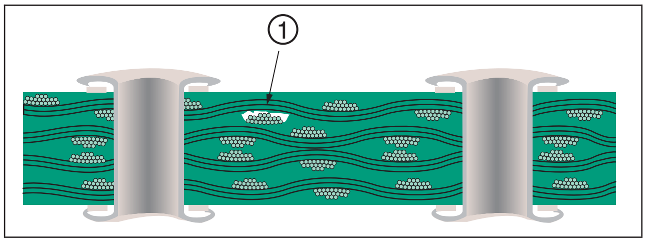

Figure 10-5
1. Measling

Figure 10-6

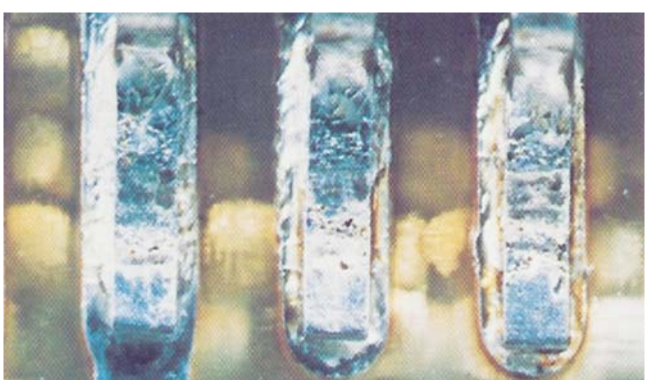

Figure 10-7

Acceptable – Class 1,2

- The criteria for measling are that the assembly is functional.

Process Indicator – Class 3

- Measled areas in laminate substrates exceed 50% of the physical spacing between internal conductors.

Note: There are no defect criteria for measles. Measling is an internal condition which may not propagate under thermal stress and has not been conclusively shown to be a catalyst for conductive anodic filament (CAF) growth. Delamination is an internal condition which may propagate under thermal stress and may be a catalyst for CAF growth. The IPC-9691 user's guide for CAF resistance testing and IPC-TM-650, Method 2.6.25, provide additional information for determining laminate performance regarding CAF growth.

10.2.1 Laminate Conditions – Measling and Crazing (cont.)

Crazing – An internal condition occurring in laminated base material in which the glass fibers are separated from the resin at the weave intersections. This condition manifests itself in the form of connected white spots or crosses below the surface of the base material and is usually related to mechanically induced stress.

See 10.2.5 Printed Boards and Assemblies – Laminate Conditions – Edge Delamination, Nicks and Crazing for edge crazing criteria.

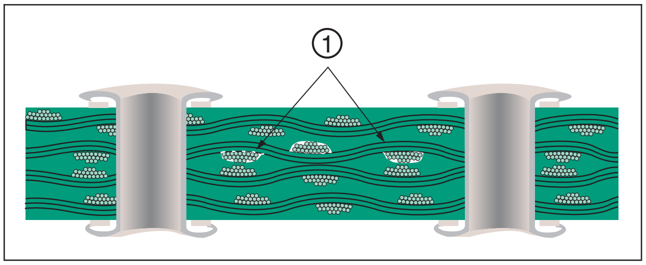

Figure 10-8
1. Crazing

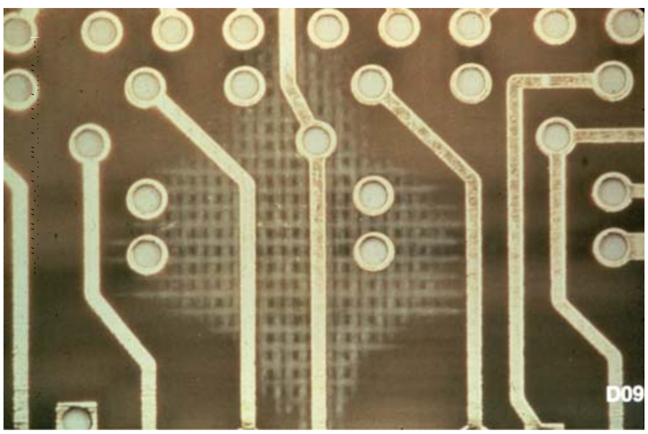

Figure 10-9

Acceptable – Class 1

- The criteria for crazing are that the assembly is functional.

Acceptable – Class 2,3

- Crazed areas in laminate substrates do not exceed 50% of the physical spacing between noncommon conductors.
- Crazing does not reduce spacing below minimum electrical clearance.
- Crazing at the edge of the board does not reduce the minimum defined distance between board edge and conductive pattern. If the minimum distance is not specified not more than 50% or 2.5 mm [0.1 in], whichever is less.

Defect – Class 2,3

- Crazed areas in laminate substrates exceed 50% of the physical spacing between noncommon conductors, see Figure 10-9.
- Unless otherwise defined, crazing at the edge of the board reduces the distance between board edge and conductive pattern more than 50% or 2.5 mm [0.1 in], whichever is less.

Defect – Class 1,2,3

- Spacing is reduced below minimum electrical clearance.

10.2.2 Laminate Conditions – Blistering and Delamination

In general, delamination and blistering occurs as a result of an inherent weakness of the material or process. Delamination or blistering between nonfunctional areas and functional areas may be acceptable provided that the imperfections are nonconductive and that other criteria are met.

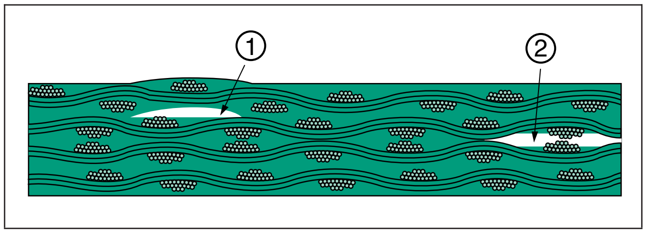

Figure 10-10
1. **Blistering**
2. **Delamination**

Blistering – Delamination in the form of a localized swelling and separation between any of the layers of a lamination base material, or between base material and conductive foil or protective coating.

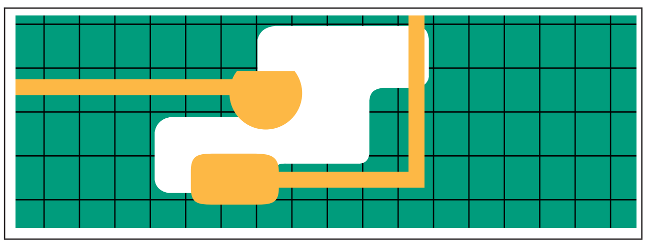

Figure 10-11

Delamination – A separation between plies within a base material, between a base material and a conductive foil or any other planar separation within a printed board.

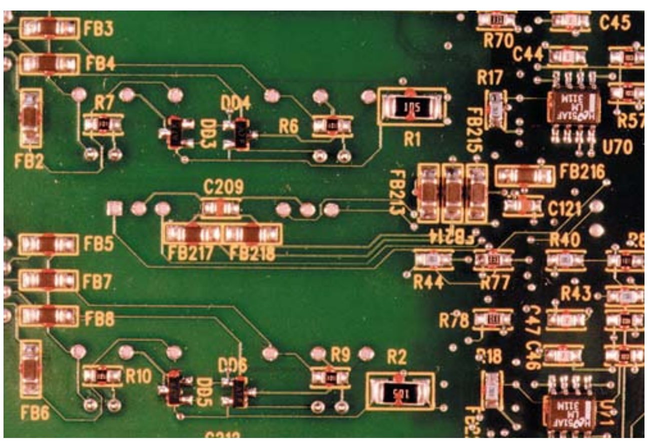

Figure 10-12

Acceptable – Class 1

- The blister or delamination spans more than 25% of the distance between conductors, but does not reduce the space between internal conductor patterns below the minimum conductor spacing.

Acceptable – Class 2,3

- The blister or delamination does not span more than 25% of the distance between adjacent conductive patterns.

10.2.2 Laminate Conditions – Blistering and Delamination (cont.)

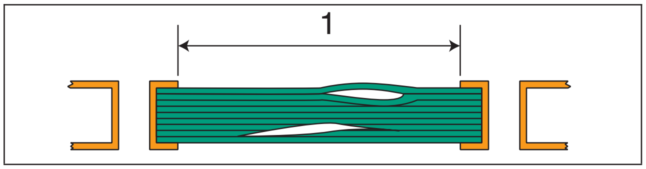

Figure 10-13
1. **Spacing between noncommon conductors**

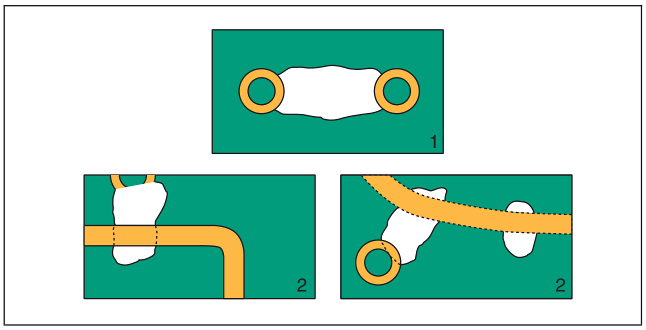

Figure 10-14

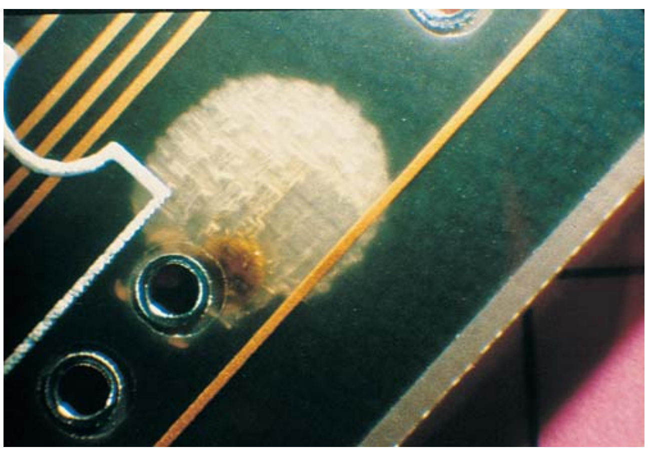

Figure 10-15

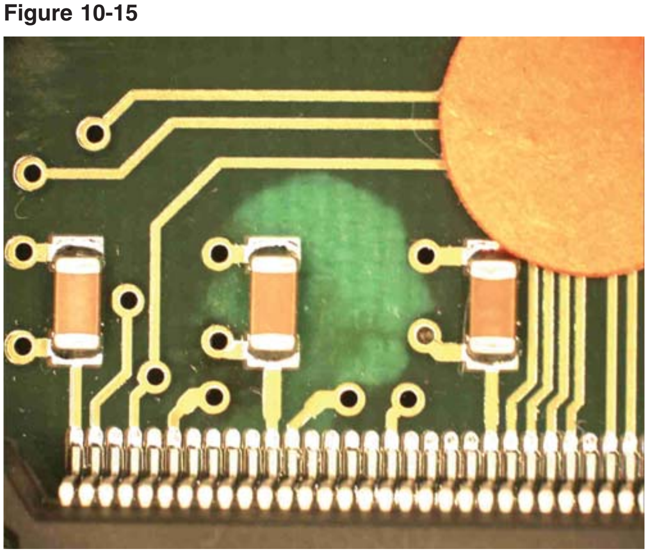

Figure 10-16

Defect – Class 2,3

- Blister/delamination exceeds 25% of the distance between plated through-holes or internal conductors.

Defect – Class 1,2,3

- Blistering/delamination reduce the space between conductive patterns below the minimum electrical clearance.

Note: Blisters or delamination areas may increase during assembly or operation. Separate criteria may need to be established.

10.2.3 Laminate Conditions – Weave Texture/Weave Exposure

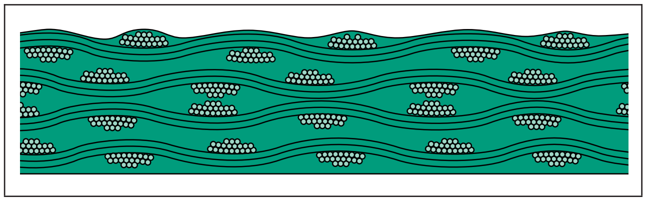

Figure 10-17

Weave Texture – A surface condition of base material in which a weave pattern of glass cloth is apparent although the unbroken fibers are completely covered with resin.

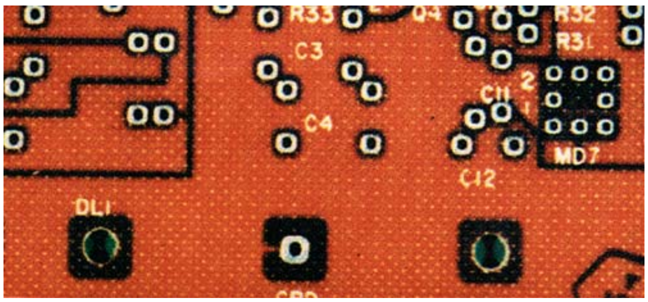

Figure 10-18

Acceptable – Class 1,2,3

- Weave texture is an acceptable condition in all classes but is confused with weave exposure because of similar appearance.

Note: Microsection may be used as a reference for this condition.

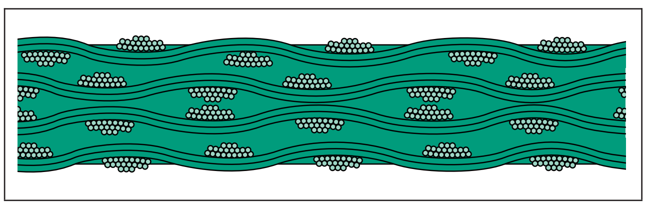

Figure 10-19

Weave Exposure – A surface condition of base material in which the unbroken fibers of woven glass cloth are not completely covered by resin.

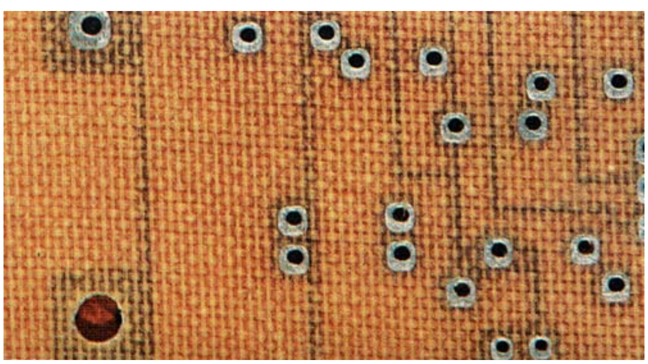

Figure 10-20

Acceptable – Class 1,2,3

- Weave exposure does not reduce the spacing between conductive patterns below specification minimums.

Acceptable – Class 1
Defect – Class 2,3

- Surface damage that cuts into laminate fibers.

Defect – Class 1,2,3

- Weave exposure reduces the spacing between conductive patterns to less than the minimum electrical clearance.

10.2.4 Laminate Conditions – Haloing

Haloing – A condition existing in the base material in the form of a light area around holes or other machined areas on or below the surface of the base material. Mechanically induced fracturing or delamination on or below the surface of the base material; a light area around the holes, other machined areas or both are usually indications of haloing.

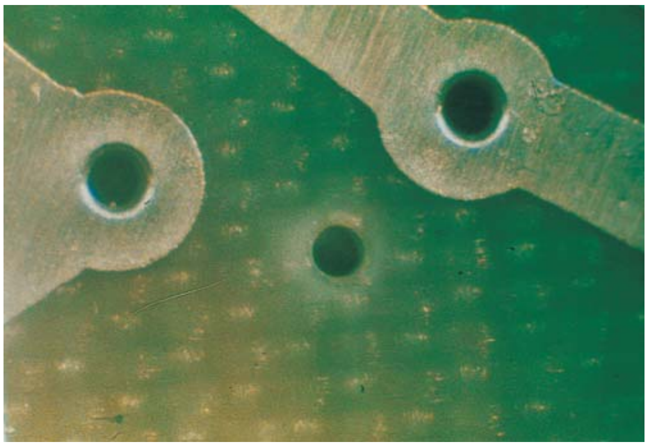

Figure 10-21

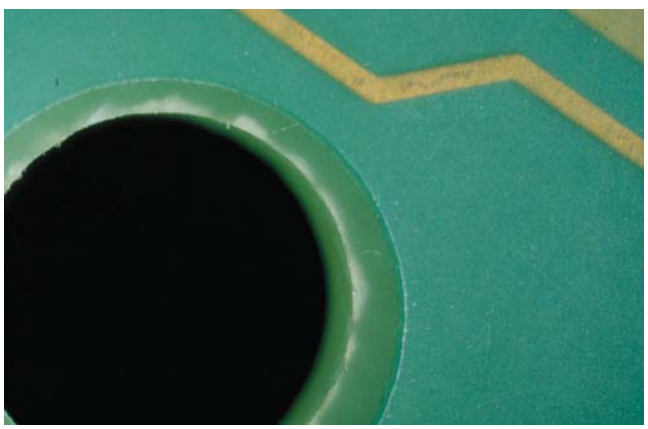

Figure 10-22

Acceptable – Class 1,2,3

- The distance between the haloing penetration and the nearest conductive feature is not less than the minimum lateral conductor spacing, or 0.1 mm [0.004 in] when the minimum lateral conductor spacing is not specified.

10.2.4 Laminate Conditions – Haloing (cont.)

Figure 10-23

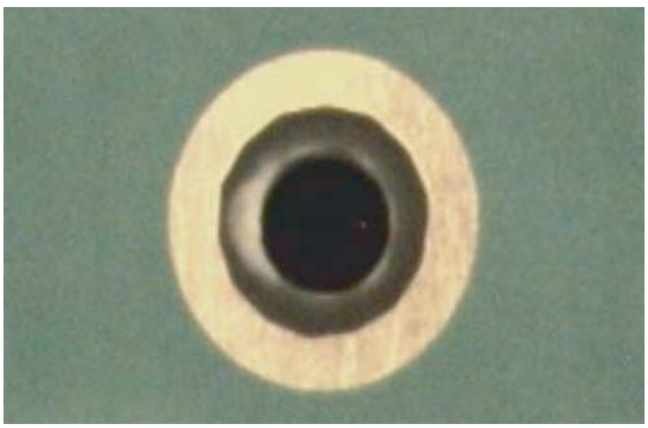

Figure 10-24

Defect – Class 1,2,3

- The distance between the haloing penetration and the nearest conductive feature is less than the minimum lateral conductor spacing, or less than 0.1 mm [0.004 in] when the minimum lateral conductor spacing is not specified.

10.2.5 Laminate Conditions – Edge Delamination, Nicks and Crazing

Delamination – A separation between plies within a base material, between a base material and a conductive foil, or any other planar separation within a printed board.

10.2.1 Printed Boards and Assemblies – Laminate Conditions – Measling and Crazing has additional crazing criteria.

Acceptable – Class 1,2,3

- Nicks do not exceed 50% of the distance from the printed board edge to the nearest conductor or 2.5 mm [0.1 in], whichever is less.
- Delamination or crazing at the edge of the printed board does not reduce spacing to the closest conductor pattern to less than the specified minimum distance. If no distance is specified, the distance is not reduced by more than 50% or 2.5 mm [0.1 in], whichever is less.
- Board edges are rough but not frayed.

10.2.5 Laminate Conditions – Edge Delamination, Nicks and Crazing (cont.)

Figure 10-25

Figure 10-26

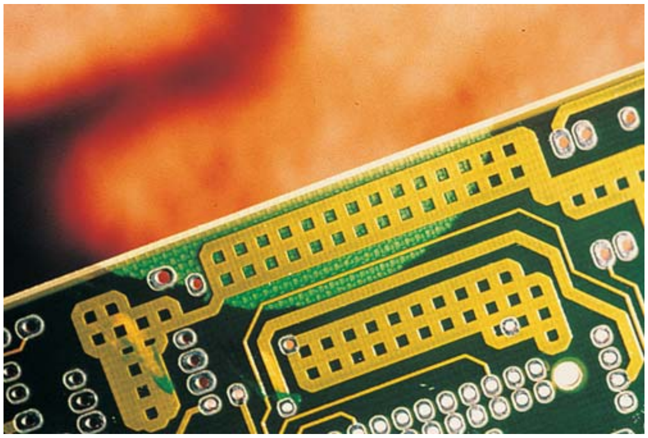

Figure 10-27

Defect – Class 1,2,3

- Nicks exceed 50% of the distance from the printed board edge to the nearest conductor or 2.5 mm [0.1 in], whichever is less, see Figure 10-25.
- Delamination or crazing at the edge of the printed board reduces spacing to the closest conductor pattern to less than the specified minimum distance. If no distance is specified, the distance is reduced by 50% or more or 2.5 mm [0.1 in], whichever is less.
- Cracks in the laminate, see Figure 10-26 arrow.

10.2.6 Laminate Conditions – Burns

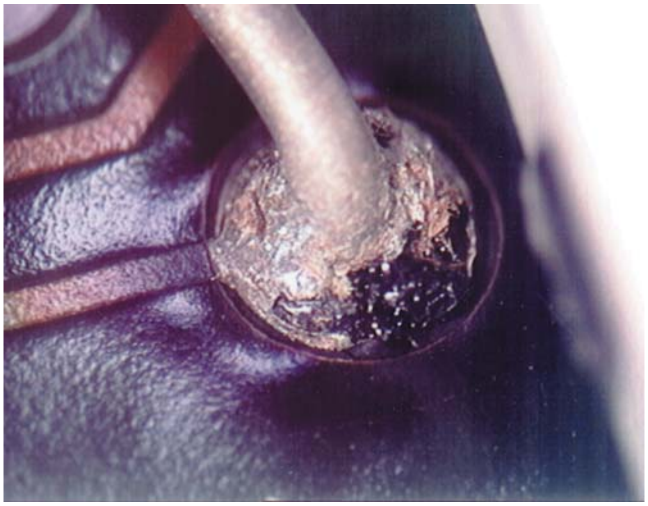

Figure 10-28

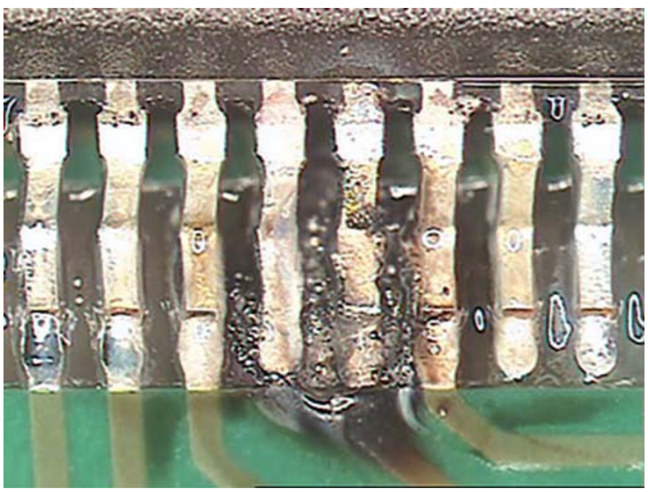

Figure 10-29

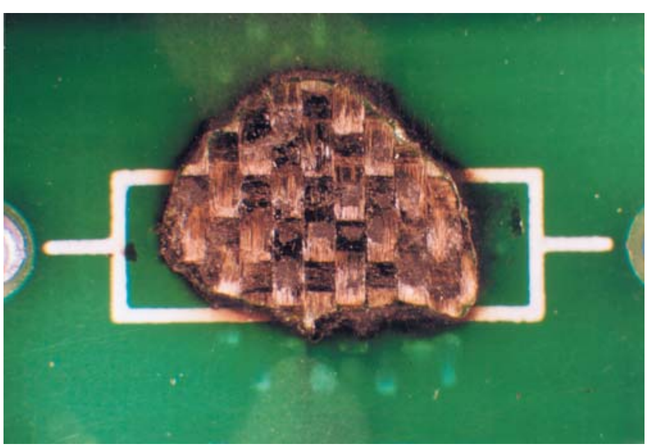

Figure 10-30

Defect – Class 1,2,3

- Burns that physically damage surface or the assembly.

10.2.7 Laminate Conditions – Bow and Twist

Figure 10-31 is an example of bow.

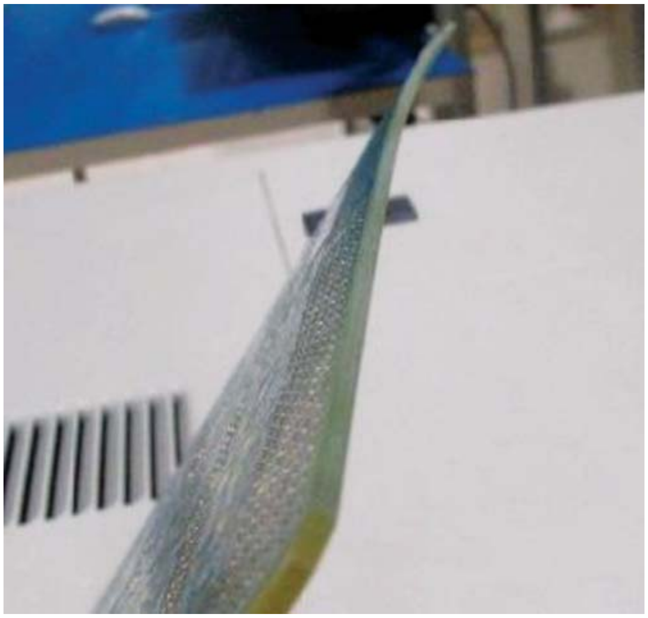

Figure 10-31

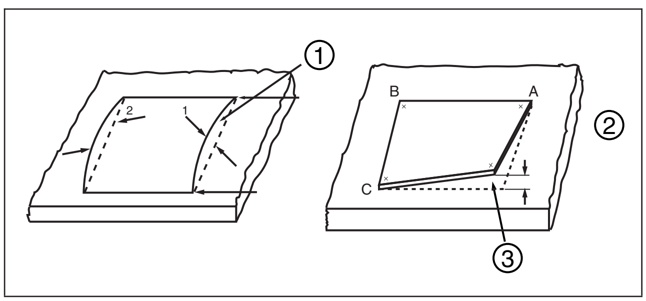

Figure 10-32
1. **Bow**
2. **Points A, B and C are touching base**
3. **Twist**

Acceptable – Class 1,2,3

- Bow and twist does not cause damage during post solder assembly operations or end use. Consider ''Form, Fit and Function'' and product reliability.

Defect – Class 1,2,3

- Bow and twist causes damage during post solder assembly operations or end use or affects form, fit or function.

Note: Bow and twist after solder should not exceed 1.5% for through-hole and 0.75% for surface mount printed board applications. IPC-TM-650 has Test Method 2.4.22 but this is specifically for bare boards. Component size and placement on assemblies often precludes use of that test method for populated assemblies. It may be necessary to confirm through testing that bow and twist has not created stress that will result in solder connection fracture, component damage or will otherwise cause damage during post solder assembly operations or use.

10.2.8 Laminate Conditions – Depanelization

These criteria are applicable to printed board assemblies with or without breakaway tabs. IPC-A-600 provides additional criteria for depanelization of bare boards.

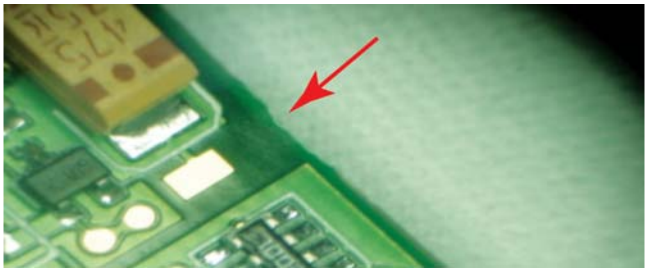

Figure 10-33

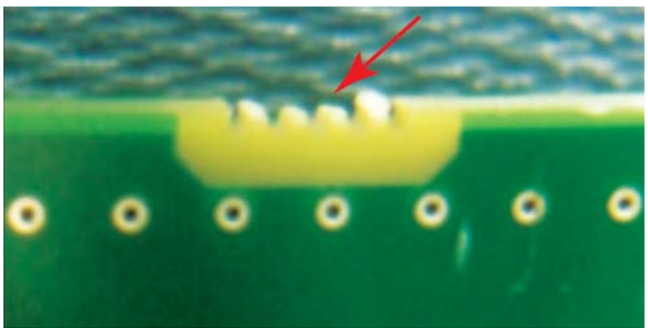

Figure 10-34

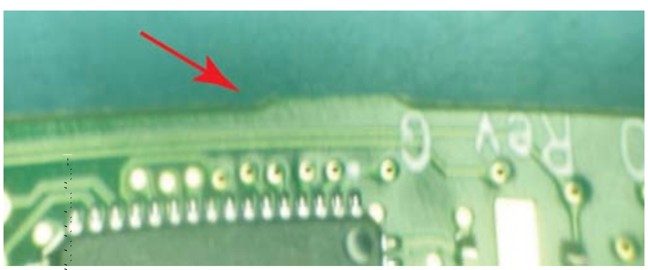

Figure 10-35

Acceptable – Class 1,2,3

- Edges are rough but not frayed.
- Nicks or routing do not exceed 50% of the distance from the board edge to the nearest conductor or 2.5 mm [0.1 in], whichever is less. See 10.2.4 Printed Boards and Assemblies – Laminate Conditions – Haloing for haloing and 10.2.1 Printed Boards and Assemblies – Laminate Conditions – Measling and Crazing for crazing.
- Loose burrs do not affect fit, form or function.

10.2.8 Laminate Conditions – Depanelization (cont.)

Figure 10-36

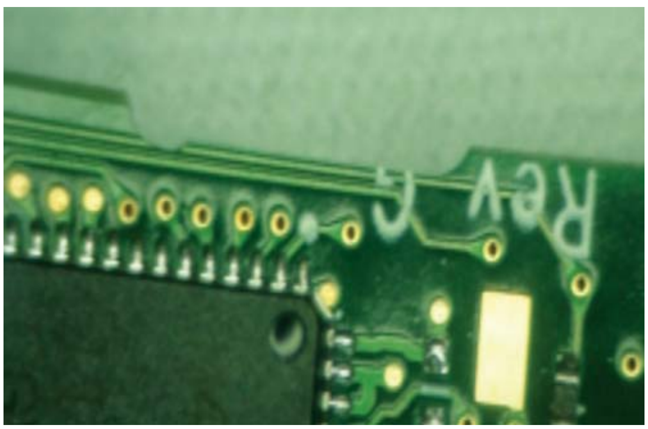

Figure 10-37

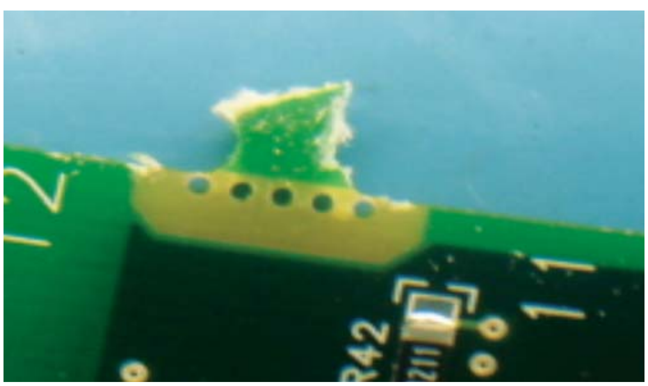

Figure 10-38

Defect – Class 1,2,3

- Edges are frayed.
- Nicks or routing exceed 50% of the distance from the board edge to the nearest conductor or 2.5 mm [0.1 in], whichever is less. See 10.2.4 Printed Boards and Assemblies – Laminate Conditions – Haloing for haloing and 10.2.1 Printed Boards and Assemblies – Laminate Conditions – Measling and Crazing for crazing.
- Loose burrs affect fit, form or function.

10.3 Conductors/Lands

10.3.1 Conductors/Lands – Reduction

These criteria are applicable to conductors and lands on rigid, flex and rigid-flex circuitry.

IPC-6010-FAM provides the requirements for conductor width and thickness reduction.

Conductor – The physical geometry of a conductor is defined by its width x thickness x length.

Conductor Width Reduction – Reduction of the conductor width (specified or derived) due to individual defects, i.e., edge roughness, nicks, pinholes and scratches.

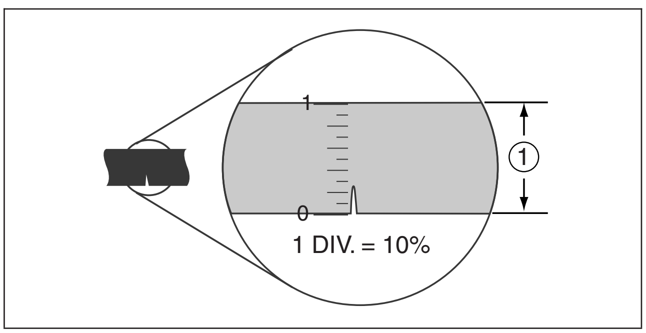

Figure 10-39
1. Minimum conductor width

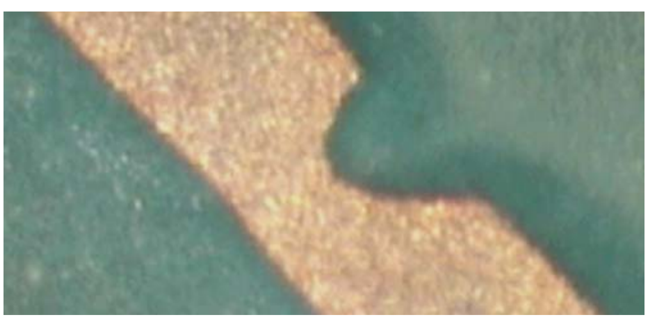

Figure 10-40

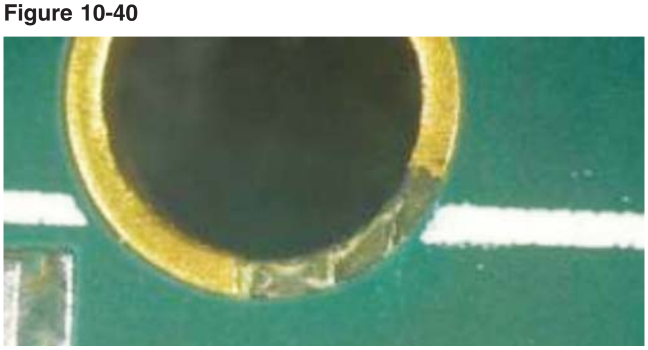

Figure 10-41

Defect – Class 1

- Reduction in width of printed conductors by more than 30%.
- Reduction in width or length of lands by more than 30%.

Defect – Class 2,3

- Reduction in width of printed conductors by more than 20%.
- Reduction in width or length of lands by more than 20%.

Note: Even small changes in cross-sectional area can have a large impact on impedance of RF circuitry. Alternate criteria may need to be developed.

10.3.2 Conductors/Lands – Lifted

Figure 10-42

Process Indicator – Class 1,2,3

- Separation between outer edge or land and laminate surface is less than one land thickness.

Note: Lifted and/or separated land area(s) is typically a result of the soldering process that warrants immediate investigation to determine root cause. Efforts to eliminate and/or prevent this condition should be made.

10.3.2 Conductors/Lands – Lifted (cont.)

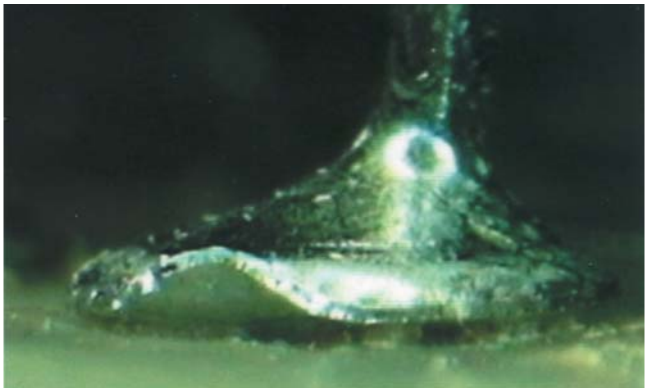

Figure 10-43

Defect – Class 1,2,3

- Separation between land and laminate surface is greater than one land thickness.
- Any separation of circuit conductor (trace) from the laminate surface.

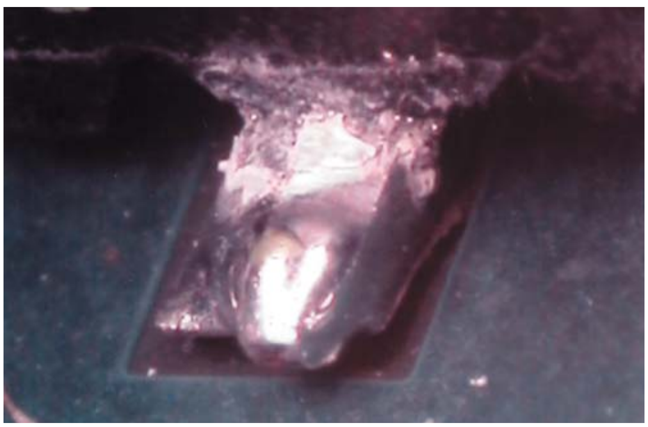

Figure 10-44

Defect – Class 3

- Any lifting of a surface mount land if there is a via in the land.

Figure 10-45

10.3.3 Conductors/Lands – Mechanical Damage

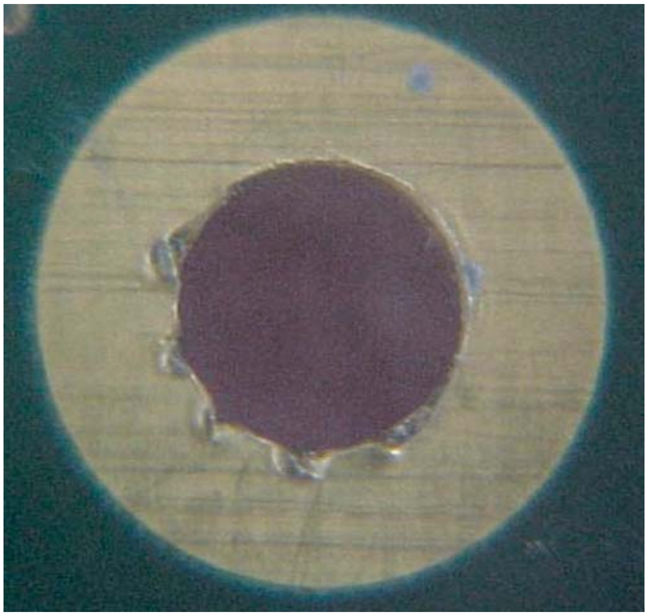

Figure 10-46

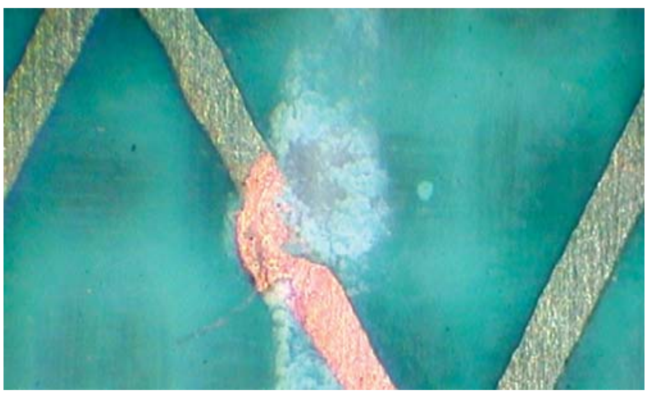

Figure 10-47

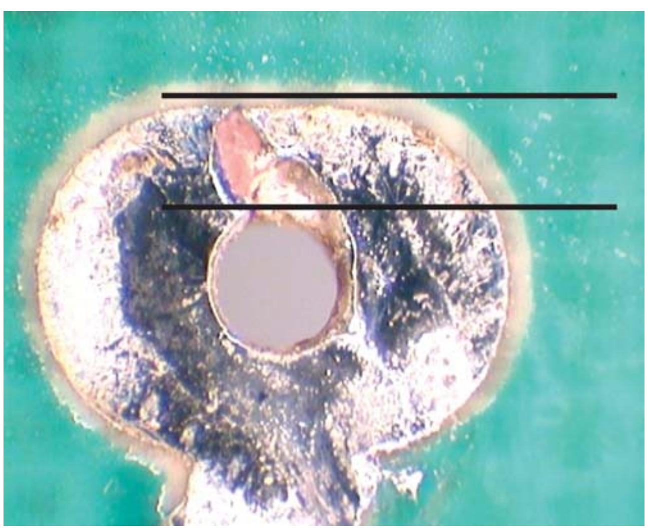

Figure 10-48

Defect – Class 1,2,3

- Damage to functional conductors or lands that affects form, fit or function.

10.4 Flexible and Rigid-Flex Printed Boards

10.4.1 Flexible and Rigid-Flex Printed Boards – Damage

The trimmed edge of the flexible printed board or the flexible section rigid-flex printed board is free of burrs, nicks, delamination or tears in excess of that allowed in the procurement documentation.

Note: Mechanically created indentations caused by contact between the coverlayer of flexible printed boards or assemblies and molten solder are not rejectable. Additionally, care should be taken to avoid bending or flexing conductors during inspection.

The deformation of a stiffener board should conform to the master drawing or the individual specification. See 10.2.4 Printed Boards and Assemblies – Laminate Conditions – Haloing and 10.2.5 Printed Boards and Assemblies – Laminate Conditions – Edge Delamination, Nicks and Crazing.

Note: For SMT or through-hole component mounting, placement, soldering, cleanliness criteria on flex assemblies, etc., follow the applicable sections of this standard.

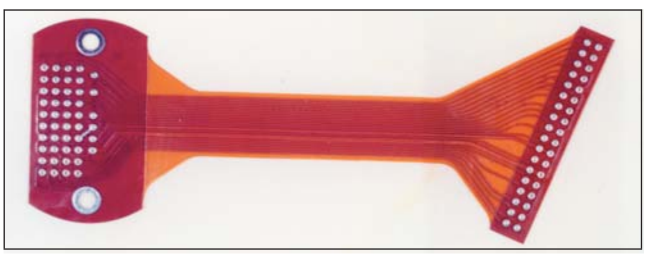

Figure 10-49

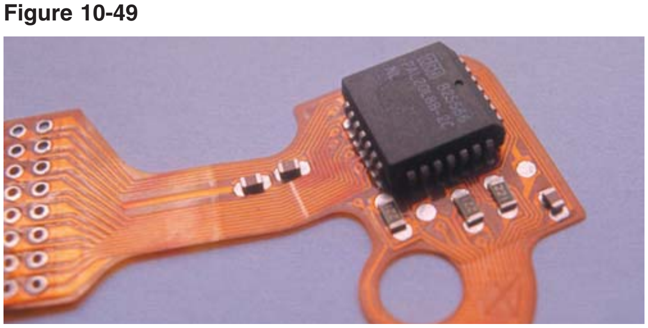

Figure 10-50

Acceptable – Class 1

- Nicks or damage along the edges of the flexible printed boards and cutouts, providing the penetration does not exceed 50% of the distance from the edge to the nearest conductor or 2.5 mm [0.1 in], whichever is less.

Acceptable – Class 2,3

- No nicks, tears or imperfections along the flexible edges of the flexible printed board.

10.4.1 Flexible and Rigid-Flex Printed Boards – Damage (cont.)

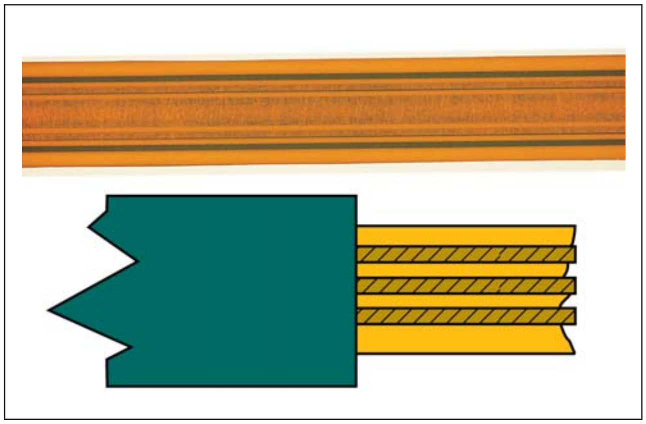

Figure 10-51

Acceptable – Class 1,2,3

- No nicks or tears in excess of that specified in the procurement documentation.
- Edge to conductor spacing of the flexible portion is within requirements specified on the procurement documentation.

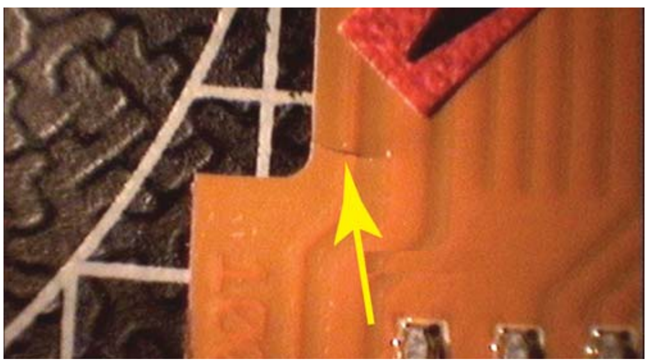

Figure 10-52

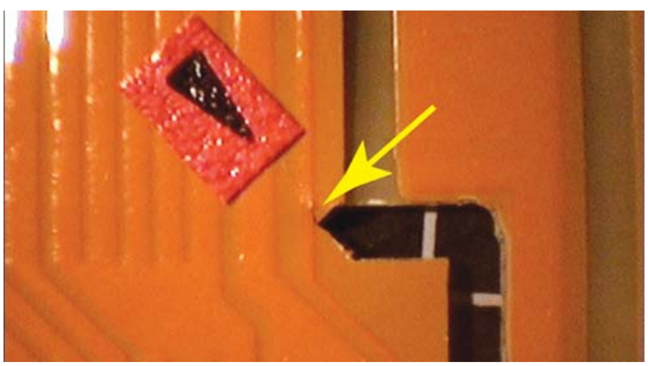

Figure 10-53

Defect – Class 1,2,3

- Edge to conductor spacing does not comply with specified requirements.
- Evidence of burns, charring or melting of the insulation.
- Cuts, nicks, gouges, tears or other physical damage affecting the flex material thickness that exposes circuitry.

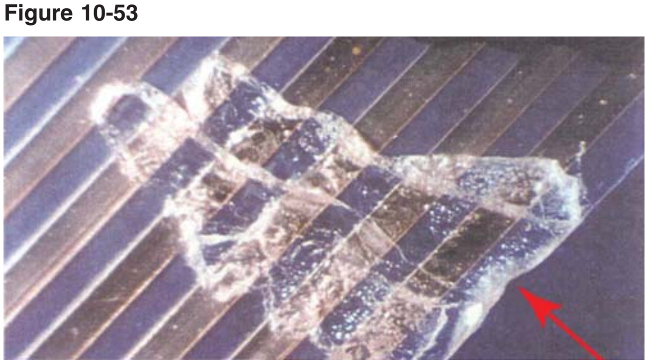

Figure 10-54

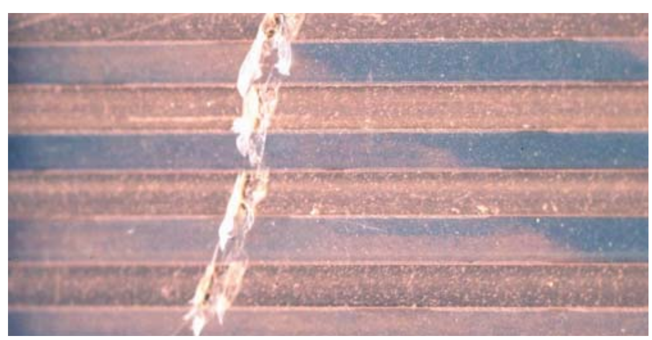

Figure 10-55

10.4.2 Flexible and Rigid-Flex Printed Boards – Delamination/Blister

10.4.2.1 Flexible and Rigid-Flex Printed Boards – Delamination/Blister – Flex

Sometimes delamination/blistering takes place in the flex circuitry during processing or the assembly soldering process.

Note: Ground and/or shield planes are treated as one conductive pattern and do not apply to adjacent pattern spacing when the imperfection is contained completely within common conductors.

There are no illustrations for these criteria.

Acceptable – Class 1,2,3

- Delamination and blistering provided the area affected does not exceed 1% of the printed board area on each side due to assembly processing prior to soldering.
- The imperfection does not reduce the spacing between conductive patterns below the minimum conductor spacing.

Acceptable – Class 2,3

- Delamination (separation) or bubbles in the coverlayers of the flexible circuitry after thermal exposure due to soldering does not span more than 25% of the distance between adjacent conductive patterns.
- The separation is no larger than 0.8 x 0.8 mm [0.03 x 0.03 in] and maintains the coverfilm seal.
- The total number of separations does not exceed three in any 25 mm x 25 mm [1 in x 1 in] of coverfilm surface area and **shall not** exceed a total area of separation greater than 25 square mm, or 5 x 5 mm [0.2 x 0.2 in].
- The imperfection does not exceed the specified minimum distance between printed board edge and conductive pattern, or 2.5 mm [0.1 in] if not specified.

10.4.2.2 Flexible and Rigid-Flex Printed Boards – Delamination/Blister – Flex to Stiffener

Not Established – Class 1
Acceptable – Class 2,3

- The distance from stiffener board edge in the section of flex circuit which is intended to remain straight is 0.5 mm [0.02 in] or less.
- The distance from stiffener board edge in the section of the flex circuit which is intended to bend is 0.3 mm [0.01 in] or less.
- Delamination (separation) or bubbles in the coverlayers of the flexible circuitry does not span more than 25% of the distance between adjacent conductive patterns.

Figure 10-56

Not Established – Class 1
Defect – Class 2,3

- The distance from stiffener board edge in the section of flex circuit which is intended to remain straight exceeds 0.5 mm [0.02 in].
- The distance from stiffener board edge in the section of flex circuit which is intended to bend exceeds 0.3 mm [0.01 in].
- Delamination (separation) or bubbles in the coverlayers of the flexible circuitry span more than 25% of the distance between adjacent conductive patterns.

10.4.3 Flexible and Rigid-Flex Printed Boards – Solder Wicking

The edge of the coverlayer does not include adhesive squeeze out.

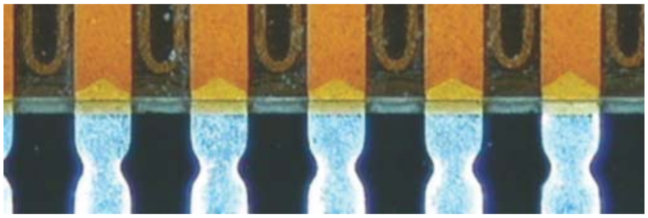

Figure 10-57

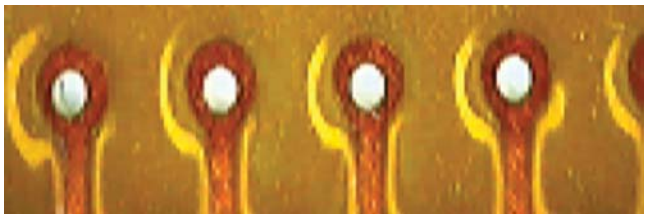

Figure 10-58

Acceptable – Class 1,2,3

- Solder wicking or plating migration does not extend into the area required to be flexible.

Acceptable – Class 2

- Solder wicking/plating migration does not extend under coverlayer more than 0.5 mm [0.02 in].

Acceptable – Class 3

- Solder wicking/plating migration does not extend under coverlayer more than 0.3 mm [0.01 in].

Figure 10-59

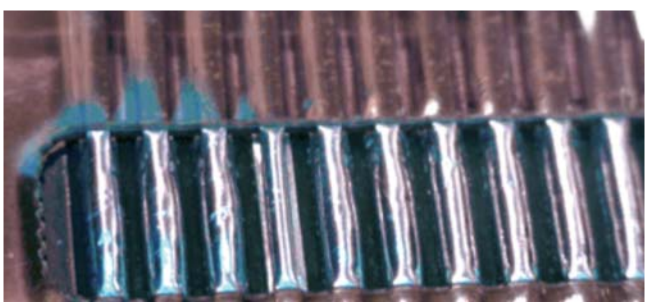

Figure 10-60

Defect – Class 2

- Solder wicking/plating migration extends under coverlayer more than 0.5 mm [0.02 in].

Defect – Class 3

- Solder wicking/plating migration extends under coverlayer more than 0.3 mm [0.01 in].

Defect – Class 1,2,3

- Solder wicking or plating migration extends into the area required to be flexible.
- Spacing as a result of solder wicking or plating migration violates minimum electrical clearance.

10.4.4 Flexible and Rigid-Flex Printed Boards – Attachment

These criteria are applicable to the solder attachment of flex on printed board (FOB). When sufficient data has been collected this will be expanded to include flex on flex (FOF) and connection using anisotropically conductive flex (ACF).

Figure 10-61

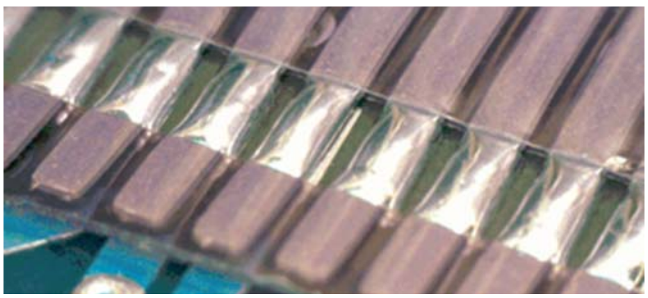

Figure 10-62

Figure 10-63

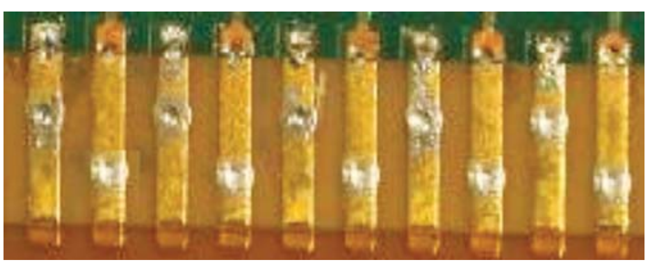

Figure 10-64

Acceptable – Class 1

- Side overhang of flex termination is equal to or less than 50% of flex termination width.

Acceptable – Class 2,3

- Side overhang of flex termination is equal to or less than 25% of flex termination width.

Acceptable – Class 1,2,3

- Vertical fill in plated through-holes in the connection areas is 50% or more.
- Wetted solder is visible in the edge semicircular plated holes.
- Unformed flex lead side fillets are 100% of lead to land interface.

10.4.4 Flexible and Rigid-Flex Printed Boards – Attachment (cont.)

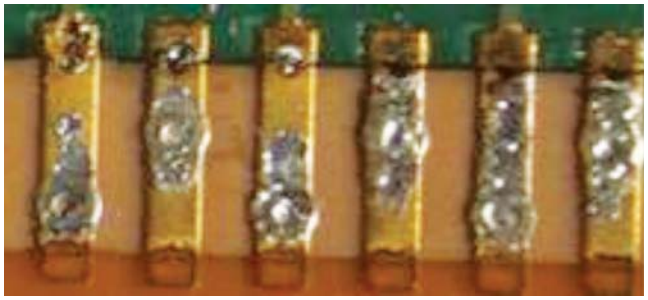

Figure 10-65

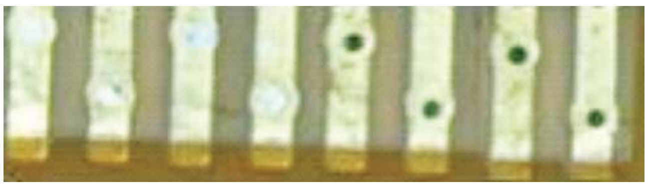

Figure 10-66

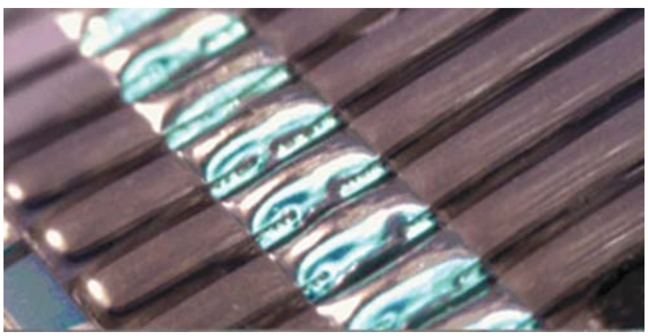

Figure 10-67

Process Indicator – Class 1,2,3

- No evidence of wetted solder in two adjacent edge semi-circular plated holes.

Defect – Class 1

- Side overhang of flex termination is more than 50% of flex termination width.

Defect – Class 2,3

- Side overhang of flex termination is more than 25% of flex termination width.

Defect – Class 1,2,3

- Vertical fill in plated-through holes in the connection areas is less than 50%.
- No evidence of wetted solder in three or more adjacent edge semicircular plated holes.
- Unformed flex lead side fillets are less than 100% of lead to land interface.

10.5 Marking

This section covers acceptability criteria for marking of printed boards and other electronic assemblies.

Marking provides both product identification and traceability. It aids in assembly, in process control and field servicing.

10.5 Marking (cont.)

Examples of the markings addressed by this section include the following:

a. Electronic Assemblies:
- Company logo
- Board fabrication part numbers and revision level
- Assembly part number, group number and revision level
- Component legends including reference designators and polarity indicators (only applies prior to assembly processing/cleaning)
- Certain inspection and test traceability indicators
- U.S. and other relevant regulatory agencies/certifications
- Unique individual serial number
- Date code

b. Modules and/or Higher Level Assemblies:
- Company logo
- Product identification numbers, e.g., drawing number, revision and serial number
- Installation and user information
- Relevant regulatory agencies' certification labels

The fabrication and assembly drawings are the controlling documents for the locations and types of markings. Marking criteria specified in the drawings will take precedence over these criteria.

In general, additive markings over metal surfaces are not recommended. Markings which serve as aids to assembly and inspection need not be visible after the components are mounted.

Assembly marking (part numbers, serial numbers) **shall** remain legible (capable of being read and understood as defined by the requirements of this standard) after all tests, cleaning and other processes to which the item is subjected.

Component markings, reference designators and polarity indicators should be legible and components should be mounted in such a manner that markings are visible. However, unless otherwise required, it is an acceptable condition if these markings are removed or damaged during normal cleaning or processing.

Markings are not deliberately altered, obliterated or removed by the manufacturer unless required by the assembly drawing(s)/documentation. Additional markings such as labels added during the manufacturing process should not obscure the original supplier's markings. Permanent labels need to comply with the adhesion requirements of 10.5.5.3. Components and fabricated parts need not be mechanically installed so that the reference designations are visible when installed.

These criteria are applicable when content marking is required.

Acceptable – Class 1,2,3
- Markings include the content specified by the controlling document.

Defect – Class 1,2,3
- Marking content incorrect.
- Marking missing.

10.5.1 Marking – Etched (Including Hand Printing)

Hand printing may include marking with indelible pen or mechanical etcher.

Figure 10-68

Acceptable – Class 1,2,3

- Edges of the lines forming a character may be slightly irregular. Open areas within characters may be filled providing the characters are legible and cannot be confused with another letter or number.
- Width of the lines forming a character may be reduced by up to 50% providing they remain legible.
- Lines of a number or letter may be broken provided the breaks do not make the marking illegible.

Figure 10-69

Acceptable – Class 1
Process Indicator – Class 2,3

- Legends are irregularly formed but the general intent of the legend or marking is discernible, see Figure 10-69.

Defect – Class 1,2,3

- Missing or illegible characters in the markings.
- Marking violates the minimum electrical clearance limits.
- Solder bridging within or between characters or characters/conductors preventing character identification.
- Lines forming a character are missing or broken to the extent that the character is not legible or is likely to be confused with another character.

10.5.2 Marking – Screened

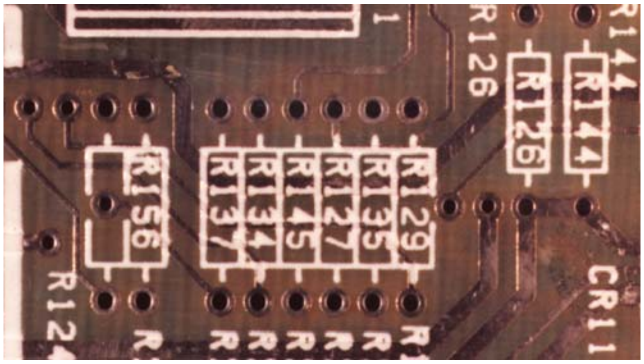

Figure 10-70

Acceptable – Class 1,2,3

- Ink may be built up outside the line of a character providing the character is legible.
- Marking ink on the land does not interfere with soldering requirements.

Acceptable – Class 1
Process Indicator – Class 2,3

- Lines of a number or letter may be broken (or the ink thin over a portion of the character) providing the breaks do not make the markings illegible.

Process Indicator – Class 2,3

- The open areas within characters may be filled providing the characters are legible, i.e., cannot be confused with another letter or number.

Defect – Class 1,2,3

- Marking ink is present on the land interfering with the solder requirements of Tables 7-4, 7-5 or 7-7, or with the surface mount soldering requirements of 8 Surface Mount Assemblies.

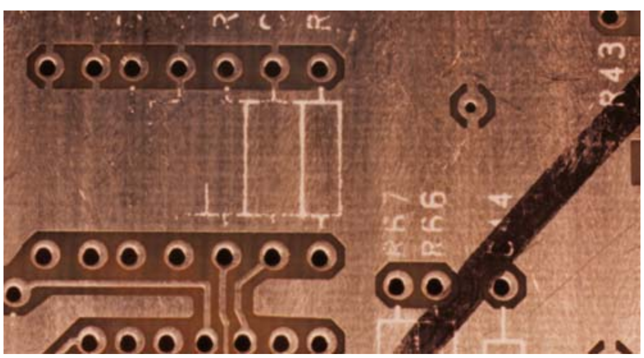

Figure 10-71

Acceptable – Class 1
Process Indicator – Class 2,3

- Marking that is smeared or blurred but is still legible.
- Multiple images are legible.

Defect – Class 1,2,3

- Missing or illegible characters in the markings.
- Open areas of characters are filled and are not legible, or are likely to be confused with another number or letter.
- Lines forming a character are missing, broken or smeared to the extent that the character is not legible or is likely to be confused with another character.

10.5.3 Marking – Stamped

Acceptable – Class 1,2,3

- Ink may be built up outside the line of a character providing the character is legible.
- Marking ink is present on the land (see soldering requirements of Tables 7-4, 7-5 or 7-7, or the surface mount soldering requirements of 8 Surface Mount Assemblies).

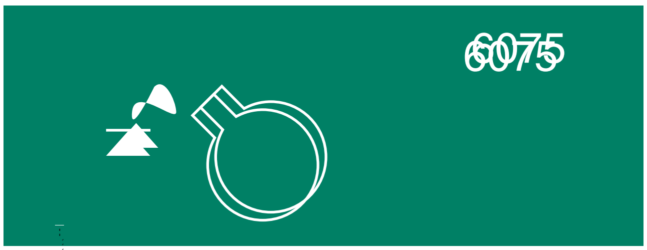

Figure 10-72

Acceptable – Class 1
Process Indicator – Class 2,3

- Lines of a number or letter may be broken (or the ink thin over a portion of the character) providing the breaks do not make the markings illegible.
- The open areas within characters may be filled providing the characters are legible, i.e., cannot be confused with another letter or number.
- Marking that has been smeared or blurred but is still legible.
- Multiple stamped markings are acceptable provided the general intent can be determined.
- Missing or smeared marking does not exceed 10% of the character and the character is still legible.

Figure 10-73

Defect – Class 1,2,3

- Marking ink is present on the land interfering with the solder requirements of Tables 7-4, 7-5 or 7-7, or with the surface mount soldering requirements of 8 Surface Mount Assemblies.
- Missing or illegible characters in the markings.
- Open areas of characters are filled and are not legible, or are likely to be confused with another number or letter.
- Lines forming a character are missing, broken or smeared to the extent that the character is not legible or is likely to be confused with another character.

10.5.4 Marking – Laser

Acceptable – Class 1,2,3

- Marking may be built up outside the line of a character providing the character is legible.

Figure 10-74

Acceptable – Class 1
Process Indicator – Class 2,3

- Multiple image is still legible.
- Missing marking is not more than 10% of the character.
- Lines of a number or letter may be broken (or thin over a portion of the character).

Defect – Class 1,2,3

- Missing or illegible characters in the markings.
- Open areas of characters are filled and are not legible, or are likely to be confused with another number or letter.
- Lines forming a character are missing, broken or smeared to the extent that the character is not legible or is likely to be confused with another character.
- The depth of the marking adversely affects the function of the part.
- Marking exposes copper on the ground plane of printed boards.
- Delamination on the printed board dielectric from marking.
- Markings touch or cross over solderable surfaces.

10.5.5 Marking – Labels

Permanent labels are commonly used to attach machine readable data, but may include text. Readability, adhesion and damage criteria apply to all permanent labels.

10.5.5.1 Marking – Labels – Bar Coding/Data Matrix

Bar coding matrix bar coding (Data Matrix) is a method of product identification for process control and traceability because of ease and accuracy of data collection and processing. This marking can occupy small areas (some can be attached to the thickness edge of the printed board) and can withstand the normal wave soldering and cleaning operations. Coding can also be laser scribed directly on to the base material. Acceptability requirements are the same as other types of markings except for legibility where machine readability replaces human readability.

10.5.5.2 Marking – Labels – Readability

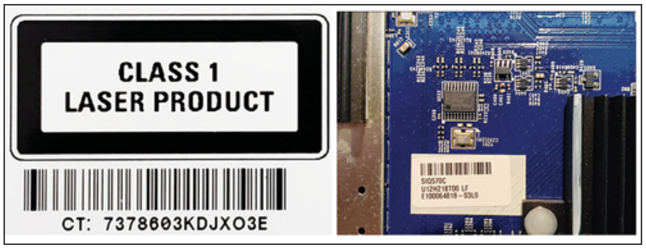

Figure 10-75

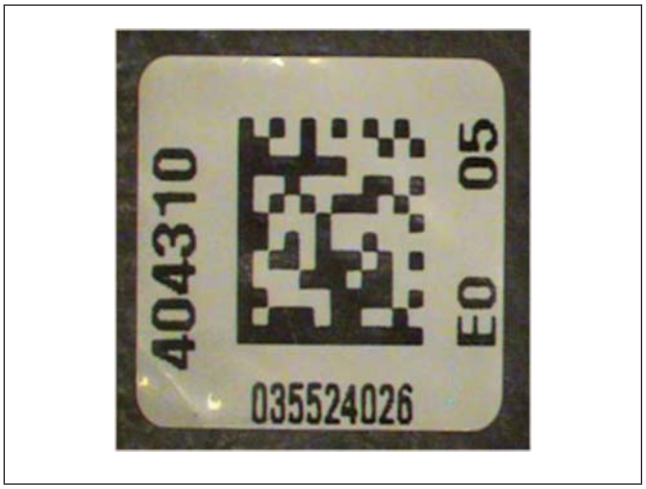

Figure 10-76

Figure 10-77

Figure 10-78

Acceptable – Class 1,2,3

- Spots or voids on printed surfaces of machine readable code are permissible provided that code can be read successfully with three (3) or fewer attempts.
- Text is legible.

Defect – Class 1,2,3

- Machine readable code cannot be successfully read within three (3) attempts.
- Missing or illegible characters in the markings, see Figures 10-77 and 10-78.

10.5.5.3 Marking – Labels – Adhesion and Damage

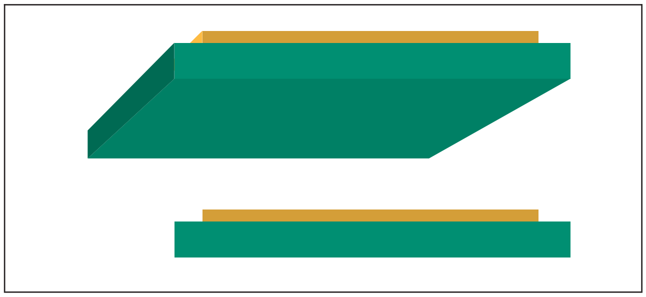

Figure 10-79

Acceptable – Class 1,2,3

- Label lifted 10% or less of the label area.
- Physical damage is 10% or less of the label area and does not affect form, fit or function.
- Damage does not affect legibility or the barcode readability.

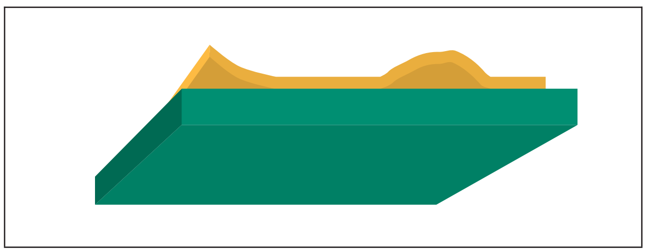

Figure 10-80

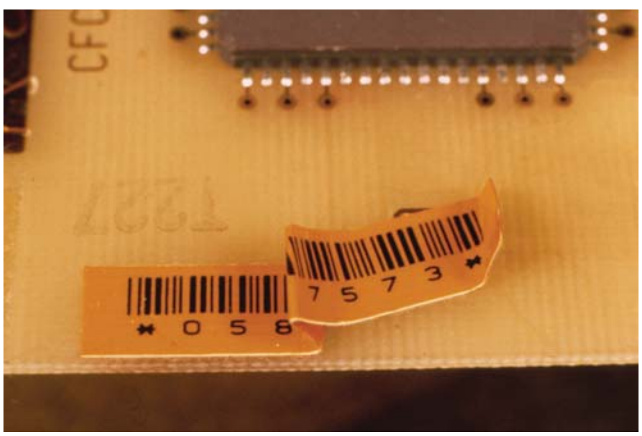

Figure 10-81

Defect – Class 1,2,3

- More than 10% of the label area is peeling.
- Missing labels.
- Label wrinkle affects readability.
- Physical damage is greater than 10% of the label area or affects form, fit or function.
- Damage affects legibility or the barcode readability.

10.5.5.4 Marking – Labels – Position

Acceptable – Class 1,2,3

- Label is applied in the required position.

Defect – Class 1,2,3

- Label is not applied in the required position.

10.5.6 Marking – Radio Frequency Identification (RFID) Tags

Radio Frequency Identification Marking (RFID tags) is widely used in industry. These tags contain an electronic circuit (a microchip) that operates at the specified frequency. The RFID tags contain electronic data that may consist of any of the aforementioned marking information, as well as additional data provided for tracking/traceability purposes. For the RFID tags to function properly, it is important that they be physically located from the specified distance away from the reader. The RF signal must not be obstructed by objects such as metal, water (depends on frequency) or any other object that would distort, or otherwise prevent proper transmission of the RF signal to the tag reader.

There are no illustrations for these criteria.

Defect – Class 1,2,3

- The RFID tag is not located within the specified distance from the tag reader such that the reader cannot access the RF signal.
- The free-air path between the RFID tag contains obstructions, e.g., metal, water, etc., that preclude transmission of the RF signal from the tag to the reader.
- The RFID tag is attached to the object in a manner that precludes transmission of the RF signal.
- The RFID tag is damaged to the extent that the information embedded therein cannot be read by the reader.
- The RF signal is distorted to the extent that the data cannot be clearly discerned using the reader.

10.6 Cleanliness

This section covers acceptability requirements for cleanliness of assemblies, which includes any components with any electrical interfacing surfaces, e.g., connector mating surfaces, compliant pins, etc. The following are examples of the more common contaminants found on assemblies. The conditions represented in this section apply to both primary and secondary sides of the assemblies. Other conditions may appear, however, and all abnormal conditions should be identified. See IPC-CH-65 for additional cleaning information.

Rationale:

- Contamination should not be judged on cosmetic or functional attributes, but as a warning that something in the cleaning system is not working properly.
- Testing a contaminant for functional effects should be performed under conditions of the expected worse case operational environment for the product.
- Every production facility should have a document defining the maximum levels and type of contaminant allowable.
- Testing with ionic extract devices based on J-STD-001, insulation resistance tests under environmental conditions and other electrical parameter tests as described in IPC-TM-650 are recommended for setting a facility standard.

See 1.12.2 Magnification Aids for inspection magnification requirements.

10.6.1 Cleanliness – Flux Residues

The flux classification (see J-STD-004) and assembly process, i.e., no-clean, clean, etc., need to be identified and considered when applying these criteria.

10.6.1.1 Cleanliness – Flux Residues – Cleaning Required

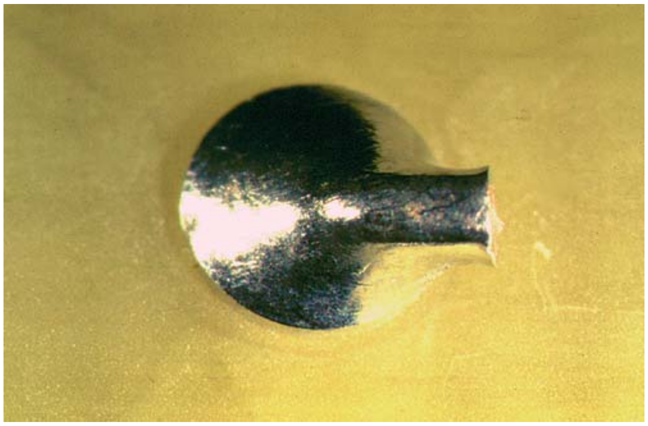

Figure 10-82

Acceptable – Class 1,2,3

- No visible flux residue.

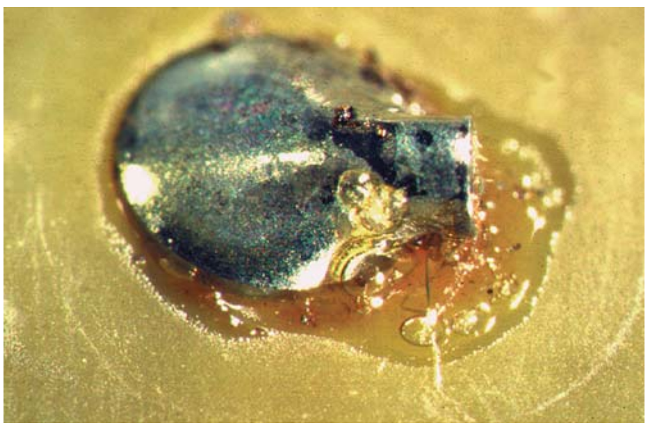

Figure 10-83

Defect – Class 1,2,3

- Visible flux residue.

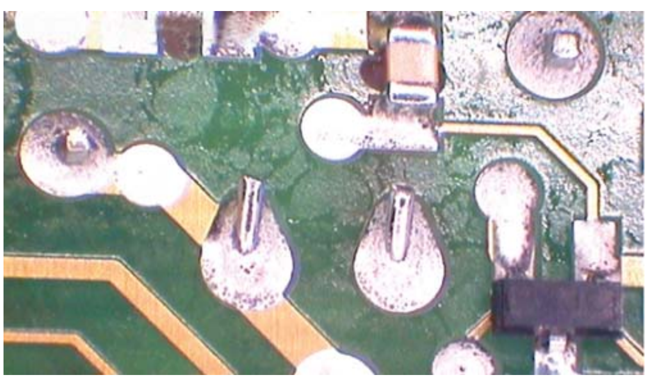

Figure 10-84

10.6.1.2 Cleanliness – Flux Residues – No Clean Process

Flux residue may be present if it is flux residue that is not intended to be cleaned.

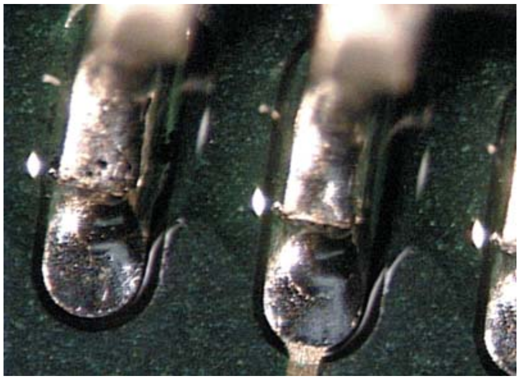

Figure 10-85

Figure 10-86

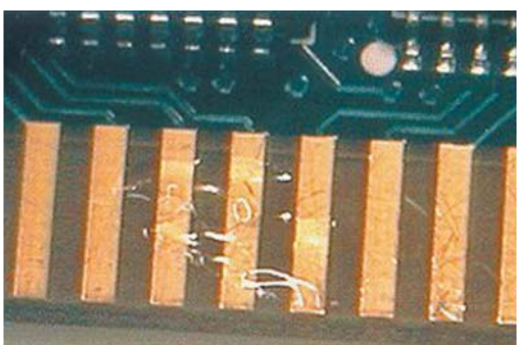

Figure 10-87

Figure 10-88

Acceptable – Class 1,2,3

- Flux residue on, around or bridging between noncommon lands, component leads and conductors.
- Flux residue does not inhibit visual inspection.
- Flux residue does not inhibit access to test points of the assembly.

Acceptable – Class 1
Process Indicator – Class 2
Defect – Class 3

- Finger prints in no clean residue.

Defect – Class 2,3

- Flux residue inhibits visual inspection.
- Flux residue inhibits access to test points.
- Wet, tacky or excessive flux residues that may spread onto other surfaces.

Defect – Class 1,2,3

- No-clean flux residue on any electrical mating surface that inhibits electrical connections.

Note 1: There is no defect for discoloration of OSP coated assemblies that come in contact with flux residues from no-clean process.

Note 2: Residue appearance may vary depending upon flux characteristics and solder processes.

10.6.2 Cleanliness – Foreign Object Debris (FOD)

For the purposes of this document, the following are defined.

Encapsulated – Enclosed within or under a material such as conformal coating, molding/potting or encapsulant material.

Entrapped – Caught within a material such as no clean flux residues.

In the following criteria, the words ''entrapped,'' ''encapsulated,'' and ''attached'' are intended to mean that service environment of the product will not cause particulate matter to become dislodged. The method to determine if the FOD could break loose in the service environment should be agreed between the Manufacturer and User.

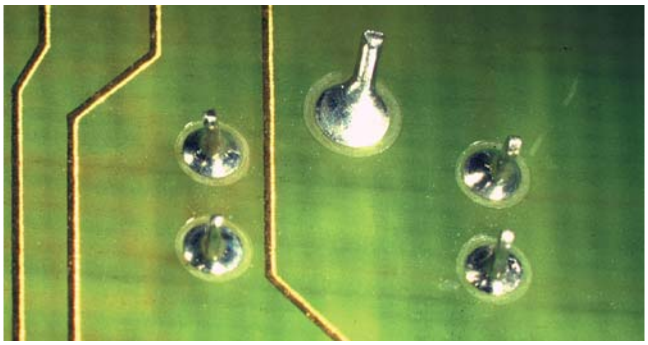

Figure 10-89

Acceptable – Class 1,2,3

- FOD meets the following criteria:
  - Attached/entrapped/encapsulated on the printed board assembly surface or solder mask.
  - Do not violate minimum electrical clearance.

Figure 10-90

Defect – Class 1,2,3

- FOD that is not attached, entrapped, encapsulated, see 5.2.7.1 Soldering – Soldering Anomalies – Excess Solder – Solder Balls and 10.8.2 Printed Boards and Assemblies – Conformal Coating – Coverage.
- Violate minimum electrical clearance.

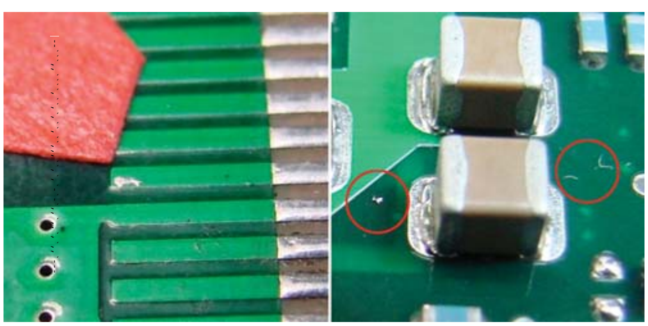

Figure 10-91

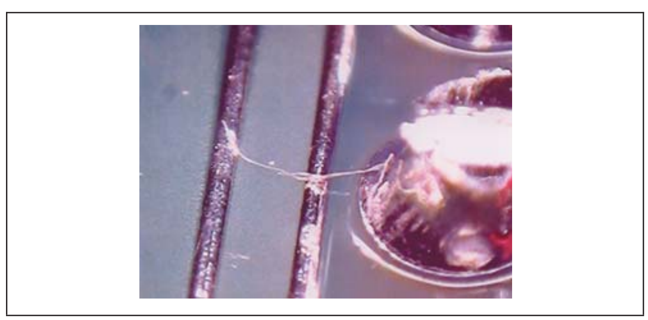

Figure 10-92

10.6.3 Cleanliness – Chlorides, Carbonates and White Residues

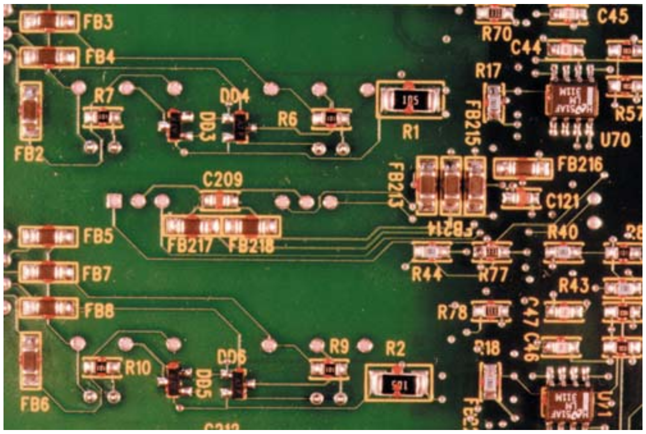

Figure 10-93

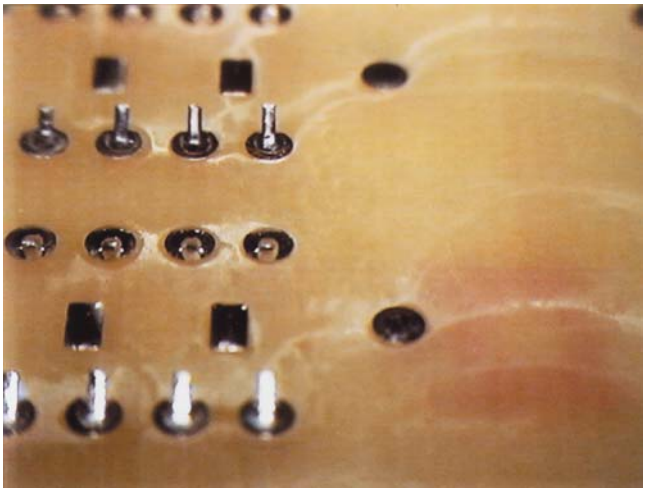

Figure 10-94

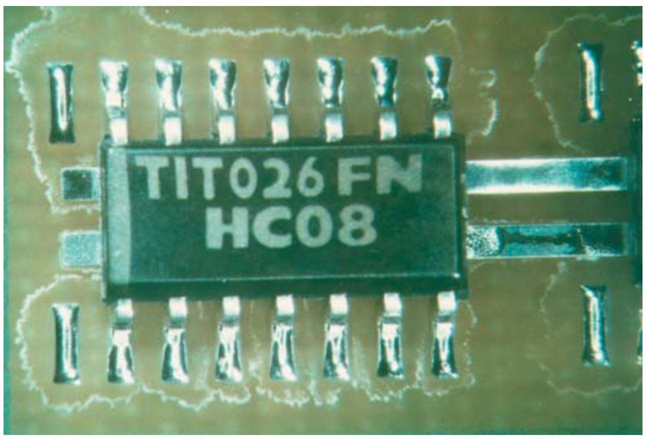

Figure 10-95

Defect – Class 1,2,3

- White residue on printed board surface.
- White residues on or around the soldered termination.
- Metallic areas exhibit crystalline white deposit.

Note: White residues resulting from no-clean or other processes are acceptable provided the residues from chemistries used have been qualified and documented as benign, see 10.6.1.2 Printed Boards and Assemblies – Cleanliness – Flux Residues – No Cleaning Process.

10.6.3 Cleanliness – Chlorides, Carbonates and White Residues (cont.)

Figure 10-96

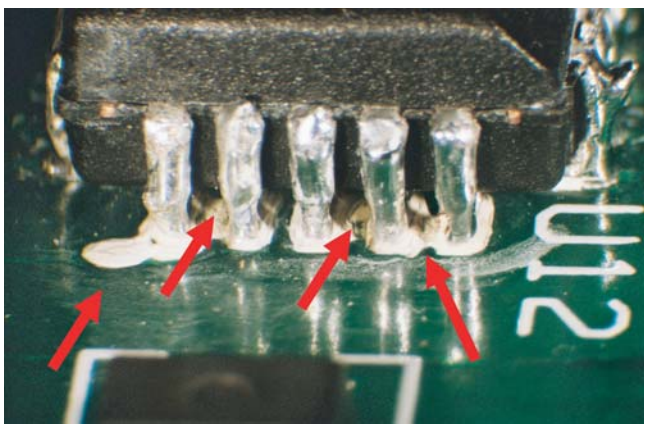

Figure 10-97

10.6.4 Cleanliness – Surface Appearance

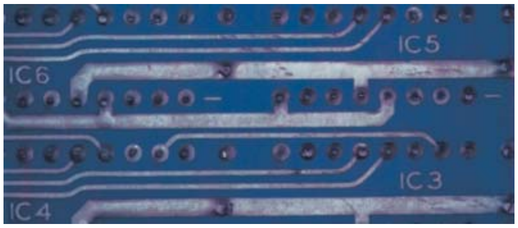

Figure 10-98


Figure 10-99

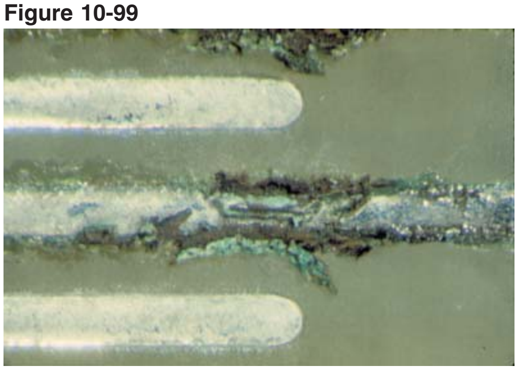
Figure 10-100

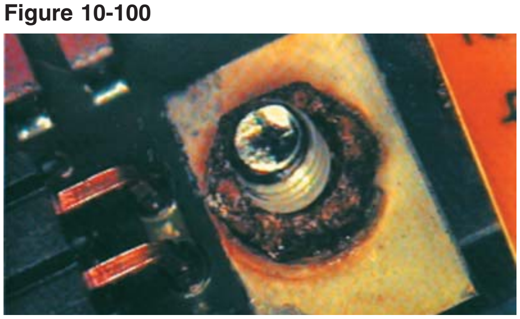
Figure 10-101

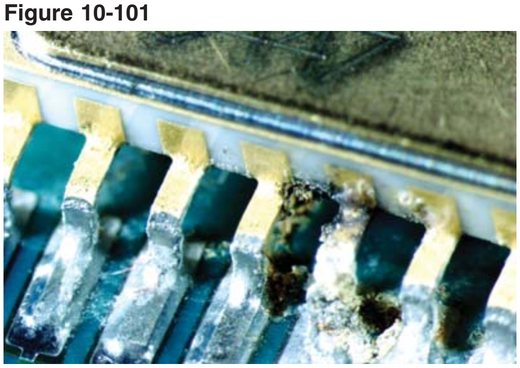
Figure 10-102

Acceptable – Class 1,2,3

- Dulling of clean metallic surfaces.

Defect – Class 1,2,3

- Colored residues or rusty appearance on metallic surfaces or hardware.
- Evidence of corrosion.

10.7 Solder Mask Coating

This section covers the acceptability requirements for solder mask coatings on electronic assemblies after assembly.

Additional information on solder mask is available in IPC-SM-840.

Solder Mask (Resist) – A heat-resisting coating material applied to selected areas to prevent the deposition of solder upon those areas during subsequent soldering. Solder mask material may be applied as a liquid or a dry film. Both types meet the requirements of this guideline.

Although not rated for dielectric strength, and therefore not satisfying the definition of an ''insulator or insulating material,'' some solder mask formulations provide limited insulation and are commonly used as surface insulation where high voltages are not a consideration.

In addition, solder mask is useful in preventing printed board surface damage during assembly operations.

Tape Test – The tape test referenced in this section is IPC-TM-650, Test Method 2.4.28.1.

See IPC-6012 and IPC-A-600.

10.7.1 Solder Mask Coating – Wrinkling/Cracking

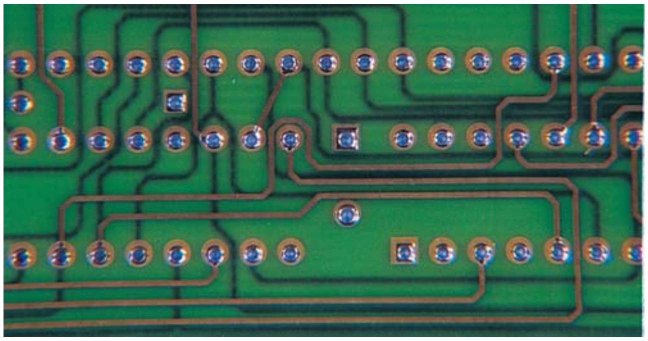

Figure 10-103

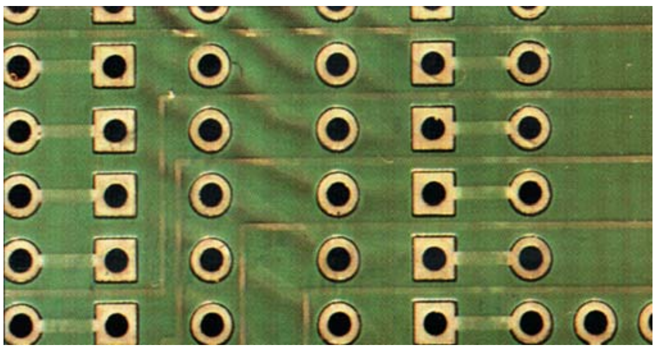

Figure 10-104

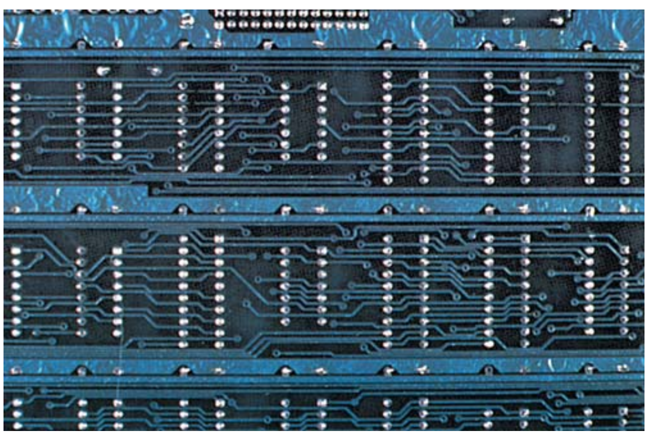

Figure 10-105

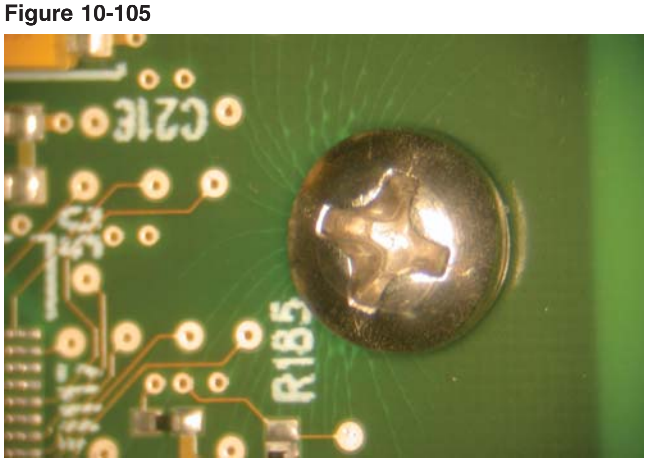

Figure 10-106

Acceptable – Class 1,2,3

- Minor wrinkling is located in an area that does not bridge between conductive patterns and meets the adhesion tape pull test, IPC-TM-650, 2.4.28.1, see Figure 10-104.
- Wrinkling of the solder mask film over area of reflowed solder is acceptable providing there is no evidence of breaking, lifting or degradation of the film. Adhesion of wrinkled areas can be verified using a tape pull test.
- Cracking of solder mask without loss of adhesion.

10.7.1 Solder Mask Coating – Wrinkling/Cracking (cont.)

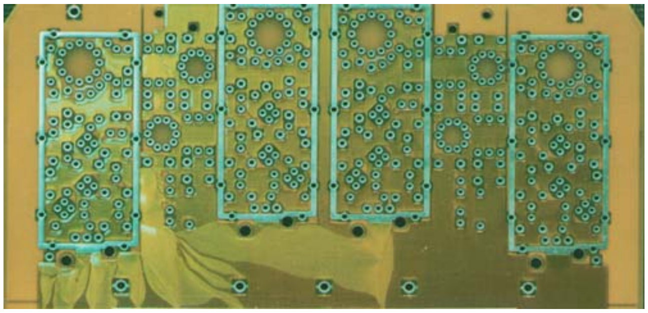

Figure 10-107

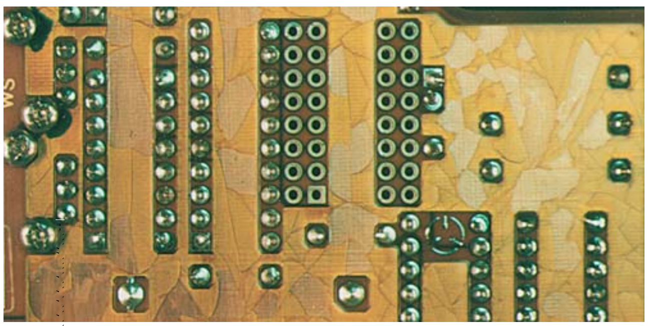

Figure 10-108

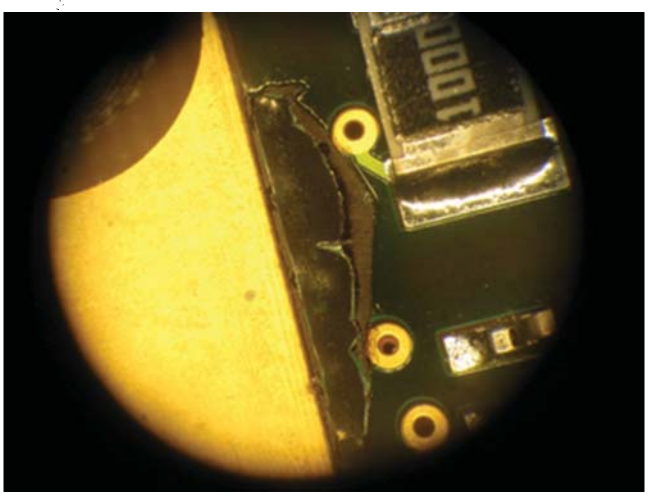

Figure 10-109

Defect – Class 1,2,3

- Solder mask particles cannot be completely removed and will affect the operation of the assembly.

10.7.2 Solder Mask Coating – Voids, Blisters, Scratches

During solder assembly operation, the mask prevents solder bridging.

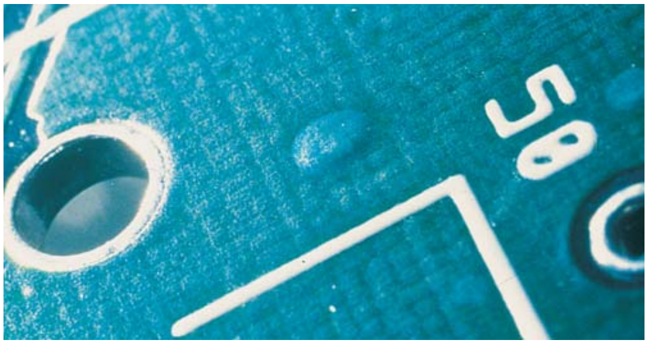

Figure 10-110

Acceptable – Class 1,2,3

- Blisters, scratches, voids that do not expose conductors and do not bridge adjacent conductors or conductive surfaces.
- Solder flux, oil or cleaning agents are not trapped under blistered areas.

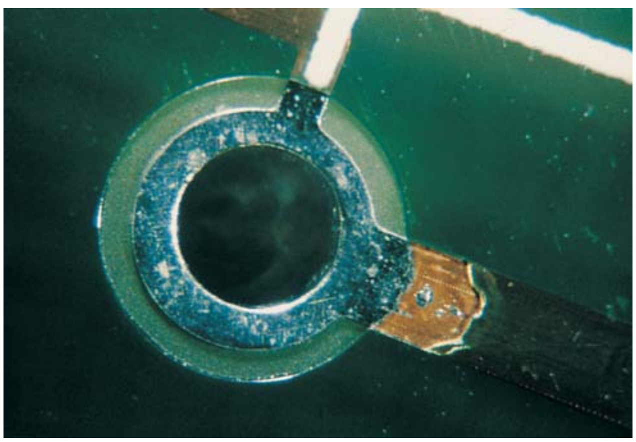

Figure 10-111

Process Indicator – Class 2,3

- Blisters/flaking expose base conductor material.

10.7.2 Solder Mask Coating – Voids, Blisters, Scratches (cont.)

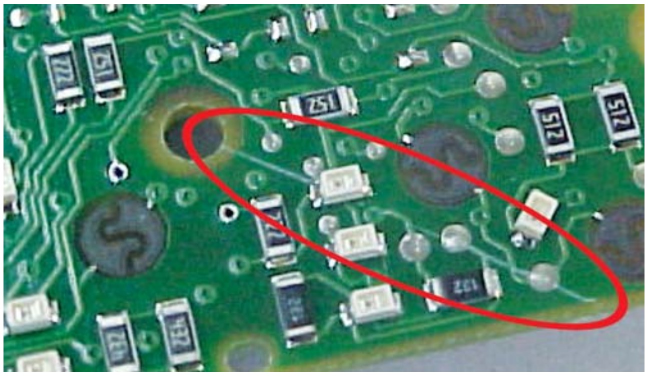

Figure 10-112

Acceptable – Class 1
Defect – Class 2,3

- Coating blisters/scratches/voids allow film to flake in critical assemblies after a tape test.
- Solder fluxes, oils or cleaning agents are trapped under coating.

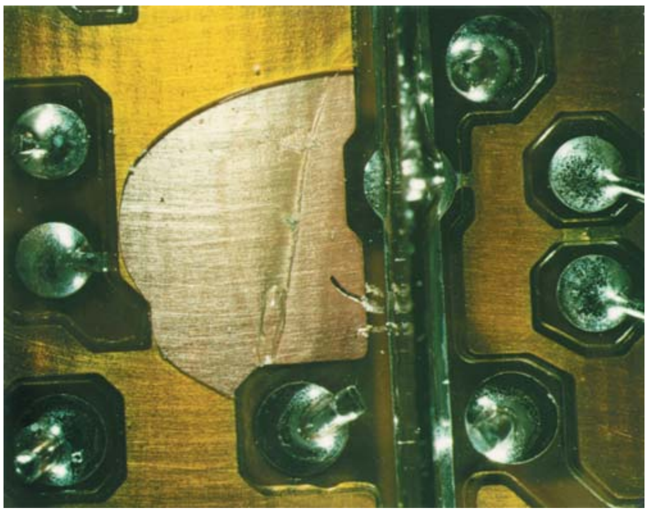

Figure 10-113

Defect – Class 1,2,3

- Coating blisters/scratches/voids bridge adjacent noncommon circuits.
- Loose particles of solder mask material that could affect form, fit or function.
- Coating blisters/scratches/voids have permitted solder bridges.

10.7.3 Solder Mask Coating – Breakdown

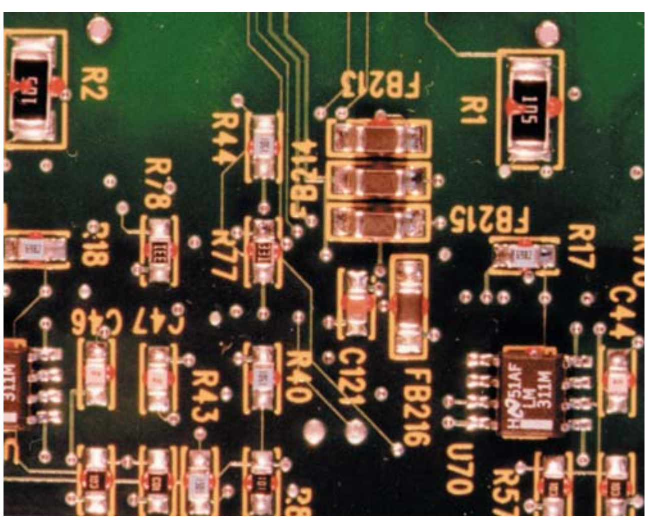

Figure 10-114

Acceptable – Class 1,2,3

- Solder mask surfaces are homogeneous with no flaking or peeling.

Defect – Class 1,2,3

- Solder mask has powdery whitish appearance with possible inclusions of solder metal.

10.7.4 Solder Mask Coating – Discoloration

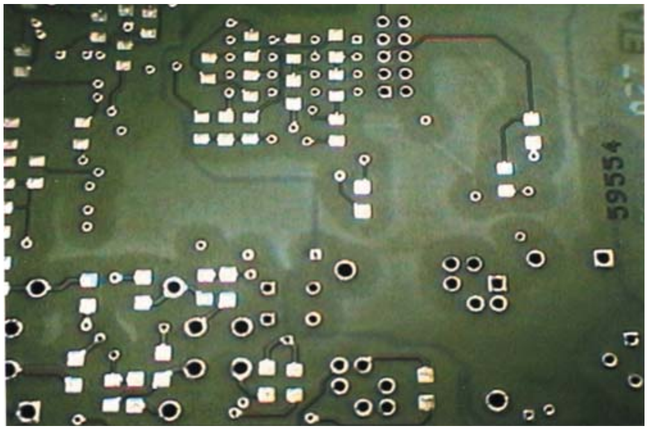

Figure 10-115

Acceptable – Class 1,2,3

• Discoloration of the solder mask material.

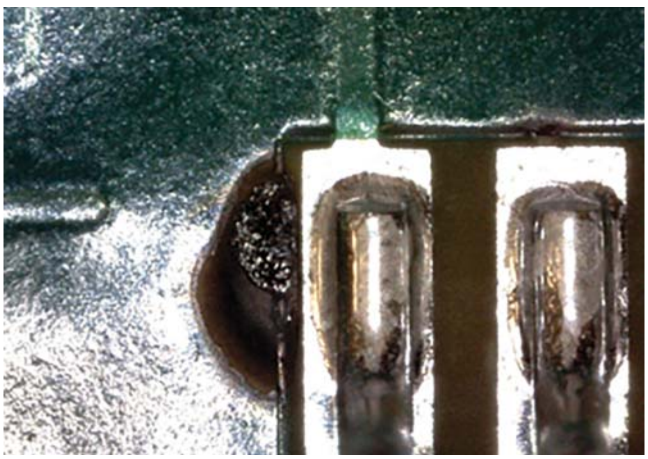

Figure 10-116

Defect – Class 1,2,3

• Burned or charred solder mask material.

10.8 Conformal Coating

This section covers the acceptability requirements for conformal coatings on electronic assemblies.

Additional information on conformal coating is available in IPC-CC-830 and IPC-HDBK-830.

10.8.1 Conformal Coating – General

Conformal coatings provide a barrier layer to the surface of an electronic assembly to provide protection against the end use environment. Variations in visual appearance are expected. Uniform coating distribution depends partly on the method of application and may affect visual appearance and corner coverage. Assemblies coated by dipping may have a drip line or localized build-up of the edge of the board. This build-up may contain a small amount of bubbles but it will not affect the functionality or reliability of the coating.

10.8.2 Conformal Coating – Coverage

The assembly may be examined with the unaided eye, see 1.12.2 Magnification Aids. Materials that contain a fluorescent pigment may be examined with blacklight to verify coverage. White light may be used as an aid for examining coverage.

Outer layer conductors/circuits covered by solder mask are not considered exposed conductors.

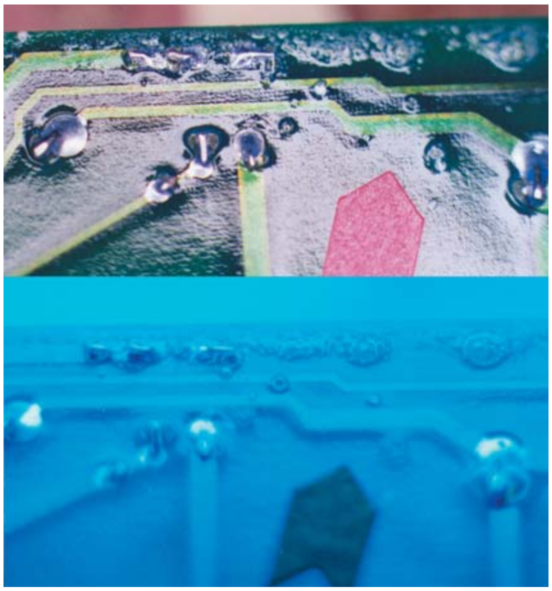

Figure 10-117

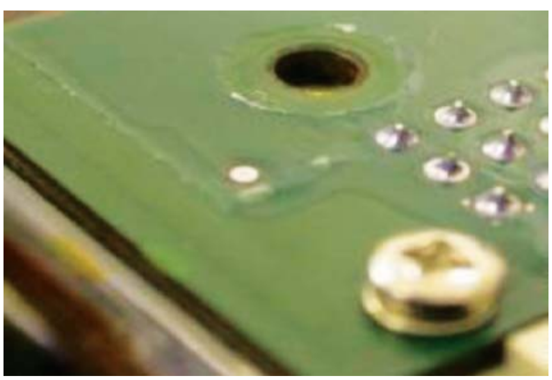

Figure 10-118

Acceptable – Class 1,2,3

- Coating is cured.
- Coating only in those areas where coating is required.
- Orange peel, see Figure 10-119.
- Entrapped material does not violate minimum electrical clearance between components, lands or conductive surfaces.
- No discoloration or loss of transparency.

Process Indicator – Class 1,2,3

- Bubbles, voids or loss of adhesion that do not bridge or expose conductive surfaces.

10.8.2 Conformal Coating – Coverage (cont.)

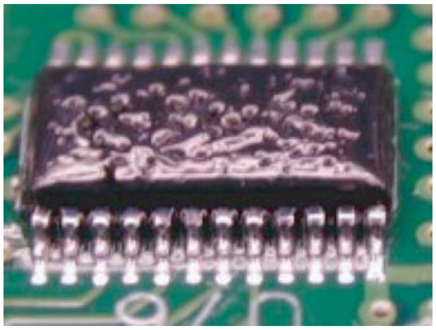

Figure 10-119

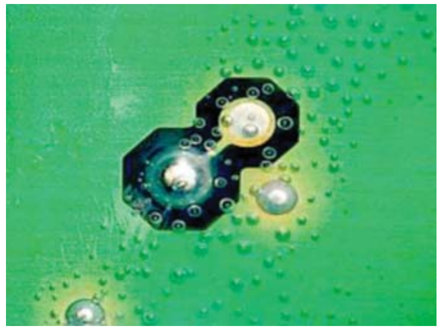

Figure 10-120

Figure 10-121

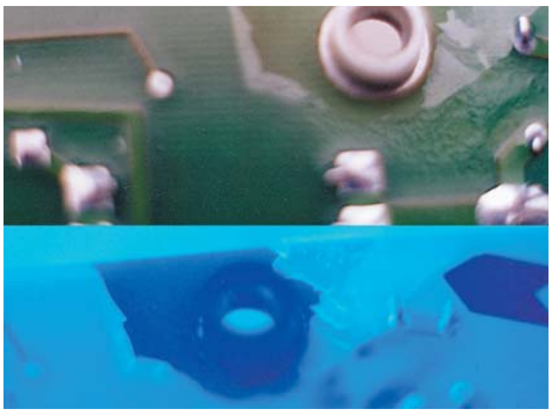

Figure 10-122

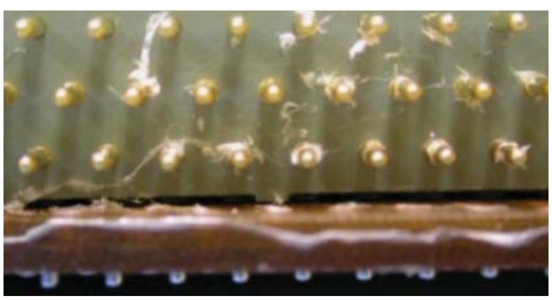

Figure 10-123

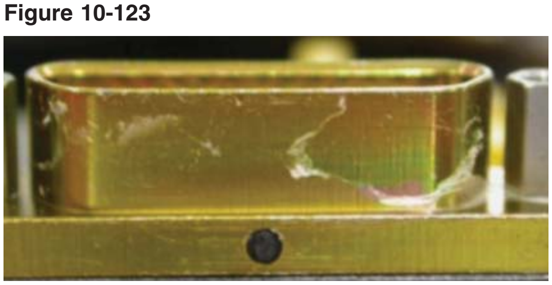

Figure 10-124

Defect – Class 1,2,3

- Coating is not cured.
- Coating is not applied to required areas.
- Coating is on areas required to be free of coating, e.g., mating surfaces, adjustable hardware, wicking into connector housings, etc.
- Bridging of adjacent noncommon conductors caused by:
  - Mealing
  - Cracking
  - Fisheyes
  - Voids or bubbles
- Any entrapped material that bridges lands or adjacent conductive surfaces, exposes circuitry or violates minimum electrical clearance between components, lands or conductive surfaces.
- Loss of transparency such that required markings cannot be read.

Note: Loss of transparency does not apply to opaque security coatings.

10.8.3 Conformal Coating – Thickness

Table 10-1 provides coating thickness requirements. The thickness **shall** be measured on a flat, unencumbered, cured surface of the assembly or a coupon that has been processed with the assembly. Coupons may be of the same type of material as the printed board or may be of a nonporous material such as metal or glass. As an alternative, a wet film thickness measurement may be used to establish the coating thickness provided there is documentation that correlates the wet and dry film thickness.

Note: Table 10-1 of this standard is to be used for assemblies. The coating thickness requirements in IPC-CC-830 are used only for test vehicles associated with coating material testing and qualification.

Table 10-1 Coating Thickness

Type AR	Acrylic	25.4 – 127.0 µm [0.001 – 0.005 in]
Type ER	Epoxy	25.4 – 127.0 µm [0.001 – 0.005 in]
Type UR	Urethane	25.4 – 127.0 µm [0.001 – 0.005 in]
Type SR	Silicone	50.8 – 203.2 µm [0.002 – 0.008 in]
Type XY	Para-xylylene	10.2 – 50.8 µm [0.0004 – 0.002 in]
Type SC	Styrene Block Copolymer	25.4 – 76.2 µm [0.001 – 0.003 in]

Acceptable – Class 1,2,3

- Coating meets the thickness requirements of Table 10-1.

Defect – Class 1,2,3

- Coating does not meet thickness requirements of Table 10-1.

10.9 Electrical Insulation Coating

10.9.1 Electrical Insulation Coating – Coverage

This material is used to provide insulation to an exposed conductor when conformal coating is insufficient to provide enough protection and encapsulation is too much.

All of the considerations used for conformal coating are applicable for insulation coating, except the surface where insulation coating is applied is generally not smooth enough for a uniform coating surface.

There are no illustrations for these criteria.

10.9.2 Electrical Insulation Coating – Thickness

Acceptable – Class 1,2,3

- Complete coverage with no exposed metal.

Defect – Class 1,2,3

- Exposed metal.

Note: The thickness requirements of 10.8.3 Printed Boards and Assemblies – Conformal Coating – Thickness do not apply.

10.10 Encapsulation

Figure 10-125

Acceptable – Class 1,2,3

- Encapsulation material extends over and surrounds all areas required to be encapsulated.
- Encapsulation material is not present in areas not designated to be encapsulated.
- Completely cured and uniform.
- The encapsulant is free of bubbles, blisters or breaks that affect the assembly operation or sealing properties of the encapsulant material.
- No visible cracks, crazing, mealing, peeling and/or wrinkles in the encapsulant material.
- Entrapped foreign material does not violate minimum electrical clearance between components, lands or conductive surfaces.
- Potting material has hardened and is tack free to the touch after curing.

Note: Minor surface swirls, striations or flow marks are not considered defects.

10.10 Encapsulation (cont.)

Defect – Class 1,2,3

- Encapsulation material missing from areas required to be encapsulated.
- Encapsulation material is present in areas not designated to be encapsulated or that interferes with the electrical or physical function of the assembly.
- Encapsulation material is not cured (exhibits tackiness).
- Bubbles, blisters or breaks that affect the assembly operation or sealing properties of the encapsulant material.
- Visible cracks, crazing, mealing, peeling and/or wrinkles in the encapsulant material.
- Any entrapped material that bridges lands or adjacent conductive surfaces, exposes circuitry or violates minimum electrical clearance between components, lands or conductive surfaces.
- Discoloration or loss of transparency.

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11 Discrete Wiring

Discrete wiring refers to a substrate or base upon which discrete wiring techniques are used to obtain electronic interconnections.

Discrete Wiring Acceptability Guidelines

The routing and terminating of discrete wires to form point-to-point electrical connections by use of special machines or tools may be employed to replace or supplement printed conductors on board assemblies. Application may be in planar, two-dimensional or three-dimensional configurations.

In addition to the criteria in this section, the criteria of 5 Soldering are applicable.

The following topics are addressed in this section.

11.1 Solderless Wrap

See MIL-STD-1130 for solderless wrap criteria.

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12 High Voltage

This section provides the unique criteria for soldered connections that are subject to high voltages, see 1.8.6 High Voltage. The term ''high voltage'' will vary by design and application. The high voltage criteria in this document are only applicable when specifically required in the drawings/procurement documentation. Convex solder fillets may obscure wetting criteria. These criteria are applicable to wires or leads attached to terminals, bare terminals, and through-hole connections. The requirements are to assure that there are no sharp edges or sharp points to help mitigate arcing (corona discharge). Additional mitigation, e.g., wire insulation, encapsulation, may be required. For high voltage strand damage, see Table 6-2.

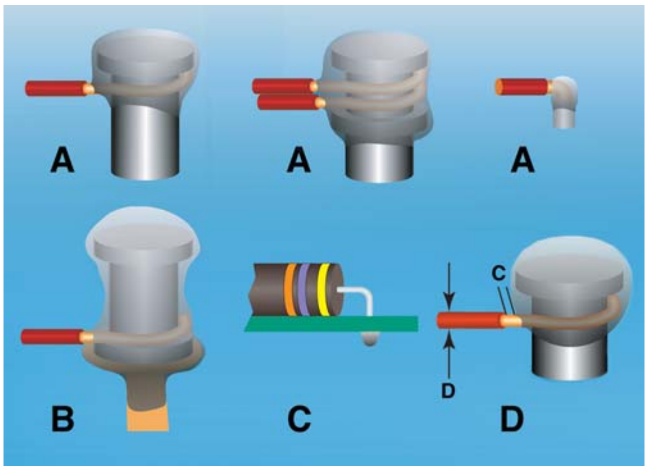

Figure 12-1

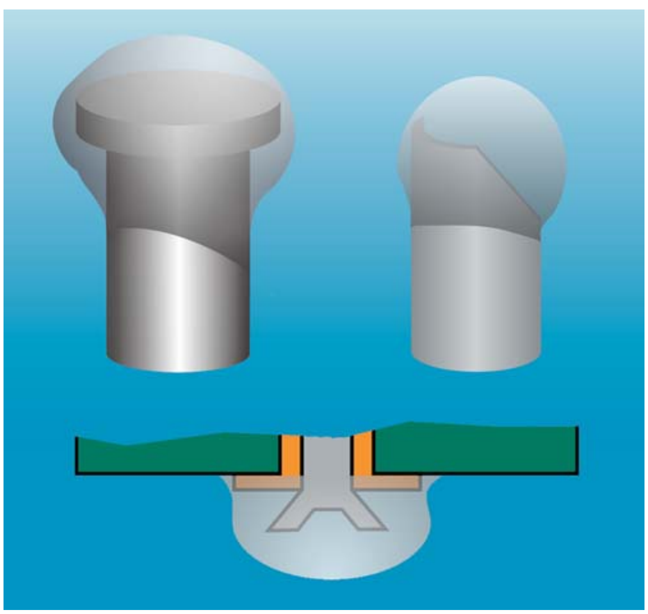

Figure 12-2

Acceptable – Class 1,2,3

- Solder connection has an egg-shaped, spherical or oval profile that follows the contour of terminal and wire wrap, see Figure 12-1.
- All sharp edges of the component lead and terminals are completely covered with a continuous smooth rounded layer of solder forming a solder ball, see Figure 12-1-A.
- Solder connections may have evidence of some layering or reflow lines, see 5.2.8 Soldering – Soldering Anomalies – Disturbed Solder.
- No evidence of sharp edges, solder points, icicles, inclusions (foreign material) or wire strands.
- Wire/lead outline is discernible with a smooth flow of solder on wire/lead and terminal. Individual strands may be discernible, see Figure 12-1-B.
- Straight-through leads facilitate ball soldering, see Figure 12-1-C.
- All sharp edges of the terminal's radial split are completely covered with a continuous smooth layer of solder forming a balled solder connection.
- There is no evidence of burrs or frayed edges on the hardware.
- Insulation clearance (C) is equal to or less than one overall diameter (D) or as defined away from the solder connection, see Figure 12-1-D.
- No evidence of insulation damage (ragged, charred, melted edges or indentations).
- Balled solder connection does not exceed specified height requirements.

12 High Voltage (cont.)

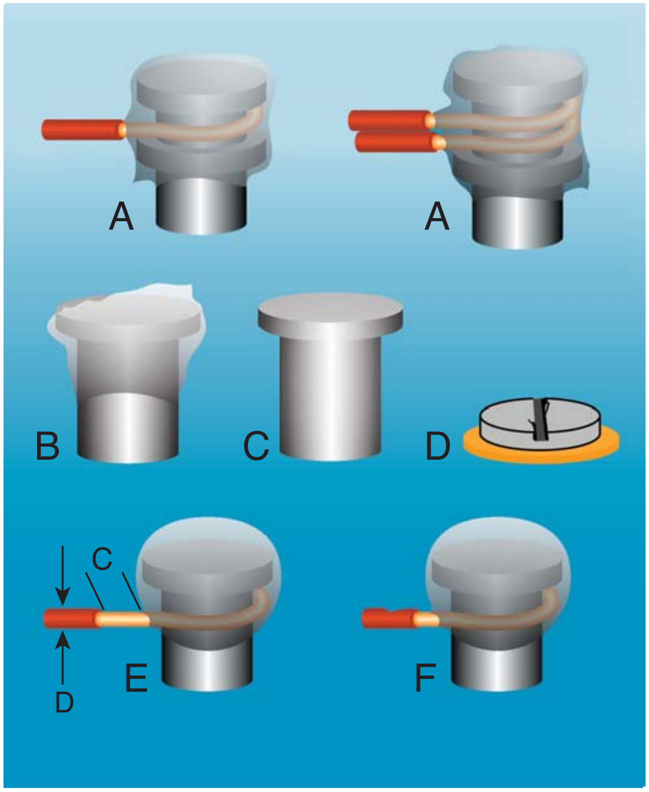

Figure 12-3

Defect – Class 1,2,3

- Discernible sharp edges, solder points, icicles, or inclusions (foreign material), see Figure 12-3-A.
- Evidence of edges not smooth and round with nicks or crevices.
- Solder follows contour of terminal and wire wrap, but there is evidence of the sharp edge of the terminal protruding, see Figure 12-3-B.
- Evidence of wire strands not completely covered or discernible in the solder connection.
- Terminal lug is void of solder, see Figure 12-3-C.
- Hardware has burrs or frayed edges, see Figure 12-3-D.
- Insulation clearance (C) is more than one wire diameter (D) or as defined, see Figure 12-3-E.
- Evidence of insulation damage (ragged, charred, melted edges or indentations), see Figure 12-3-F.
- Balled solder connection does not comply with height or profile (shape) requirements.

13 Jumper Wires

These criteria do not constitute authority for repair or modification of assemblies when prior authorization is required by the User, see 1.1 Scope. This section establishes visual acceptability criteria for the installation of discrete wires used to interconnect both through-hole and surface mounted components on printed boards.

Information concerning rework and repair can be found in IPC-7711/7721.

Staking material, insulation, wire type and termination locations (end points) are typically specified by engineering documentation. Unless specified otherwise in the engineering documentation, wires may be terminated at supported or unsupported holes, to terminal standoffs, conductor lands, or component terminations. Unless specific routing or support/staking points are specified in the engineering documentation, the following requirements apply.

Jumper wires and their terminations **shall not** violate minimum electrical clearance. If jumper wires are insulated, the requirements of 7.3 Through-Hole Technology – Supported Holes and 7.4 Through-Hole Technology – Unsupported Holes apply to supported or unsupported holes, lapped or wrapped connections.

When soldering to a land, with or without a component lead on the land, the available contact area is the longest dimension across the solderable surface, e.g., land or component lead (including a diagonal).

The following items are addressed in this section.

13.1 Jumper Wires – Wire Routing

The requirements of 6.5 Terminal Connections – Routing – Wires and Wire Bundles – Bend Radius and 6.6 Terminal Connections – Stress Relief apply.

Wires may pass over thermal mounting plates and brackets.

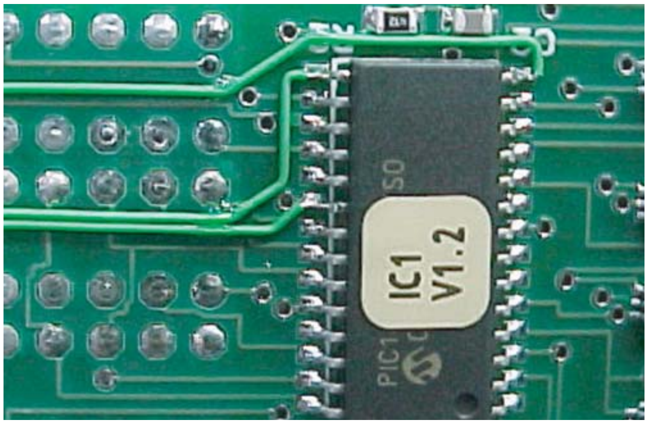

Figure 13-1

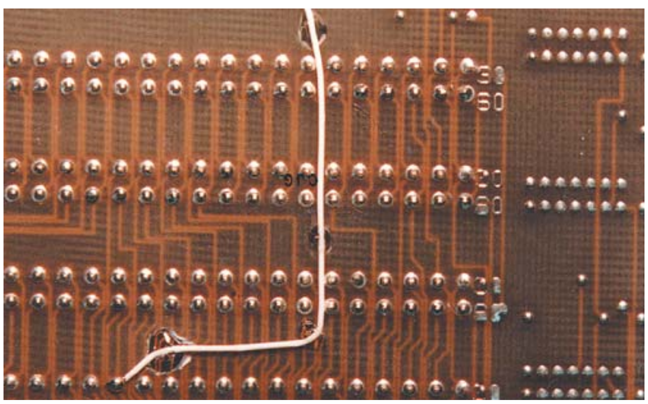

Figure 13-2

Acceptable – Class 1,2,3

- The wire is not so loose that it can extend above the height of adjacent components.

Acceptable – Class 1
Defect – Class 2,3

- Wire routed under or over components.
- Wires are routed over board edges, moving parts, assembly mounting surfaces, e.g., card guides or rails, patterns or vias used as test points, or beyond the assembly dimensions specified in the design.
- The wire is loose and can extend above the height of adjacent components.

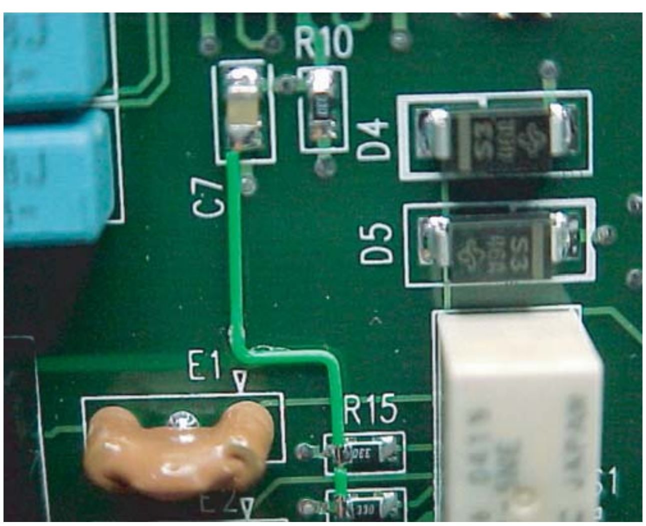

Figure 13-3

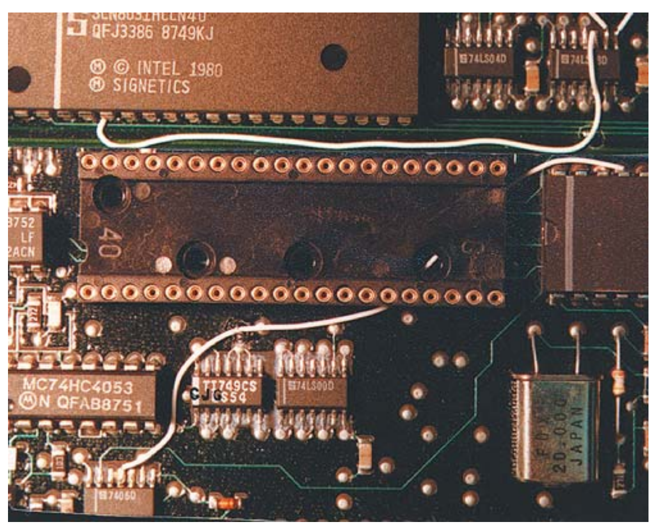

Figure 13-4

13.2 Jumper Wires – Wire Staking – Adhesive or Tape

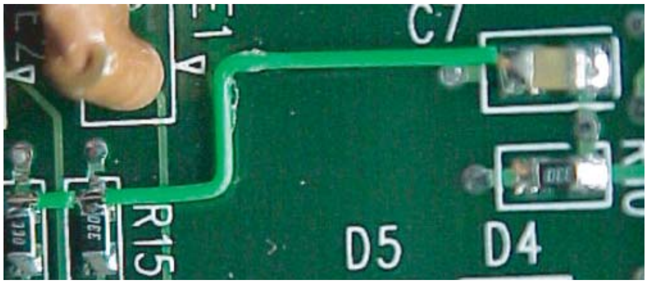

Figure 13-5

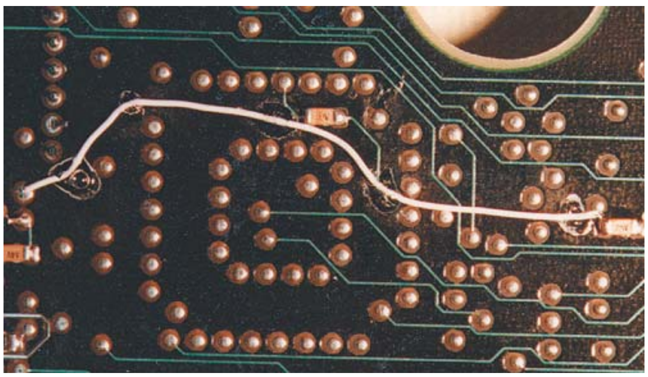

Figure 13-6

Acceptable – Class 1,2,3

- Jumper wires are staked at intervals as specified by engineering documentation or:
  - Within the radius of the bend for each change of direction.
  - As close to the solder connection as possible.
- Staking tape/adhesive does not overhang the board edge(s) or violate edge spacing requirements.

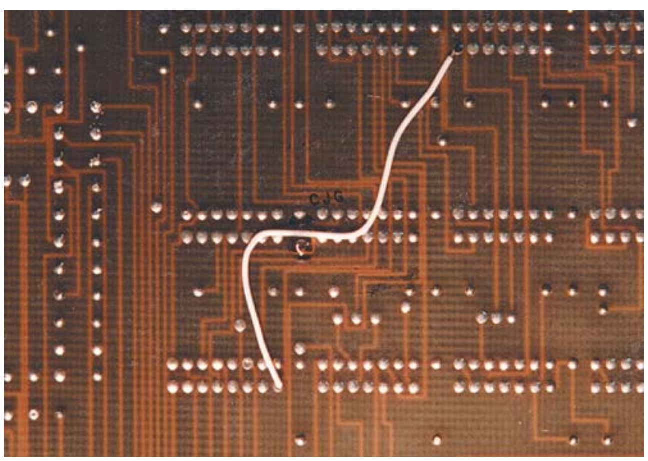

Figure 13-7

Acceptable – Class 1
Defect – Class 2,3

- Jumper wires are not staked:
  - Within the radius of the bend for each change of direction.
  - As close to the solder connection as possible.
- Staking extends or overhangs beyond the board edge or footprint.

Defect – Class 1,2,3

- Adhesive is not cured.
- Adhesive interferes with the formation of required solder connections.
- Adhesive interferes with stress relief of adjacent components.
- Staking contacts a moving part.

13.3 Jumper Wires – Terminations

For a jumper wire attached to a component other than axial leaded, the wire may be wrapped or lap soldered parallel to the vertical portion of the lead on the component side.

Acceptable – Class 1,2,3

- Conductor end is discernible in the solder connection.

Defect – Class 1,2,3

- Conductor end is not discernible in the solder connection.
- Minimum electrical clearance is violated.

13.3.1 Jumper Wires – Terminations – Lap

13.3.1.1 Jumper Wires – Terminations – Lap – Component Lead

The following criteria apply when lap soldering to the vertical face of a through-hole or SMT lead. For gull wing leads, see 13.3.4.2 Jumper Wires – Terminations – SMT – Gull Wing.

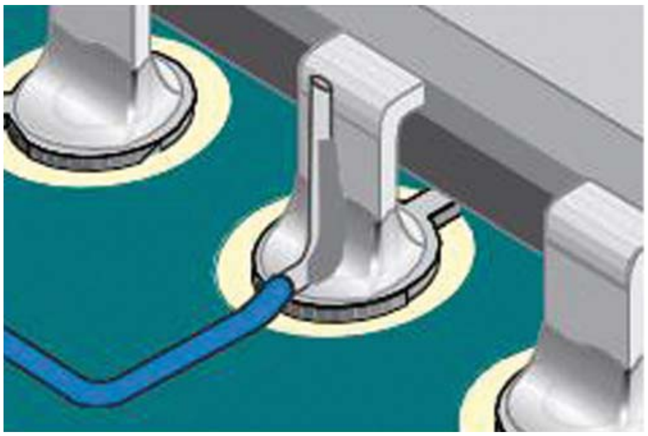

Figure 13-8

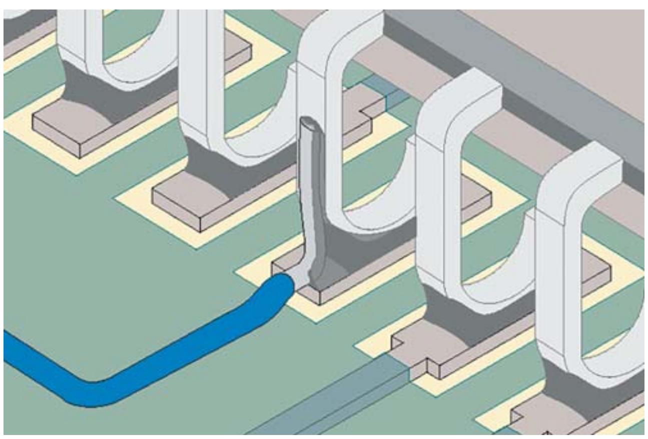

Figure 13-9

Acceptable – Class 1, 2

- Solder connection is 100% of the lead when the available contact area is less than two conductor diameters.

Acceptable – Class 3

- Solder connection is 100% of the lead when the available contact area is less than two conductor diameters and the wire is staked or otherwise mechanically secured.

Acceptable – Class 1,2,3

- Solder connection extends a minimum of two conductor diameters.
- Wire lap soldered to lead does not extend beyond the knee of the component lead.

13.3.1.1 Jumper Wires – Terminations – Lap – Component Lead (cont.)

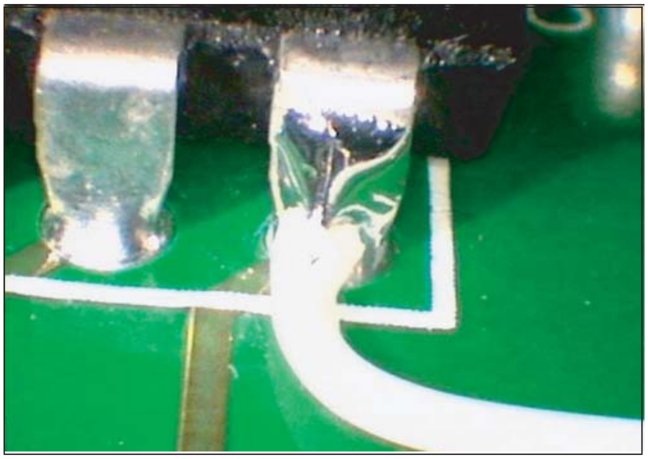

Figure 13-10

Defect – Class 1,2

- Solder connection is less than two conductor diameters when the available contact area is at least two conductor diameters.
- Solder connection is less than 100% of the lead when the available contact area is less than two conductor diameters.

Defect – Class 3

- When the available contact area is at least two conductor diameters, solder connection is less than two conductor diameters.
- When the available contact area is less than two conductor diameters:
  - Solder connection is less than 100% of the available contact area.
  - The wire is not staked.

Defect – Class 1,2,3

- Wire extends beyond the knee of the component lead.

13.3.1.2 Jumper Wires – Terminations – Lap – Land

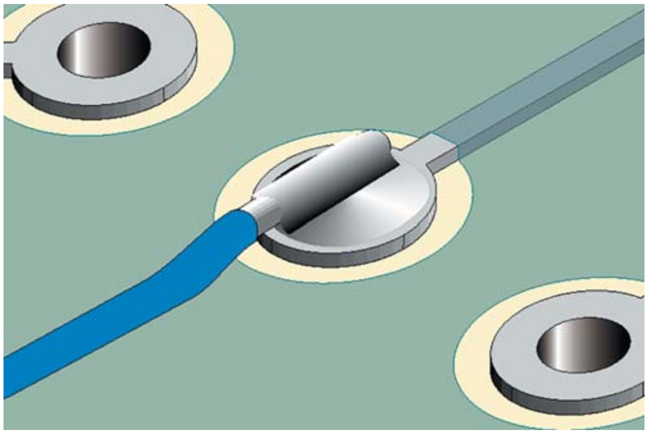

Figure 13-11

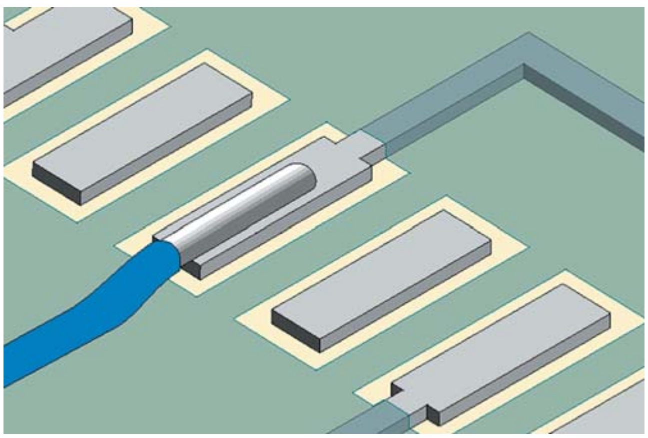

Figure 13-12

Acceptable – Class 1,2,3

- Solder connection extends a minimum of two conductor diameters when the available contact area is at least two conductor diameters.

Acceptable – Class 1,2

- Solder connection is 100% of the land when the available contact area is less than two conductor diameters.

Acceptable – Class 3

- Solder connection is 100% of the land when the available contact area is less than two conductor diameters and the wire is staked or otherwise mechanically secured.

Defect – Class 1,2,3

- Solder connection is less than two conductor diameters when the available contact area is at least two conductor diameters.
- Solder connection is less than 100% of the land when the available contact area is less than two conductor diameters.

Defect – Class 3

- When the available contact area is less than two conductor diameters, the solder connection is not staked or mechanically supported.

13.3.2 Jumper Wires – Terminations – Wire in Hole

A wire may be soldered in a supported hole without a component lead per 7.3.3 Through-Hole Technology – Supported Holes – Wire/Lead Protrusion.

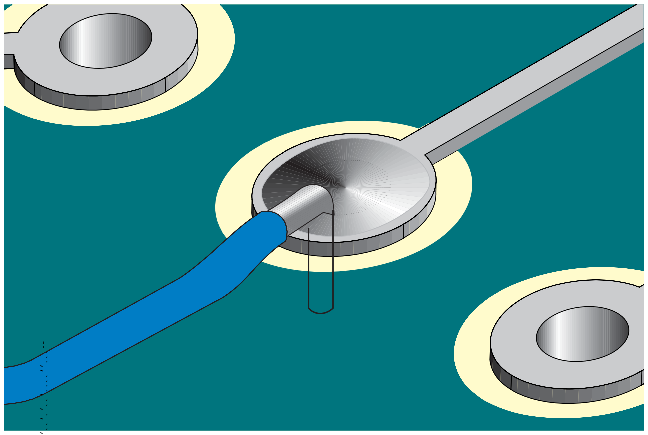

Figure 13-13

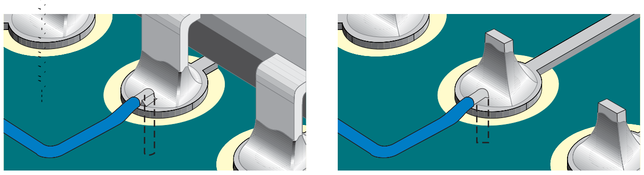

Figure 13-14

Acceptable – Class 1,2,3

- Wire soldered into an open PTH/via hole.

Acceptable – Class 1,2
Defect – Class 3

- Wire soldered into a supported hole with a component lead.

13.3.3 Jumper Wires – Terminations – Wrapped

The jumper wire may be attached by wrapping the wire to the component lead.

Jumper wires 30 AWG and smaller are not required to comply with 6.15 Terminal Connections – AWG 30 and Smaller Diameter Wires – Lead/Wire Placement.

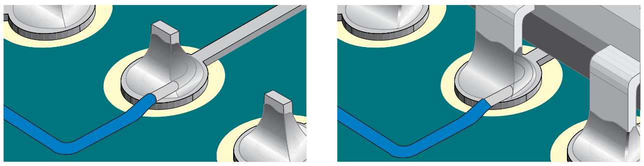

Figure 13-15

Acceptable – Class 1,2,3

- Conductor is wrapped a minimum of 90° on a flat lead or 180° on a round lead.

Figure 13-16

Defect – Class 1,2,3

- Conductor is wrapped less than 90° on a flat or less than 180° on a round lead.

13.3.4 Jumper Wires – Terminations – SMT

The available contact area is the longest dimension across the solderable surface, e.g., land or component lead, including a diagonal.

13.3.4.1 Jumper Wires – Terminations – SMT – Chip and Cylindrical End Cap Components

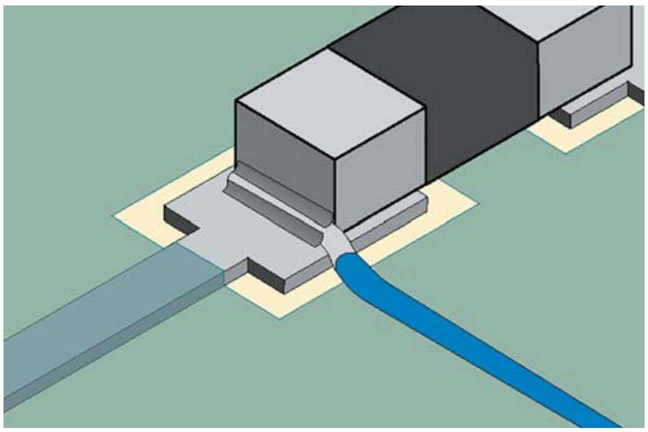

Figure 13-17

Acceptable – Class 1,2,3

- Solder connection extends a minimum of two conductor diameters when the available contact area is at least two conductor diameters.

Acceptable – Class 1,2

- Solder connection is 100% of the land when the available contact area is less than two conductor diameters.

Acceptable – Class 3

- Solder connection is 100% of the land when the available contact area is less than two conductor diameters and the wire is staked or otherwise mechanically secured.

Defect – Class 1,2,3

- Solder connection is less than two conductor diameters when the available contact area is at least two wire diameters.
- Wire soldered on top of chip component termination.
- Solder connection is less than 100% of the land when the available contact area is less than two conductor diameters.

Defect – Class 3

- When the available contact area is less than two conductor diameters, the solder connection is not staked or mechanically supported.

13.3.4.2 Jumper Wires – Terminations – SMT – Gull Wing

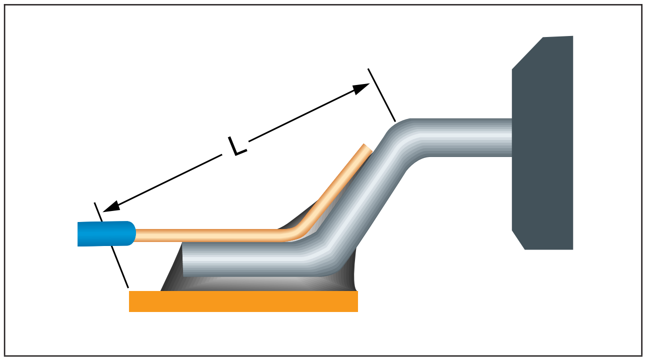

Figure 13-18

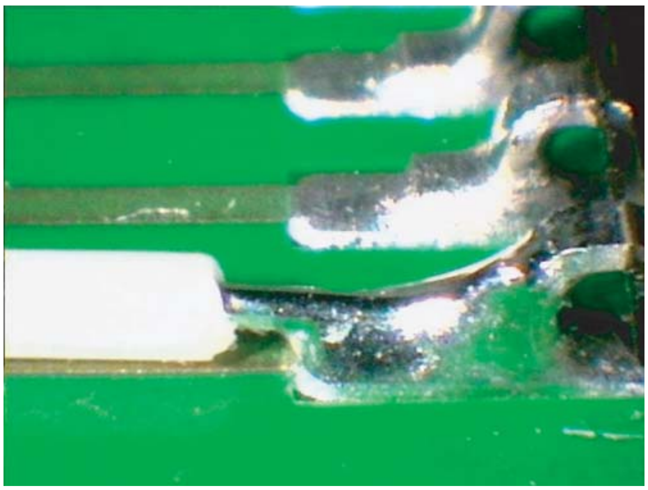

Figure 13-19

Acceptable – Class 1,2,3

- Conductor length and solder wetting are equal to or greater than 75% from edge of land to knee of lead (L).
- The conductor end does not extend past the lead knee bend.

13.3.4.2 Jumper Wires – Terminations SMT – Gull Wing (cont.)

Figure 13-20

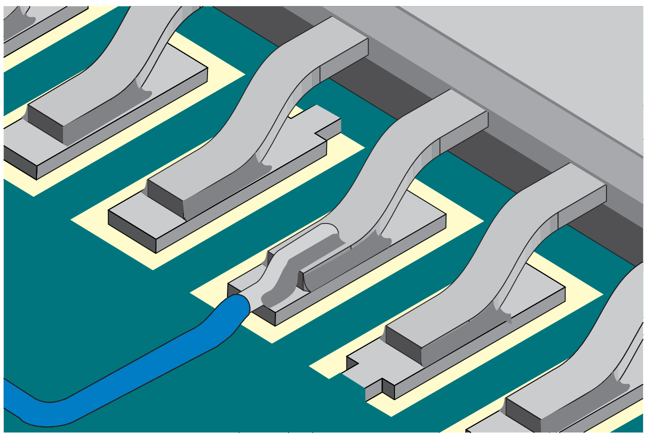

Figure 13-21

Defect – Class 1,2,3

- Conductor length and solder wetting is less than 75% from edge of land to knee of lead (L).
- Conductor end extends past knee of bend.

13.3.4.3 Jumper Wires – Terminations – SMT – Castellations

As an exception to 13.3 Jumper Wires – Terminations, conductor ends are not required to be discernible in the solder connection.

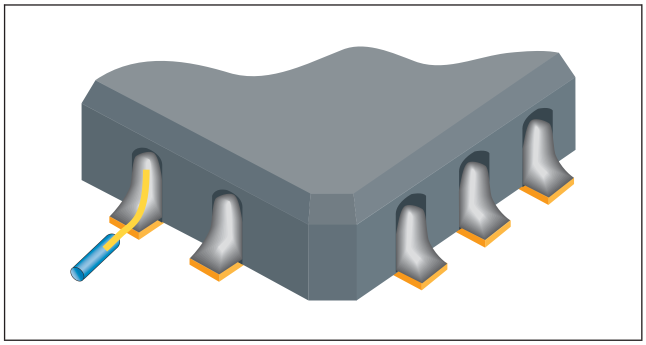

Figure 13-22

Acceptable – Class 1,2,3

- Conductor length and solder wetting is at least 75% from the top of land to the top of castellation.
- Conductor is placed against the back of the castellation.

Defect – Class 1,2,3

- Conductor length and solder wetting is less than 75% from the top of the land to the top of the castellation.
- Conductor end extends past the top of the component.

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Minimum Electrical Clearance

NOTE: This Appendix A is quoted from IPC-2221 Generic Standard on Printed Board Design and is provided for information only. It is current as of publication date of this document. The User has the responsibility to determine the most current revision level of IPC-2221 and specify the specific application to their product. Paragraph and table numbers are from IPC-2221.

The following statement from IPC-2221 applies to this Appendix ONLY: **1.4 Interpretation – "Shall,"** the imperative form of the verb, is used throughout this standard whenever a requirement is intended to express a provision that is mandatory.

IPC-2221 – **6.3 Electrical Clearance** Spacing between conductors on individual layers should be maximized whenever possible. The minimum spacing between conductors, between conductive patterns, and between conductive materials (such as conductive markings or mounting hardware) and conductors **shall** be in accordance with Table 6-1, and defined on the master drawing.

Layer to layer conductive spaces (z-axis) should be in accordance with Table 6-1. Z-axis minimum spacing requirements may be reduced with appropriate qualification.

Note: The designer should be aware that the profile roughness of the copper foil determines the minimum dielectric distance between opposing copper points within a thin core laminate. See also IPC-4101 for tolerances by class and thickness of core; IPC-4562 for surface roughness of copper foil types; and IPC-6012 for the method to determine minimum dielectric thickness. Designers should be careful not to use minimum dielectric spacing values to determine overall printed board thickness.

See Section 10 for additional information on process allowances affecting electrical clearance.

When mixed voltages appear on the same board and they require separate electrical testing, the specific areas **shall** be identified on the master drawing or appropriate test specification. When employing high voltages and especially AC and pulsed voltages greater than 200 volts potential, the dielectric constant and capacitive division effect of the material **shall** be considered in conjunction with the recommended spacing.

For voltages greater than 500V, the (per volt) table values **shall** be added to the 500V values. For example, the electrical spacing for a Type B1 board with 600V is calculated as:

600V – 500V = 100V
0.25 mm [0.00984 in] + (100V x 0.0025 mm)
= 0.50 mm [0.0197 in] clearance

When, due to the criticality of the design, the use of other conductor spacings is being considered, the conductor spacing on individual layers (same plane) **shall** be made larger than the minimum spacing required by Table 6-1 whenever possible. Board layout should be planned to allow for the maximum spacing between external layer conductive areas associated with high impedance or high voltage circuits. This will minimize electrical leakage problems resulting from condensed moisture or high humidity. Complete reliance on coatings to maintain high surface resistance between conductors **shall** be avoided.

IPC-2221 – **6.3.1 B1–Internal Conductors** Internal conductor-to-conductor, and conductor-to-plated-through hole electrical clearance requirements at any elevation (see Table 6-1).

IPC-2221 – **6.3.2 B2–External Conductors, Uncoated, Sea Level to 3050 m [10,007 feet]** Electrical clearance requirements for uncoated external conductors are significantly greater than for conductors that will be protected from external contaminants with conformal coating. If the assembled end product is not intended to be conformally coated, the bare board conductor spacing **shall** require the spacing specified in this category for applications from sea level to an elevation of 3050 m [10,007 feet] (see Table 6-1).

IPC-2221 – **6.3.3 B3–External Conductors, Uncoated, Over 3050 m [10,007 feet]** External conductors on uncoated bare board applications over 3050 m [10,007 feet] require even greater electrical spacings than those identified in category B2 (see Table 6-1).

IPC-2221 – **6.3.4 B4–External Conductors, with Permanent Polymer Coating (Any Elevation)** When the final assembled board will not be conformally coated, a permanent polymer coating over the conductors on the bare board will allow for conductor spacings less than that of the uncoated boards defined by category B2 and B3. The assembly electrical clearances

Minimum Electrical Clearance (cont.)

of lands and leads that are not conformally coated require the electrical clearance requirements stated in category A6 (see Table 6-1). This configuration is not applicable for any application requiring protection from harsh, humid, contaminated environments.

Typical applications are computers, office equipment, and communication equipment, bare boards operating in controlled environments in which the bare boards have a permanent polymer coating on both sides. After they are assembled and soldered the boards are not conformal coated, leaving the solder joint and soldered land uncoated.

Note: All conductors, except for soldering lands, **shall** be completely coated in order to ensure the electrical clearance requirements in this category for coated conductors.

IPC-2221 – **6.3.5 A5–External Conductors, with Conformal Coating Over Assembly (Any Elevation)** External conductors that are intended to be conformal coated in the final assembled configuration, for applications at any elevation, will require the electrical clearances specified in this category.

Typical applications are military products where the entire final assembly will be conformal coated. Permanent polymer coatings are not normally used, except for possible use as a solder resist. However, the compatibility of polymer coating and conformal coating must be considered, if used in combination.

IPC-2221 – **6.3.6 A6–External Component Lead/Termination, Uncoated, Sea Level to 3050 m [10,007 feet]** External component leads and terminations, that are not conformal coated, require electrical clearances stated in this category.

Typical applications are as previously stated in category B4. The B4/A6 combination is most commonly used in commercial, nonharsh environment applications in order to obtain the benefit of high conductor density protected with permanent polymer coating (also solder resist), or where the accessibility to components for rework and repair is not required.

IPC-2221 – **6.3.7 A7–External Component Lead/Termination, with Conformal Coating (Any Elevation)** As in exposed conductors versus coated conductors on bare board, the electrical clearances used on coated component leads and terminations are less than for uncoated leads and terminations.

Table 6-1 Electrical Conductor Spacing

Voltage Between Conductors (DC or AC Peaks)	Minimum Spacing						
	Bare Printed Board				Assembly		
	B1[1]	B2	B3	B4	A5	A6	A7
0-15	0.05 mm [0.002 in]	0.1 mm [0.004 in]	0.1 mm [0.004 in]	0.05 mm [0.002 in]	0.13 mm [0.00512 in]	0.13 mm [0.00512 in]	0.13 mm [0.00512 in]
16-30	0.05 mm [0.002 in]	0.1 mm [0.004 in]	0.1 mm [0.004 in]	0.05 mm [0.002 in]	0.13 mm [0.00512 in]	0.25 mm [0.00984 in]	0.13 mm [0.00512 in]
31-50	0.1 mm [0.004 in]	0.64 mm [0.025 in]	0.64 mm [0.025 in]	0.13 mm [0.00512 in]	0.13 mm [0.00512 in]	0.4 mm [0.016 in]	0.13 mm [0.00512 in]
51-100	0.1 mm [0.004 in]	0.64 mm [0.025 in]	1.5 mm [0.0591 in]	0.13 mm [0.00512 in]	0.13 mm [0.00512 in]	0.5 mm [0.020 in]	0.13 mm [0.00512 in]
101-150	0.2 mm [0.0079 in]	0.64 mm [0.025 in]	3.2 mm [0.126 in]	0.4 mm [0.016 in]	0.4 mm [0.016 in]	0.8 mm [0.031 in]	0.4 mm [0.016 in]
151-170	0.2 mm [0.0079 in]	1.25 mm [0.0492 in]	3.2 mm [0.126 in]	0.4 mm [0.016 in]	0.4 mm [0.016 in]	0.8 mm [0.031 in]	0.4 mm [0.016 in]
171-250	0.2 mm [0.0079 in]	1.25 mm [0.0492 in]	6.4 mm [0.252 in]	0.4 mm [0.016 in]	0.4 mm [0.016 in]	0.8 mm [0.031 in]	0.4 mm [0.016 in]
251-300	0.2 mm [0.0079 in]	1.25 mm [0.0492 in]	12.5 mm [0.4921 in]	0.4 mm [0.016 in]	0.4 mm [0.016 in]	0.8 mm [0.031 in]	0.8 mm [0.031 in]
301-500	0.25 mm [0.00984 in]	2.5 mm [0.0984 in]	12.5 mm [0.4921 in]	0.8 mm [0.031 in]	0.8 mm [0.031 in]	1.5 mm [0.0591 in]	0.8 mm [0.031 in]
≥500 See para. 6.3 For calc.	0.0025 mm/ volt	0.005 mm/ volt	0.025 mm/ volt	0.00305 mm/ volt	0.00305 mm/ volt	0.00305 mm/ volt	0.00305 mm/ volt

Note 1. These values presume woven fiberglass coated with epoxy-based resin systems; other sytems may have different values.

Protecting the Assembly – ESD and Other Handling Considerations

Information in this chapter is general in nature. Process controls are outside the scope of this standard, and unless separately required, this information is for guidance only.

B.1 ESD Prevention

ESD recommendations herein are based on requirements in ANSI/ESD S20.20, and additional information can be found in IEC-61340-5-1, IEC 61340-5-2, IEC 61340-5-3, MIL-STD-1686, and other related documents.

Electrostatic Discharge (ESD) is the rapid transfer of a static electric charge from one object to another at a different electrical potential. Electrostatic Discharge Sensitive (ESDS) components and assemblies are damaged by these electrical energy surges. ESD concentrates high temperature in a very small area inside the part, which can melt (or even vaporize) microscopic conductors, damage insulation, or blow through dielectric layers. An electrostatic charge in close proximity to sensitive electronics can cause damage even without physical contact.

The relative sensitivity of a component to ESD depends upon its construction and materials. In general, components with higher operating speeds, smaller circuit elements, and those designed to react to smaller electrical sources or wider frequency ranges are more susceptible. ESD is a more serious problem than even a few years ago, and this trend will continue.

ANSI/ESD S20.20 is designed to protect ESDS items that are sensitive to electrostatic discharges of 100 volts Human Body Model (HBM) and above, and 200 volts Charged Device Model (CDM) and above. ESDS items that are sensitive to lower voltages will require extraordinary protections, which are not covered in this document.

ESDS components can fail to operate, or may change in value due to improper handling or processing. These failures can be immediate or latent. Immediate failures usually require replacement of the component. However, the consequences of latent failure are more serious, because even though the product may pass inspection and functional test, it will fail in service after it leaves the Manufacturer.

Electronics may be sensitive to ESD even if ESD protection has been incorporated into circuit designs and packaging. In general, assemblies that incorporate ESDS components are also ESD sensitive. ESD sensitivity of a product may be based on the most sensitive component in the assembly. It is important that ESDS parts and assemblies be packaged in ESD protective enclosures, and when removed from protective enclosures, handled only within an ESD Protected Area (EPA).

Note: Electrical Overstress or ''EOS'' is damage caused by unwanted introduction of electrical energy during electrical test or other processing. Unlike ESD, EOS is induced in an item through its connection with a separate electronic or power generating device. EOS cannot be prevented through ESD controls defined in ANSI/ESD S20.20, and is not covered in this Appendix.

B.1.1 ESD Control Program

Any ESD control program relies on the training, awareness, and compliance of individuals handling and transporting ESDS items. An ESD Control Program plan should be documented, and specify:

- ESD Protected Area (EPA) requirements, see B.1.2 ESD Protective Area (EPA) Requirements.
- Personnel grounding and handling requirements, see B.1.2 ESD Protective Area (EPA) Requirements.
- Preventing or mitigating static charge generation, see B.1.3 Minimizing Static Change.
- ESD protective packaging, see B.1.4 ESD Protective Packaging.
- Training, see B.1.5 Training.
- Qualified ESD protective equipment, see B.1.6 Tools and Equipment.
- Periodic compliance verification (testing) of ESD protective equipment, see B.1.7 Compliance Verification.
- Marking, see B.1.8 General Handling.
- Compliance audits

The organization should designate an ESD Control Program Manager or Coordinator to administer and verify compliance to the ESD Control Program Plan. The Plan should include the following elements.

Protecting the Assembly – ESD and Other Handling Considerations (cont.)

B.1.2 ESD Protective Area (EPA) Requirements

ESDS items outside ESD protective packaging should be handled within an EPA. The EPA should have clearly defined boundaries. Within an EPA, ESD sensitive items and all other conductors, including individuals handling or transporting ESDS items, should be electrically connected to a known ground, thus creating equal electrical potential between all items and personnel.

ESD protective worksurfaces, e.g., ''static mats,'' should be static dissipative, with resistance to ground of less than 1 x 10^9 ohms. Worksurfaces should be kept clean to prevent buildup of insulating layers. Seated individuals should be grounded by a wrist strap and cord with resistance to ground of less than 3.5 x 10^7 ohms. Standing individuals should be grounded by a footwear/flooring system with resistance to ground of less than 1 x 10^9 ohms, or by a wrist strap and cord as described above. ESD protective footwear (heel straps or shoes) should be tested at least daily.

All grounds at the workstation should be tied to a common point, which is then connected to building AC electrical service (''green wire'') ground. If access to known ground is unavailable, e.g., on shipboard or an aircraft, protection can be maintained at a potential higher than ''zero'' voltage if all items in the system are at the same potential.

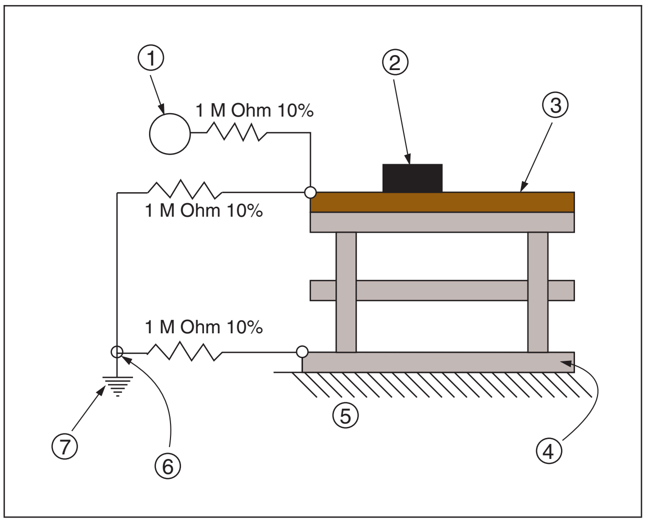

Figure B-1 EPA Grounding

1. **Personal wrist strap**
2. **ESDS item**
3. **ESD protective table top or mat**
4. **ESD protective floor or mat**
5. **Building floor**
6. **Common ground point**
7. **Ground**

CAUTION: Wrist straps and other ground connections typically incorporate a nominal one megohm resistor to protect the individual from any harmful line voltages that might be caused by faulty equipment in the work environment. Individuals working around voltages higher than 250V should not be grounded. Ground fault circuit interrupters (GFCI) or electrical interlocks should be considered wherever personnel might encounter high voltages.

B.1.3 Minimizing Static Charge

Static charge results when different materials that are in close contact are rubbed together or separated, causing electrons to transfer from one to the other. The magnitude of the charge varies with the type of material and the speed of rubbing or separation. In general, electrically insulating materials (with surface or volume resistance greater than 10^{11} ohms) generate higher charges.

Table B-1 Typical Static Charge Sources

Work surfaces	Waxed, painted or varnished surfaces Untreated vinyl and plastics Glass
Floors	Sealed concrete Waxed or finished wood Floor tile and carpeting
Clothes and personnel	Non-ESD smocks Synthetic materials Non-ESD Shoes Hair
Chairs	Finished wood Vinyl Fiberglass Nonconductive wheels
Packaging and handling materials	Plastic bags, wraps, envelopes Bubble wrap, foam Styrofoam Non-ESD totes, trays, boxes, parts bins
Assembly tools and materials	Pressure sprays Compressed air Synthetic brushes Heat guns, blowers Copiers, printers

A person can develop a significant charge with simple movements such as walking, sitting, or unpacking devices. In the absence of ESD protective practices, normal activities in a work area can generate many thousands of volts on an insulator.

Table B-2 Typical Static Voltage Generation

Source	10-20% Humidity	65-90% Humidity
Walking on carpet	35,000 volts	1,500 volts
Walking on vinyl flooring	12,000 volts	250 volts
Worker at a bench	6,000 volts	100 volts
Vinyl envelopes (work instructions)	7,000 volts	600 volts
Plastic bag picked up from the bench	20,000 volts	1,200 volts
Work chair with foam pad	18,000 volts	1,500 volts
Components sliding inside packaging tubes	5,000 volts	3,000 volts

When a charged individual touches a device, as in a hand assembly operation, some of the energy stored on the individual's body is discharged to the device or through the device to ground. Even without physical contact, a high static charge on an insulator can induce a charge on a nearby conductor such as a tool or an individual. This can then cause damage when discharged into an ESD sensitive item. The damage may not be seen or felt; an electrostatic discharge below 3000 volts cannot be felt by a human, but can still damage an ESDS item.

Insulators may create potentially damaging static charges, and cannot be grounded (they do not lose their electrostatic charge when attached to ground). All unnecessary insulators, including tools, personal items, and paper should be removed from the EPA. To minimize charge generation, process-required insulators should be kept at a safe distance from ESDS items, or high static charges should be neutralized through ionization. To determine whether mitigation is needed, charges on insulators close to ESDS items should be measured periodically.

Protecting the Assembly – ESD and Other Handling Considerations (cont.)

B.1.4 ESD Protective Packaging

Outside an EPA, ESDS items should be stored or transported while completely enclosed inside ESD protective packaging, usually static shielding bags or boxes. Static shielding packaging prevents an electrostatic discharge from passing through the package and into the ESDS item, causing damage.

Static protective packaging incorporates ''antistatic'' materials. In contrast to insulators, antistatic materials are ESD protective. They are low-charging, which means they do not readily generate static charge. They are also static dissipative, with surface or volume resistance greater than or equal to 10^4 and less than 10^{11} ohms. This resistance range is higher than conductors but less than insulators, which ensures that any static charge can dissipate safely to ground.

ESD shielding packaging is constructed with an antistatic innermost layer in contact with the ESDS item(s), and a conductive layer to protect against static fields. ESD shielding bags (and moisture barrier bags) are laminated with layers of antistatic, conductive, and (in some cases) insulating materials. ESD shielding bags should be closed using ziplocks, ESD labels, or antistatic tape (staples are not recommended). ESD protective boxes are often constructed of conductive plastic or cardboard with antistatic foam on the inside.

Static protective packaging should be clearly marked, see B.1.8 ESD Prevention – Warning Labels. The color of the packaging material can be misleading; black material may be conductive, static dissipative, or insulating, and pink material (so called ''pink poly'') may be static dissipative or insulating. Some newer antistatic or static dissipative materials may be clear or blue. Opaque, shiny moisture barrier bags are usually ESD shielding, see B.3 Moisture Sensitive Devices. Crinkled ESD shielding bags should be replaced, as the crinkles indicate cracks or breaks in the static shielding conductive layer (which is usually aluminized Mylar). Pink poly and materials formulated with topical antistatic coatings are known to increase in resistance over time, and should be checked periodically and replaced if necessary.

B.1.5 Training

Individuals should be trained before handling or transporting ESDS items, and should receive recurrent training in ESD awareness and prevention. Within an EPA, untrained individuals should be escorted by trained personnel.

B.1.6 Tools And Equipment

The following ESD protective equipment and packaging should be qualified during initial selection or before use:

- Worksurfaces, e.g., static mats
- Wrist strap or other grounding cords
- Wristbands
- Personnel wrist strap connections
- Constant Monitoring Equipment for personnel grounding
- Footwear or foot grounders, e.g., heel straps
- ESD Flooring
- ESD Seating (if used)
- Static Control Garments (if used)
- Ionization, e.g., ionizing air blowers
- Shelving used to store unprotected ESDS items
- Mobile equipment, e.g., carts, pick-and-place trolleys, used to store or transport ESDS items
- Electrical soldering/desoldering hand tools (including soldering irons)

It may not be practical to qualify or specify ESD protective packaging of purchased electronic components or assemblies, but packaging materials purchased for use should be qualified. Qualification should be documented, either through laboratory evaluation or testing, or more frequently by reviewing and maintaining copies of equipment specifications, manufacturer's certifications, or calibration records.

Manufacturing equipment should not transfer damaging energy to component terminations, including spike voltages. Soldering and desoldering tools should meet requirements of ANSI/ESD S20.20.

Protecting the Assembly – ESD and Other Handling Considerations (cont.)

B.1.7 Compliance Verification

ANSI/ESD S20.20 requires periodic testing of some ESD protective systems, including work surface resistance to ground, because equipment performance may degrade with use. Some process equipment may require periodic preventive maintenance or replacement.

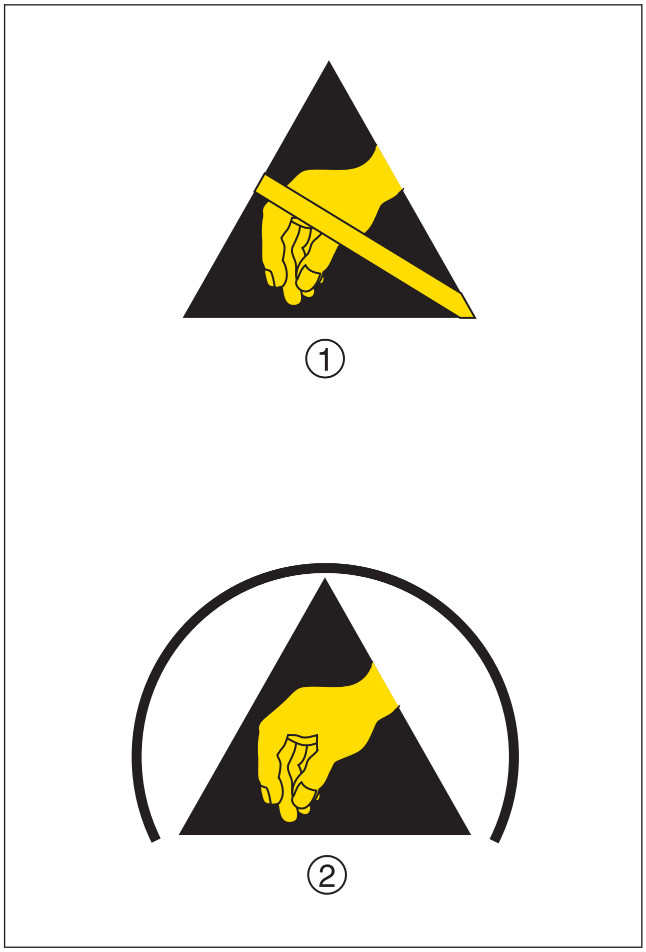

Figure B-2
1. ESD Susceptibility Symbol
2. ESD Protective Symbol

B.1.8 ESD Prevention – Warning Labels

Warning labels are available for posting in EPAs and placement on ESD sensitive devices, assemblies, equipment, and packaging to alert personnel to the risk of inflicting ESD damage.

Symbol (1) is used to indicate that an electrical or electronic device or assembly is susceptible to damage from an ESD event.

Note that the absence of this symbol does not necessarily mean that the assembly is not ESD sensitive. When any doubt exists about the ESD sensitivity of an assembly or component, it should be handled as ESD sensitive until it is determined otherwise.

Symbol (2) ESD protective symbol adds an arc over the triangle and no slash across the hand. It is used to identify items that are specifically designed to provide ESD protection for ESD sensitive items.

Protecting the Assembly – ESD and Other Handling Considerations (cont.)

B.2 General Handling

Foreign Object Damage (FOD) recommendations herein are based on AS9146.

B.2.1 Handling Considerations

To protect product from contamination or foreign objects, keep work surfaces, tools, handling containers, racks, and other equipment clean and orderly. Handle assemblies by the edges only, and avoid touching solderable surfaces with bare hands. Handle assemblies with care, using two hands whenever possible. These principles are especially critical for no-clean processing.

Table B-3 Recommended Practices for Handling Electronic Assemblies

1. Keep workstations clean and orderly. Dispose of any debris and clean up any spills promptly. Avoid eating, drinking, or use of tobacco products, including the use of e-cigarettes, in the work area.
2. Remove any unnecessary tools, chemicals, components, manufacturing aids, and documentation from the work area.
3. If you hear or see something drop, pick it up immediately.
4. Minimize the handling of electronic assemblies and components to prevent damage.
5. When gloves are used, change as frequently as necessary to prevent contamination from dirty gloves.
6. Do not handle solderable surfaces with bare hands or fingers. Body oils and salts may interfere with adhesion of conformal coatings, adhesives, or encapsulants. Whenever possible, handle assemblies by the edges only.
7. Use only approved hand creams or lotions that do not contain silicone, which can interfere with adhesion of coatings, adhesives, or encapsulants.
8. Never stack electronic assemblies or physical damage may occur. Packaging should include static dissipative cushioning foam or nests. Special racks may be provided in assembly areas for temporary storage, and transport carts should have side guards or other features to prevent shifting.
9. Work surfaces, carts, racks, and packaging used for handling or transport should be clean and free of Foreign Object Debris (FOD).

Protecting the Assembly – ESD and Other Handling Considerations (cont.)

B.2.2 Preventing Contamination

Normal cleaning procedures may not remove all contaminants, so it is important to minimize the opportunities for contamination. Fingerprints may be hard to remove and will often show up on conformally coated boards after exposure to humidity or environmental testing. The best solution is prevention:

- Wash hands frequently.
- Change gloves or finger cots often, see B.2.3 Handling Considerations – Gloves and Finger Cots.
- Whenever possible, handle assemblies only by the edges.
- Avoid touching solderable surfaces or areas that will be conformally coated or encapsulated.
- Use provided pallets or carriers.

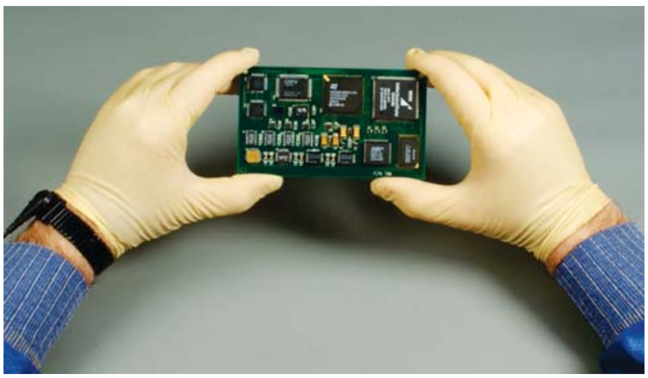

Figure B-3

B.2.3 Handling Considerations – Gloves and Finger Cots

Gloves or finger cots may create a false sense of protection, and within a short time they can become more contaminated than bare hands. When used, gloves or finger cots should be replaced often. Gloves and finger cots should be evaluated for resistance to solvents and abrasion, operator comfort, and ESD protective properties.

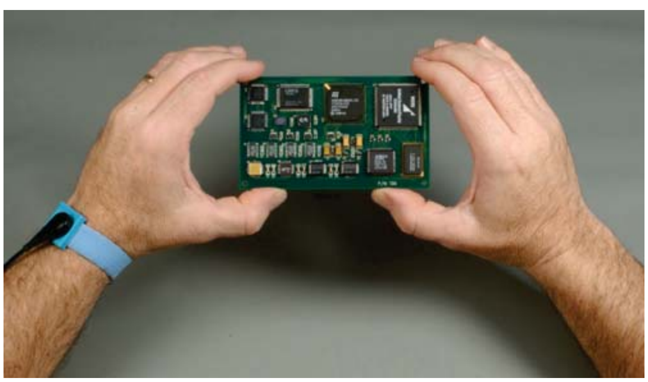

Figure B-4

Protecting the Assembly – ESD and Other Handling Considerations (cont.)

B.3 Moisture Sensitive Devices

Moisture sensitive components should be packaged and handled in accordance with IPC/JEDEC J-STD-033, and printed boards should be packaged and handled per IPC-1602.

Atmospheric moisture absorbed into permeable plastic bodies of some electronic components and printed boards can expand during reflow soldering, causing delamination or cracking of critical structures within the component. The damage is not usually visible, and can lead to latent failures that occur after the product has been placed into service.

Depending on construction, components vary in rate of absorption and sensitivity to absorbed moisture, and their Moisture Sensitivity Level (MSL) can be classified in accordance with IPC/JEDEC J-STD-020 or ECA/IPC/JEDEC J-STD-075. Printed boards can also be damaged by absorbed moisture, but design variables and details of construction make moisture sensitivities difficult to classify.

Baking can be used to remove absorbed moisture, but also can degrade solderability. In general, baking should be minimized, and process controls and moisture protective packaging should be used to minimize moisture uptake. When not being worked on, moisture sensitive components and printed boards should be packaged or stored in a dry environment, such as a heat-sealed moisture barrier bag with desiccant and a humidity indicator card (HIC).

Any time a moisture sensitive item is removed from dry packaging, the humidity indicator card should be checked. When read promptly, the HIC indicates the current relative humidity inside the moisture barrier bag, not the cumulative moisture exposure of the contents. In general, moisture sensitive components should be evaluated for baking if the 5% dot has turned fully pink, and the 10% dot is not blue. Printed boards should be evaluated for baking if the 10% dot is pink.

Note: HICs with other colors are available, and instructions will be printed on the card.

HICs should be discarded if the 60% dot has changed color, because this level of humidity may compromise accuracy of the 5% and 10% dots. ''Type 2 Nonreversible Spot'' HICs should be discarded if the 60% dot has spread outside the black circular border.

When outside of dry packaging or dry storage, process controls should be implemented to minimize exposure of the moisture sensitive item to ambient conditions of temperature and humidity. Time of exposure to ambient conditions (outside of dry storage) should be tracked or otherwise controlled, e.g., by monitoring process cycle time. Floor audits should be considered to ensure compliance.

Note: Per IPC/JEDEC J-STD-033, dry storage may reverse ambient exposure time and even reset the ''floor life clock.'' Depending on the MSL, to reset the floor life clock, components should be kept in dry storage for either 5X or 10X the exposure time. Depending on MSL, if time of exposure to ambient conditions exceeds the specified limits, returning components to dry storage may not pause or reset the floor life clock.

Moisture sensitive components that are known or suspected to have exceeded the specified floor life for their moisture sensitivity level should be baked in accordance with the component manufacturer's recommendations or IPC/JEDEC J-STD-033.

Printed boards that are suspected of having absorbed excess moisture should be baked in accordance with IPC-1602. Moisture content of printed boards may also be measured per IPC-TM-650 Method 2.6.28.

Index

Index (cont.)

Standard Improvement Form

IPC-A-610H

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

Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to:

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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:

____

____

____

____

3. Other suggestions for document improvement:

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Submitted by:

Name ______________________________ Telephone ______________

Company ______________________________ E-mail ______________

Address ______________________________

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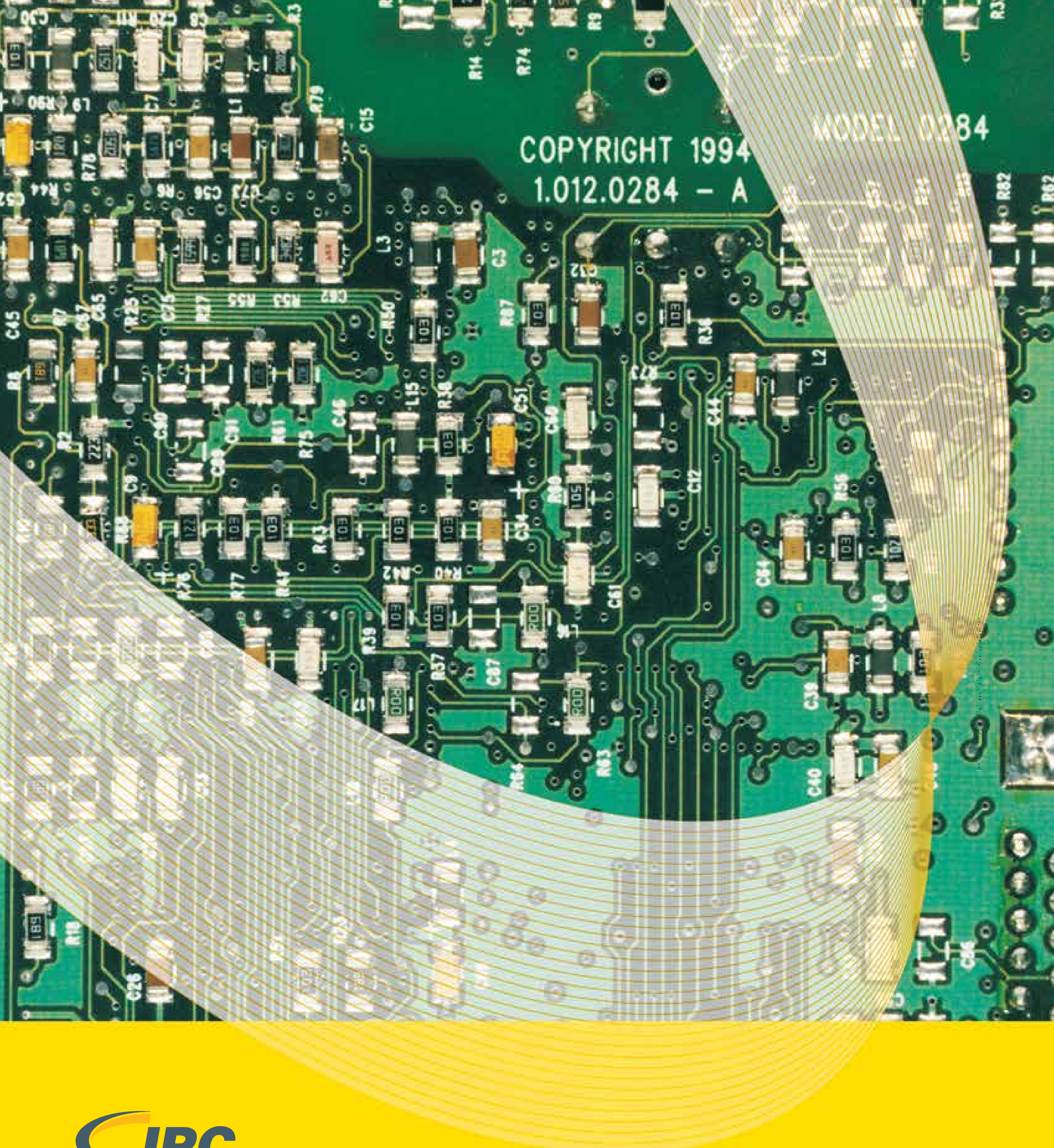

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