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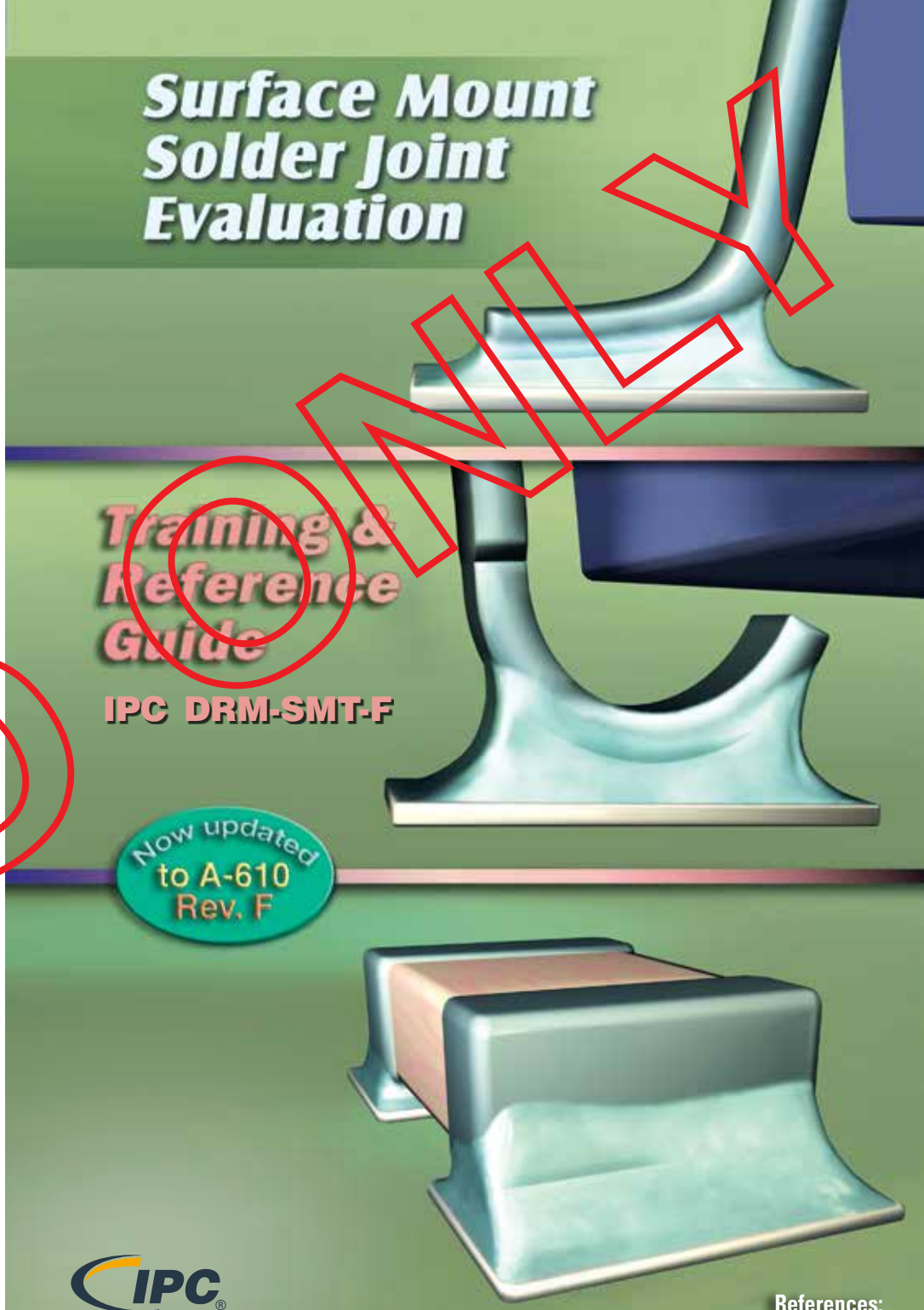
Surface Mount Solder Joint Evaluation

Training & Reference Guide

IPC DRM-SMT-F



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References:
IPC-A-610 Rev. F – July 2014

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Introduction

This Surface Mount Solder Joint Evaluation *Training and Reference Guide* provides visual examples of conditions found in surface mount solder joints for rectangular chips, J-leads, gull-wings, BGAs and BTCs. It also defines the dimensional acceptability requirements for each, as determined by industry consensus standards This manual references and illustrates portions of the following document:

IPC-A-610 Rev. F, Acceptability of Electronic Assemblies, which illustrates the requirements for many types of solder connections.

Acceptance Criteria

In this *Training and Reference Guide*, minimum and maximum dimensional acceptance criteria are shown for each class of component type. Solder joints falling outside these parameters will be deemed as unacceptable, according to the standards set in the IPC-A-610.

A target example is also given to show the ideal case scenario. Photographs of various solder conditions follow the dimensional criteria for each component type.

Notes:
Accept and/or reject decisions must be based on applicable documentation, e.g. contract, drawings, referenced documents, and specifications such as the: IPC-A-610 and IPC J-STD-001.

Lead Free Soldering

The primary difference between the solder connections created with processes using tin-lead alloys and processes using lead free alloys is related to the visual appearance of the solder.

Acceptable lead free and tin-lead connections may exhibit similar appearances, but lead free alloys are more likely to have:

- Surface roughness (grainy or dull)
- Greater wetting contact angles*

All other solder criteria are the same.

*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 degree contact angles as typical.

Denotes Lead Free

Classification

Surface mount solder joint requirements are divided into three classes depending on the ultimate use, life expectancy and operating environment of the electronic assembly. These classes are as follows:

Class 1—General Electronic Products

Consumer type products, suitable for applications where the major requirement is how it functions, not necessarily for extended life, reliability of service, or cosmetic perfection.

Class 2—Dedicated Service Electronic Products

Commercial type products, where continued performance and extended life is required and for which uninterrupted service is desired but not critical. Typically, the user environment is not extreme in such things as temperature or contamination, and would not cause failures.

Class 3—High Performance Electronic Products

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 for life-support, flight control, and other *high-reliability* systems.

Note:
The inspector does not select the class for the part under inspection. Documentation which specifies the applicable class for the part under inspection should be provided to the inspector.

Terminology

Below are definitions that may be helpful in describing surface mount solder joints (also see: IPC-T-50):

Adhesive – In surface mounting, a glue used to adhere surface mount components to the printed wiring board.

Area Array Components – Components with terminations arranged in a grid pattern on the bottom of the package, including Ball Grid Arrays and BTCs (Bottom Termination Components such as QFN, DFN, LGA, etc.)

Assembly – A number of components, subassemblies, or combinations thereof joined together on a printed wiring board.

Blow Hole – A void in the solder joint caused by gas escaping from the molten solder.

Body – The non-metallized, or non-leaded part of any electronic component.

Chip – Rectangular "Chip" Component, a surface mounted electronic component with terminations, or metallized contact areas instead of leads.

Cold Solder Connection – A solder connection that exhibits poor wetting and that is characterized by a gray, porous appearance.

Component – An individual part or combination of parts that, when together, perform an electrical function.

Component Mounting – The act of attaching components to the printed wiring board, or the method in which they are attached.

Conductor – A single electrically conductive path in a larger conductive pattern.

Contact (Wetting) Angle – The angle formed by the edge, or meniscus, of the solder fillet on the surface of the land.

Defect – A condition failing to meet acceptability requirements, or is otherwise cause for rejection.

Dewetting – A condition that results when molten solder coats a surface and then recedes to leave irregularly-shaped mounds of solder that are separated by an area that is covered with a thin film of solder, and with the basis metal not exposed.

Disturbed Solder Connection – A solder connection that is characterized by an appearance caused by motion between the metals being joined while the solder was solidifying.

Excess Solder Connection – A solder connection that is characterized by the complete obscuring of the surfaces of the connected metals and/or by the presence of solder beyond the connection area.

Flux – A compound that, when heated, promotes the wetting of a base metal by molten solder.

Flux Residue – A flux-related contaminant that is present on or near the surface of a solder connection.

Gull Wing – A type of surface mount component lead that is bent in a configuration similar in shape to a seagull's wing.

Heel – The lowest bend in any surface mount lead, just before the lead makes actual contact with the land.

J-Lead – A type of surface mount lead that is bent down and under the component, forming the shape of the letter "J."

Knee – The uppermost bend of a component lead, closest to the component body.

Land – A portion of a conductive pattern that is usually used for making electrical connections, for component attachment, or both.

Lead – A length of insulated or uninsulated metallic conductor that is used for electrical interconnections.

Nonwetting – The partial adherence of molten solder to a surface that it has contacted and basis metal remains exposed.

Pinhole – A small hole that penetrates from the surface of a solder connection to a void of indeterminate size within the solder connection.

Process Indicator – A detectable variation in quality, other than a defect, that may be a reflection of improper material, equipment, personnel or process.

Residue – Any visual or measurable form of process-related contamination.

Solder – A metal alloy with a melting temperature that is below 427°C (800°F).

Solder Ball – A small sphere of solder adhering to a laminate, resist, or conductor surface—generally occurring after wave or reflow soldering.

Solder Bridging – The unwanted formation of a conductive path of solder between conductors.

Solder Fillet – A normally-concave surface of solder that is at the intersection of the metal surfaces of a solder connection.

Solder Paste – Finely divided particles of solder, with additives to promote wetting and other properties, suspended in a cream flux. The cream holds the surface mounted device in place until reflow soldering.

Solderability – The ability of a metal to be wetted by molten solder.

Soldering – The joining of metallic surfaces with solder without the melting of the base material.

Target Solder Condition – An ideal solder connection, though not always achievable or necessary. One that is feathered-out to a thin edge, indicating proper solder flow and wetting action. With no sharp protrusions of solder or evidence of contamination.

Termination – The metallized area of a chip component, the metallic lead of a component, or the land or terminal where a solder connection is formed.

Toe – The end or tip of a lead on a surface mount component.

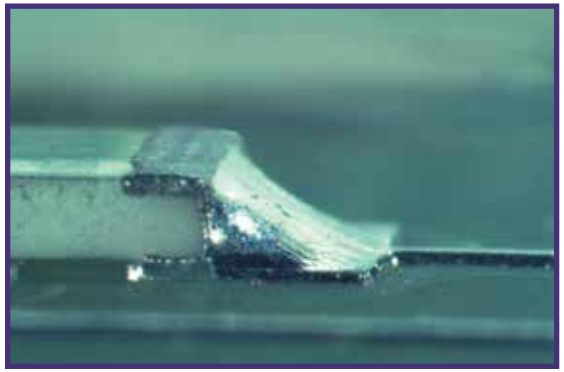
Tombstoning – The complete lifting of a chip component, with one end having no solder connection to the land.

Webbing – A continuous film or curtain of solder that is parallel to, but not necessarily adhering to, a surface that should be free of solder.

Wetting – The formation of a relatively uniform, smooth, unbroken film of solder to a basis metal.

Chip Components • Class 1

Target Condition

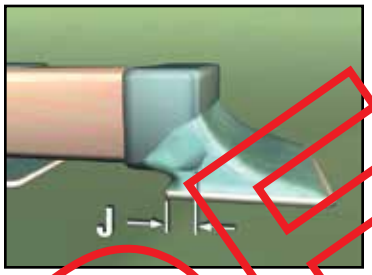


This photo represents an **ideal** surface mount solder joint for any class of rectangular chip component.

Notes: *Solder joints are semi-transparent to show relationship between land and termination. Side Overhang, Dimension* ***(A),*** *must not violate minimum electrical clearance. Minimum Side Joint Length, Dimension* ***(D),*** *is not required for chips, only a properly wetted fillet must be evident. The references below are applicable to the dimensional criteria for 1-, 3-, or 5-side termination Chip components.*

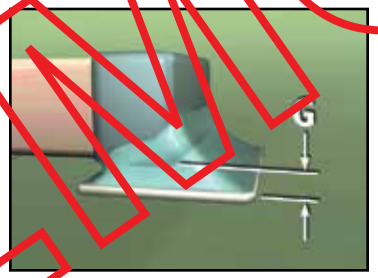
References: A-610F: 8.3.2, Table 8-2; 8.3.2.1 through 8.3.2.8

Acceptance Criteria



End Overlap (J)

Some amount of overlap between the component termination and the land is **required** for **minimum** acceptance.



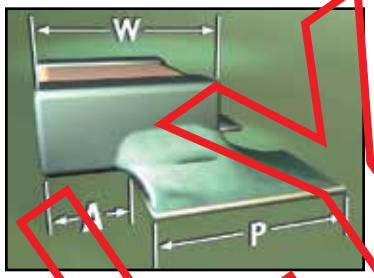
Solder Thickness (G)

The **minimum** distance between the land and component termination is **not specified.** Only a properly wetted fillet must be evident.

Acceptance Criteria

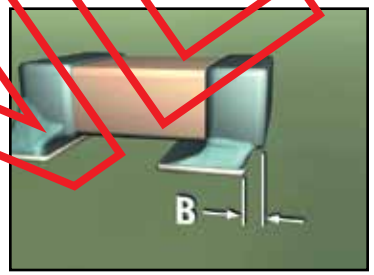
Side Overhang (A)

The component may overhang the side of the land a **maximum** of 50% of the width of the component termination **(W)**, or 50% of the width of the land **(P)**, whichever is less.



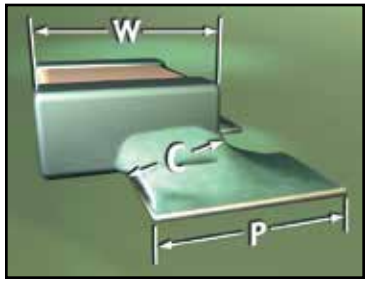
End Overhang (B)

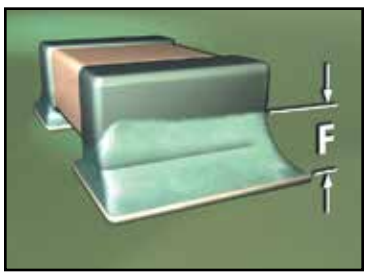
Any part of the component termination extending beyond the land is **unacceptable**



End Joint Width (C)

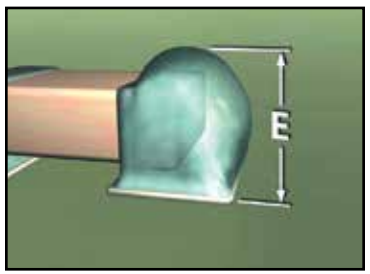
The width of the solder joint at its narrowest point must be a **minimum** of 50% the width of the component termination **(W)**, or 50% of the width of the land **(P)**, whichever is less.





Fillet Height (F)

Wetting is evident on termination's vertical surfaces as a **minimum** fillet height.

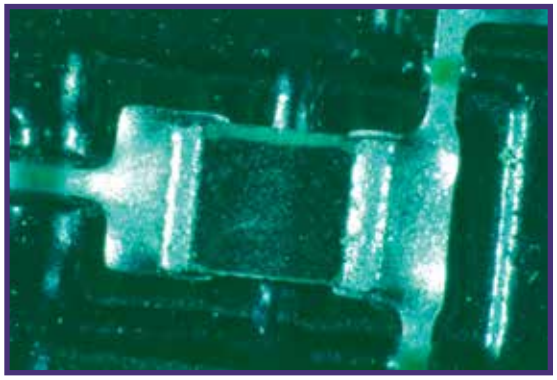


Fillet Height (E)

The solder may overhang the land, and extend onto the top or side of the termination, but **not touch** the top or side of the component body, as a **maximum** fillet height.

Chip Components • Class 2

Target Condition

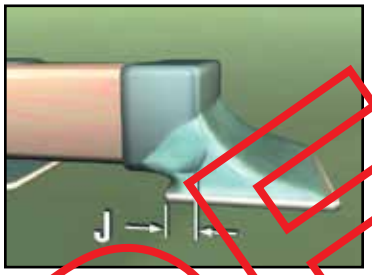


This photo represents an **ideal** surface mount solder joint for any class of rectangular chip component.

Notes: *Solder joints are semi-transparent to show relationship between land and termination. Side Overhang, Dimension* ***(A),*** *must not violate minimum electrical clearance. Minimum Side Joint Length, Dimension* ***(D),*** *is not required for chips, only a properly wetted fillet must be evident. The references below are applicable to the dimensional criteria for 1-, 3-, or 5-side termination Chip components.*

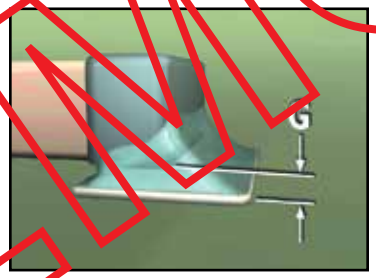
References: A-610F: 8.3.2, Table 8-2; 8.3.2.1 through 8.3.2.8

Acceptance Criteria



End Overlap (J)

Some amount of overlap between the component termination and the land is **required** for **minimum** acceptance.



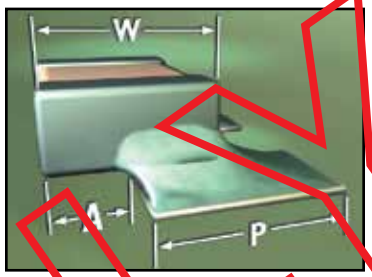
Solder Thickness (G)

The **minimum** distance between the land and component termination is **not specified.** Only a properly wetted fillet must be evident.

Acceptance Criteria

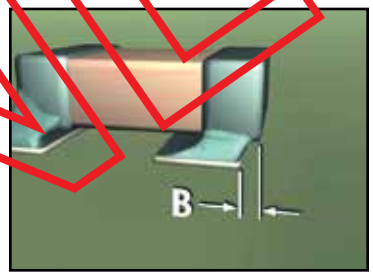
Side Overhang (A)

The component may overhang the side of the land a **maximum** of 50% of the width of the component termination **(W)**, or 50% of the width of the land **(P)**, whichever is less.



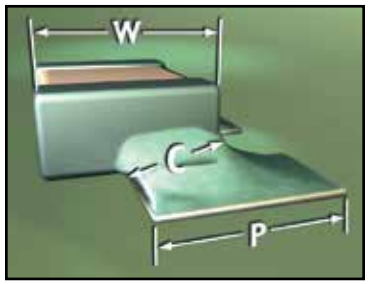
End Overhang (B)

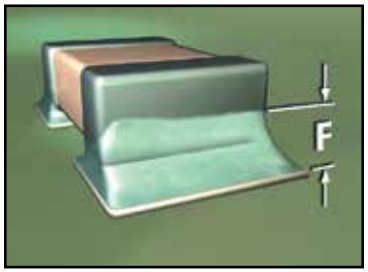
Any part of the component termination extending beyond the land is **unacceptable.**



End Joint Width (C)

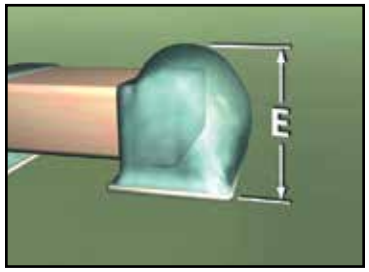
The width of the solder joint at its narrowest point must be a **minimum** of 50% the width of the component termination **(W)**, or 50% of the width of the land **(P)**, whichever is less.





Fillet Height (F)

Wetting is evident on termination's vertical surfaces as a **minimum** fillet height.

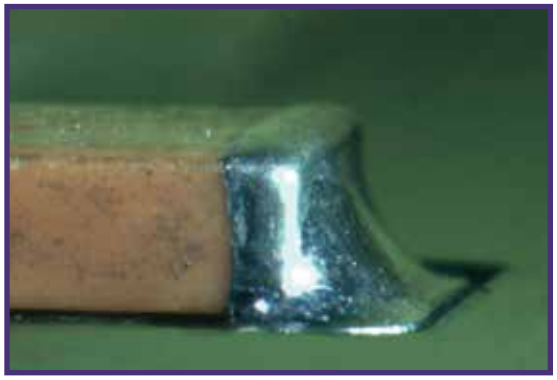


Fillet Height (E)

The solder may overhang the land, and extend onto the top or side of the termination, but **not touch** the top or side of the component body, as a **maximum** fillet height.

Chip Components • Class 3

Target Condition

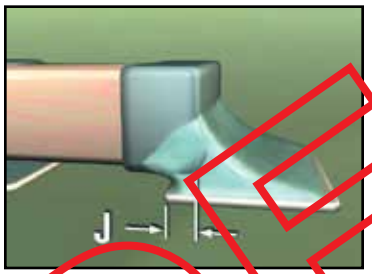


This photo represents an **ideal** surface mount solder joint for any class of rectangular chip component.

Notes: *Solder joints are semi-transparent to show relationship between land and termination. Side Overhang, Dimension* ***(A),*** *must not violate minimum electrical clearance. Minimum Side Joint Length, Dimension* ***(D),*** *is not required for chips, only a properly wetted fillet must be evident. The references below are applicable to the dimensional criteria for 1-, 3-, or 5-side termination Chip components.*

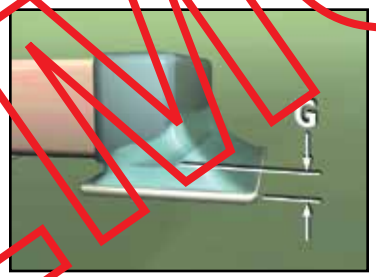
References: A-610F: 8.3.2, Table 8-2; 8.3.2.1 through 8.3.2.8

Acceptance Criteria



End Overlap (J)

A 25% overlap contact between the component termination and the land is **required** for **minimum** acceptance.



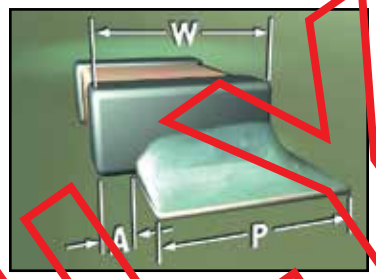
Solder Thickness (G)

The **minimum** distance between the land and component termination is **not specified.** Only a properly wetted fillet must be evident.

Acceptance Criteria

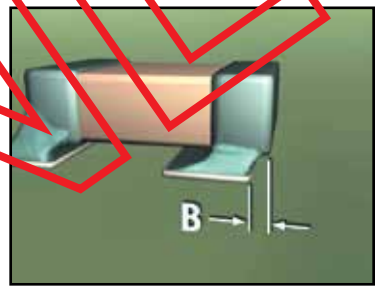
Side Overhang (A)

The component may overhang the side of the land a **maximum** of 25% of the width of the component termination **(W)**, or 25% of the width of the land **(P)**, whichever is less.



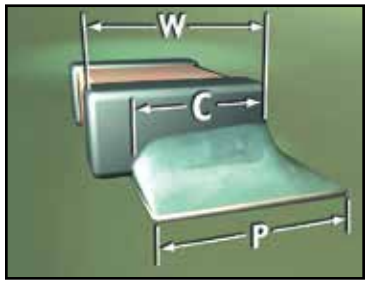
End Overhang (B)

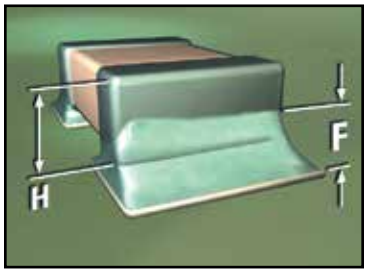
Any part of the component termination extending beyond the land is **unacceptable.**



End Joint Width (C)

The width of the solder joint at its narrowest point must be a **minimum** of 75% the width of the component termination **(W)**, or 75% of the width of the land **(P)**, whichever is less.

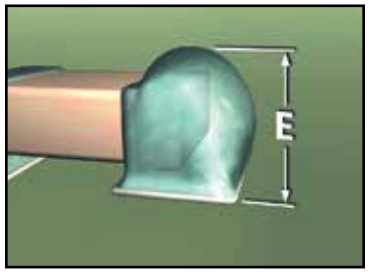




Fillet Height (F)

The **minimum** fillet height must extend at least 25% of the height of the component termination **(H)***, or 0.5 mm (0.02 in.), whichever is less.

Including any measurement for solder thickness* *(G).***



Fillet Height (E)

The solder may overhang the land, and extend onto the top or side of the termination, but **not touch** the top or side of the component body, as a **maximum** fillet height.

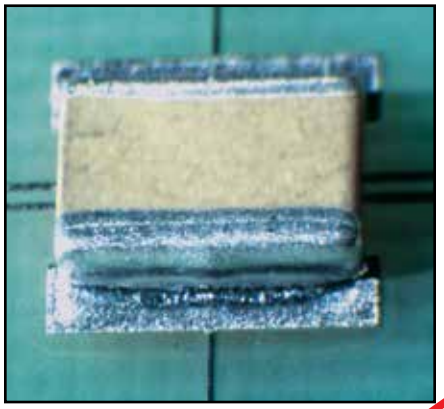
Photos | Class 3 | Class 2 | Class 1 | Gull Wing Components | J-Lead Components | Chip Components | Area Array Components

Chip Solder Conditions

The following pages show photographs of some of the major solder defects and process indicators for surface mounted Chip components.

These examples each contain a description as well as a reference to the appropriate section in the IPC-A-610F.

Insufficient Solder



Solder fails to meet minimum fillet height. No evidence of properly wetted fillet.

Defect, Class 1, 2, 3

Reference
A-610: Section 8.3.2.6

Excess Solder

Solder extends onto the top or side of the component body.

Defect, Class 1, 2, 3

Reference
A-610: Section 8.3.2.5

End Overlap

Insufficient end overlap.

Defect, Class 1, 2, 3

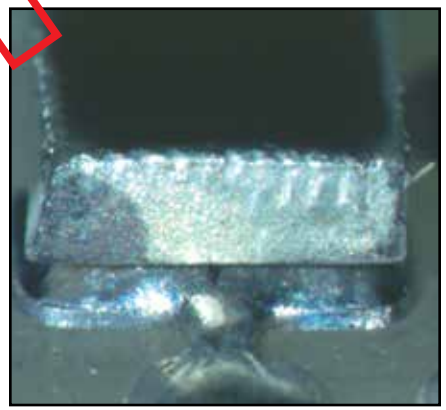
Reference
A-610: Section 8.3.2.8, Fig. 8-37

Nonwetting

Solder has not adhered to the land or termination. No metallic bond.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.4

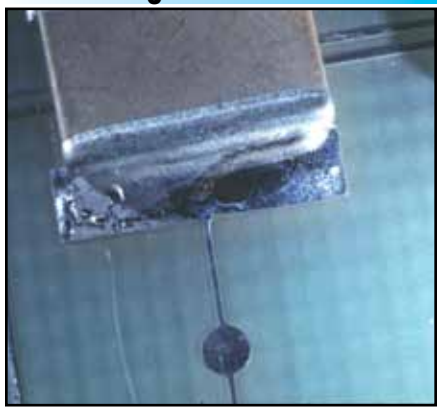


Dewetting

Molten solder coats surface then pulls back, leaving only a thin film of solder covering the land in some areas, and irregular mounds of solder in others.

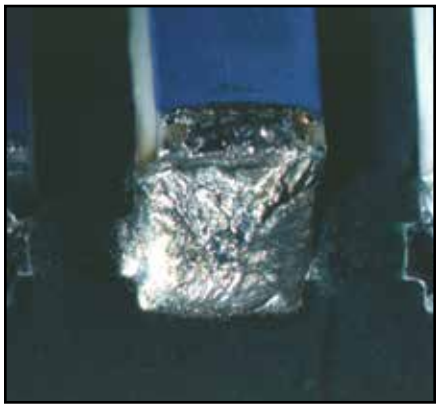
Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.6, Fig. 5-26



Photos
Class 3
Class 2
Class 1
Gull Wing Components
J-Lead Components
Chip Components
Area Array Components

Disturbed Joint

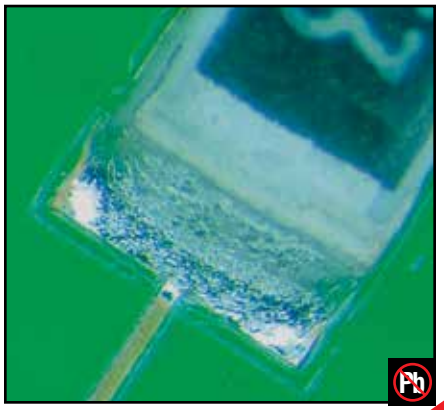


Characterized by uneven surface from movement in the joint while cooling.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.8

Lead Free Joint

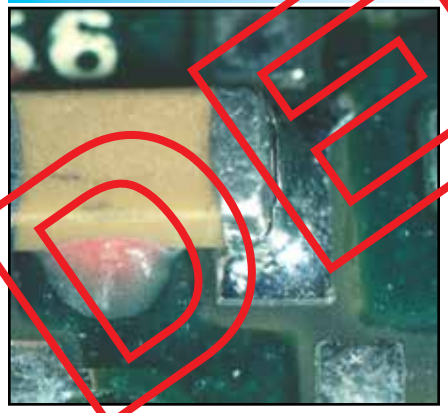


Lead free solder joints typically have a grainy or dull appearance.

Acceptable, Class 1, 2, 3

Reference
A-610: Section 5.1

Fractured/Cracked Joint



Fractured or cracked solder joint.

Defect, Class 1, 2, 3

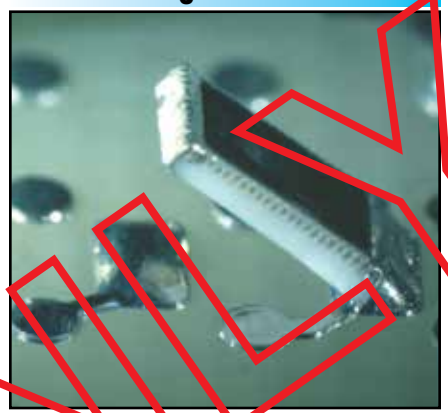
Reference
A-610: Section 5.2.9

Tombstoning

One end of the component termination is completely lifted off the land.

Defect, Class 1, 2, 3

Reference
A-610: Section 8.3.2.9.4

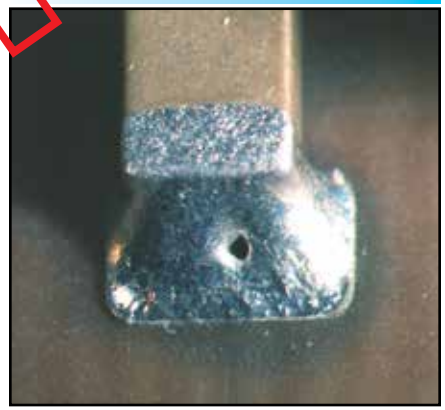


Pinholes

An escape of air or gas (outgassing) during the soldering process through tiny "pin" holes. Allowable condition as long as minimum soldering requirements have been met.

Acceptable Class 1
Process Indicator
Class 2, 3

Reference
A-610: Section 5.2.2

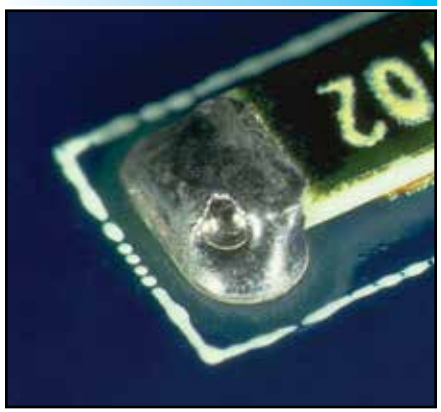


Blowholes

Larger holes (than pinholes) in the solder joint allowing voids, or trapped gasses, to escape from the solder joint. Allowable condition as long as minimum soldering requirements have been met.

Acceptable Class 1
Process Indicator
Class 2, 3

Reference
A-610: Section 5.2.2



Photos
Class 3
Class 2
Class 1
Gull Wing Components
J-Lead Components
Chip Components
Area Array Components

Solder Splashes

Solder splashes that are not attached, entrapped, encapsulated, that impact form, fit or function, or that violate minimum electrical clearance.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.7.3

Solder Bridging

A connection of solder across conductors or lands that should not be joined.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.7.2

Solder Balls

Any balls of solder that are not entrapped in a permanent coating, or attached to a metal contact, or violate minimum electrical clearance requirements.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.7.1

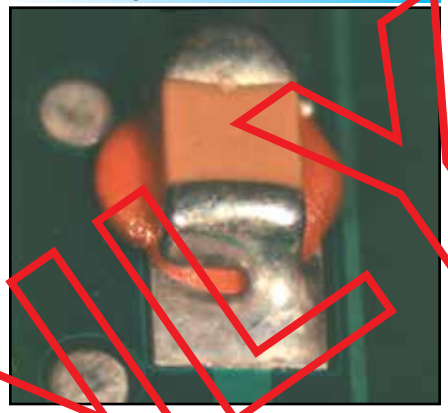
Mounting Adhesive on the Land

Any adhesive material in termination area is:

Acceptable Class 1
Process Indicator Class 2
Defect Class 3

Note: Adhesive material causing less than minimum end joint width is also a Defect: Class 1, 2.

Reference
A-610: Section 8.1

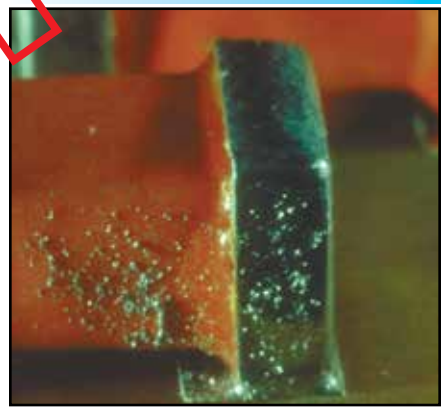


Solder Fines

Typically small balls of the original solder paste that have splattered around the connection during reflow. If violating minimum electrical clearance, or not encapsulated, nor attached to a metal surface, then:

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.7.1, Fig. 5-33

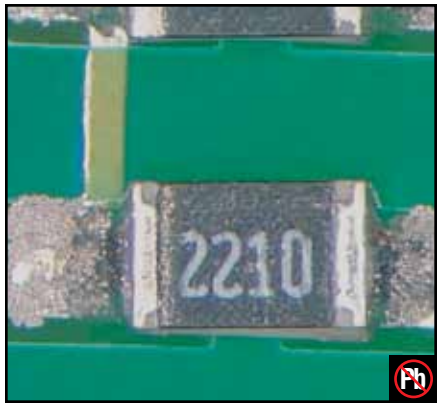


Incomplete Reflow

The solder paste had insufficient heat to reflow properly.

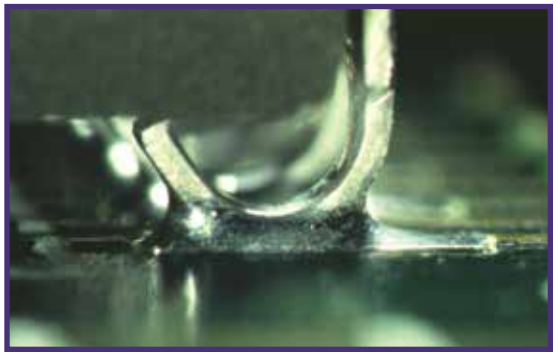
Defect, Class 1, 2, 3

Reference
A-610: Section 5,2.3, Fig. 5-15



J-Lead Components • Class 1

Target Condition

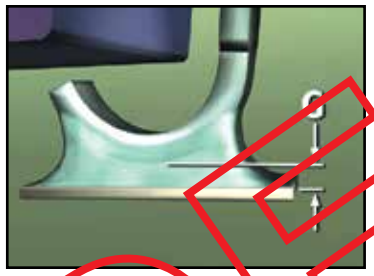


This photo represents an **ideal** surface mount solder joint for any class of J-lead component.

Notes: *Solder joints are semi-transparent to show relationship between land and lead. Side Overhang, Dimension* **(A)**, *must not violate minimum electrical clearance. The references below are applicable to the dimensional criteria for J-Lead components.*

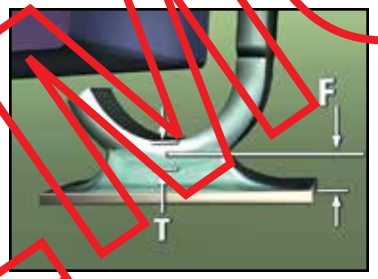
References: A-610F: 8.3.7, Table 8-7; 8.3.7.1 through 8.3.7.7

Acceptance Criteria



Solder Thickness (G)

The **minimum** distance between the land and component lead is **not specified**. Only a properly wetted fillet must be evident.



Heel Fillet Height (F)

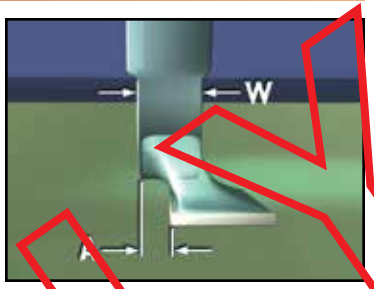
The heel fillet must extend up to at least 50% the thickness of the component lead **(T)***, as a **minimum** fillet height.

Including any measurement for solder thickness* *(G)****.*

Acceptance Criteria

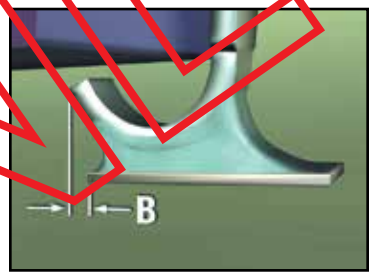
Side Overhang (A)

The component lead may overhang the side of the land a **maximum** of 50% the width of the lead **(W)**.



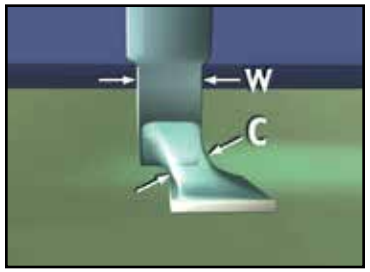
Toe Overhang (B)

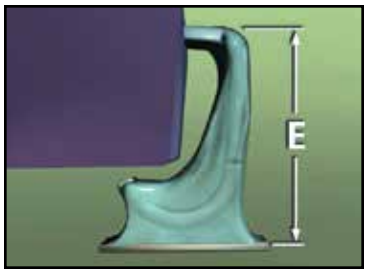
The maximum distance the end or tip of the lead may extend over the edge of the land is **not specified**. Lead tip must not violate minimum electrical clearance.



End Joint Width (C)

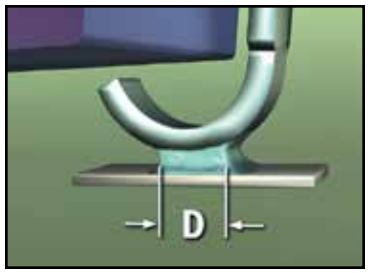
The width of the solder joint at its narrowest point needs to be a **minimum** of 50% lead width **(W)**.





Heel Fillet Height (E)

The solder may **not touch** the component body as a **maximum** fillet height.

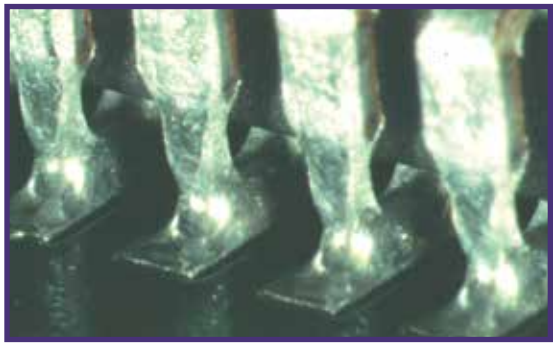


Side Joint Length (D)

The length of the solder joint at its narrowest point, **has no minimum** requirement. Only a properly wetted fillet must be evident.

J-Lead Components • Class 2

Target Condition

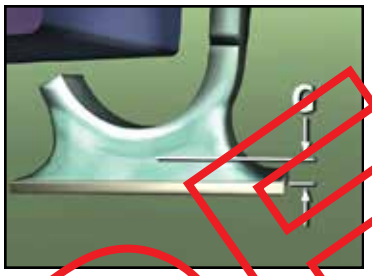


This photo represents an **ideal** surface mount solder joint for any class of J-lead component.

Notes: *Solder joints are semi-transparent to show relationship between land and lead. Side Overhang, Dimension* **(A),** *must not violate minimum electrical clearance. The references below are applicable to the dimensional criteria for J-Lead components.*

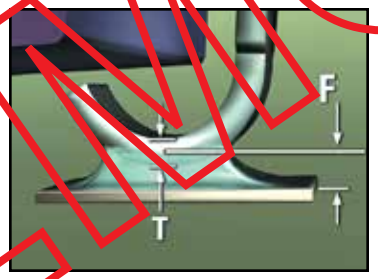
References: A-610F: 8.3.7, Table 8-7; 8.3.7.1 through 8.3.7.7

Acceptance Criteria



Solder Thickness (G)

The **minimum** distance between the land and component lead is **not specified**. Only a properly wetted fillet must be evident.



Heel Fillet Height (F)

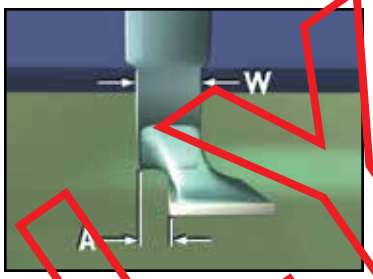
The heel fillet must extend up to at least 50% the thickness of the component lead **(T)***, as a **minimum** fillet height.

Including any measurement for solder thickness* *(G)****.*

Acceptance Criteria

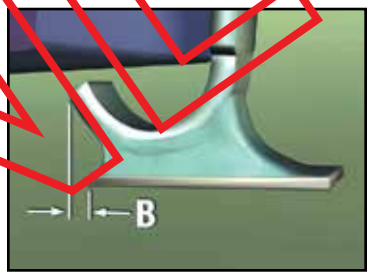
Side Overhang (A)

The component lead may overhang the side of the land a **maximum** of 50% the width of the lead **(W)**.



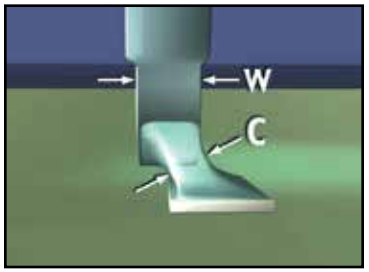
Toe Overhang (B)

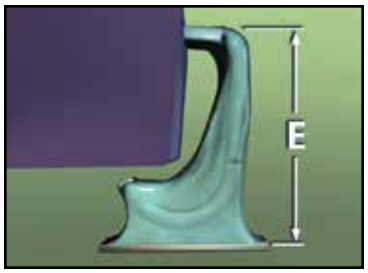
The **maximum** distance the end or tip of the lead may extend over the edge of the land is **not specified**. Lead tip must not violate minimum electrical clearance.



End Joint Width (C)

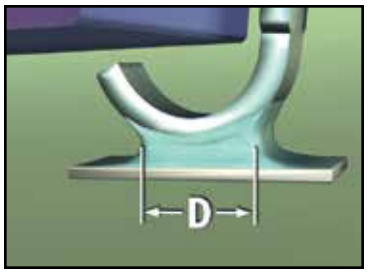
The width of the solder joint at its narrowest point needs to be a **minimum** of 50% lead width **(W)**.





Heel Fillet Height (E)

The solder may **not touch** the component body as a **maximum** fillet height.

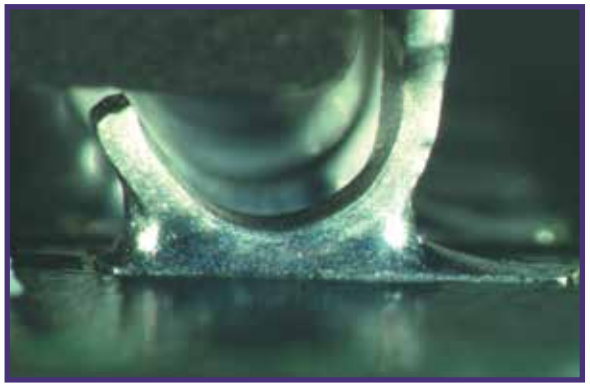


Side Joint Length (D)

The length of the solder joint at its narrowest point, must be a **minimum** of 150% the width of the lead **(W)**.

J-Lead Components • Class 3

Target Condition

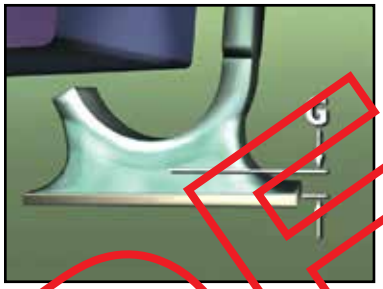


This photo represents an **ideal** surface mount solder joint for any class of J-lead component.

Notes: *Solder joints are semi-transparent to show relationship between land and lead. Side Overhang, Dimension* ***(A),*** *must not violate minimum electrical clearance. The references below are applicable to the dimensional criteria for J-Lead components.*

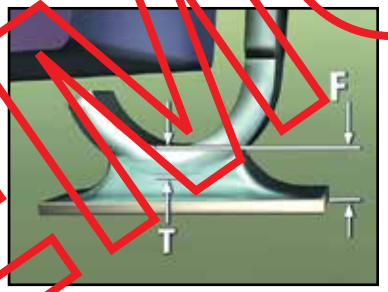
References: A-610F: 8.3.7, Table 8-7; 8.3.7.1 through 8.3.7.7

Acceptance Criteria



Solder Thickness (G)

The **minimum** distance between the land and component lead is **not specified**. Only a properly wetted fillet must be evident.



Heel Fillet Height (F)

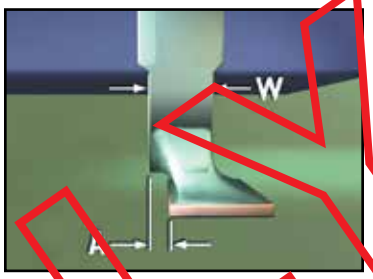
The **minimum** heel fillet height must extend up to at least 100% of the Lead Thickness **(T)***.

Including any measurement for solder thickness* *(G)****.*

Acceptance Criteria

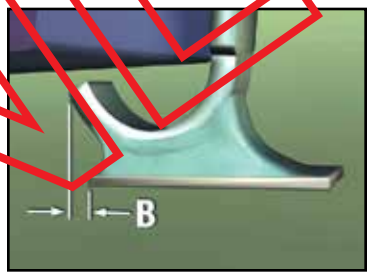
Side Overhang (A)

The component lead may overhang the side of the land a **maximum** of 25% the width of the lead **(W)**.



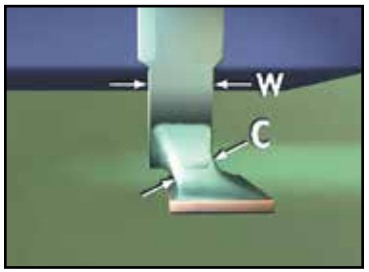
Toe Overhang (B)

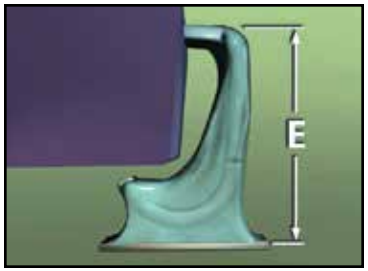
The **maximum** distance the end or tip of the lead may extend over the edge of the land is **not specified**. Lead tip must not violate minimum electrical clearance.



End Joint Width (C)

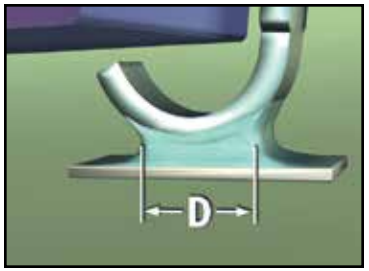
The width of the solder joint at its narrowest point needs to be a **minimum** of 75% lead width **(W)**.





Heel Fillet Height (E)

The solder may **not touch** the component body as a **maximum** fillet height.



Side Joint Length (D)

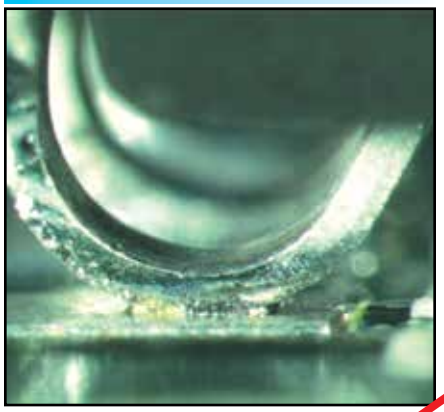
The length of the solder joint at its narrowest point, must be a **minimum** of 150% the width of the lead **(W)**.

J-Lead Solder Conditions

The following pages show photographs of some of the major solder defects and process indicators for surface mounted J-lead components.

These examples each contain a description as well as a reference to the appropriate section in the IPC-A-610F.

Insufficient Solder



Solder fails to meet minimum fillet height. No evidence of properly wetted fillet.

Defect, Class 1, 2, 3

Reference
A-610: Section 8.3.7.6,
Fig. 8-136

Excess Solder

Solder touches the component body.

Defect, Class 1, 2, 3

Reference
A-610: Section 8.3.7.5,
Fig. 8-131

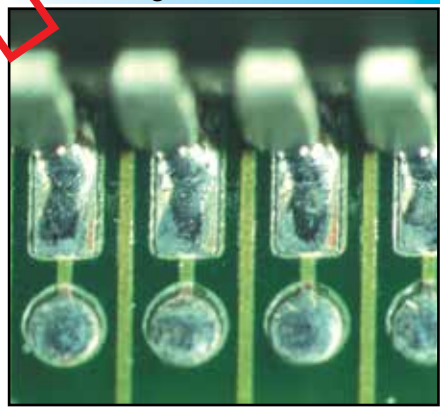
Nonwetting

Solder has not adhered to the land or termination. No metallic bond.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.4

Dewetting

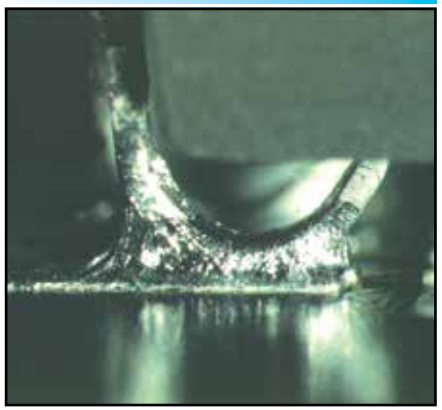


Molten solder coats surface then pulls back, leaving only a thin film of solder covering the land in some areas, and irregular mounds of solder in others.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.6

Disturbed Joint

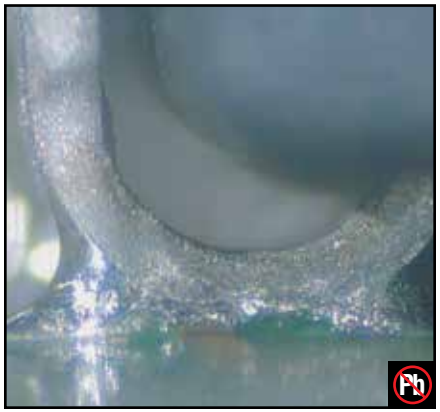


Characterized by uneven surface from movement in the joint while cooling.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.8,
Fig. 5-43

Lead Free Joint

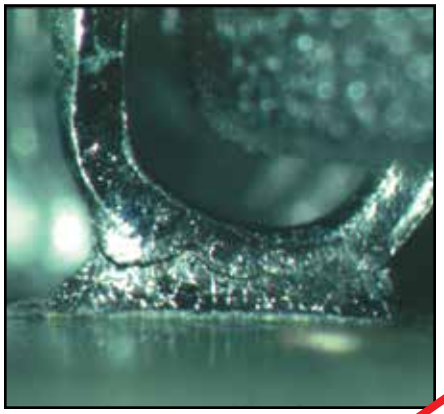


Lead free solder joints typically have a grainy or dull appearance, or greater wetting contact angles.

Acceptable, Class 1, 2, 3

Reference
A-610: Section 5.1

Fractured/Cracked Joint



Fractured or cracked solder joint.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.9,
Fig. 5-46

Open Connection

One lead, or series of leads on a component, is out of alignment (coplanarity), and prevents formation of a proper solder joint.

Defect, Class 1, 2, 3

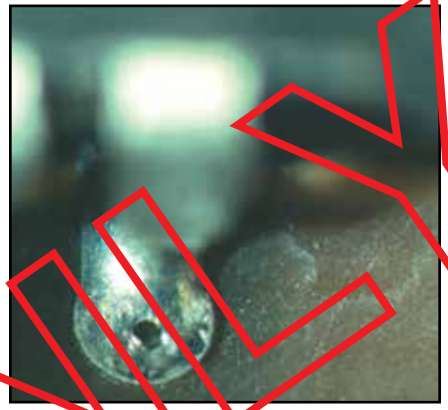
Reference
A-610: Section 8.3.7.8,
Fig. 8-138

Blowholes

Larger holes (than pinholes) in the solder joint allowing voids, or trapped gasses, to escape from the solder joint. Allowable condition as long as minimum soldering requirements have been met.

Acceptable, Class 1
Process Indicator, Class 2, 3

Reference
A-610: Section 5.2.2,
Fig. 5-10

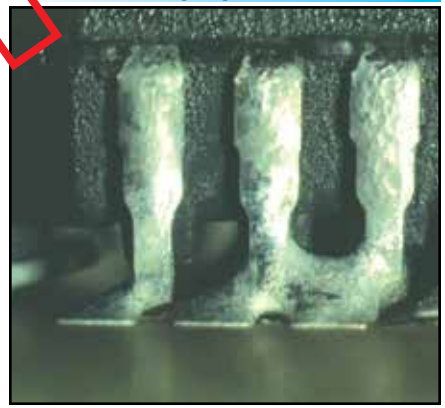


Solder Bridging

A connection of solder across conductors that should not be joined.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.7.2,
Fig. 5-35

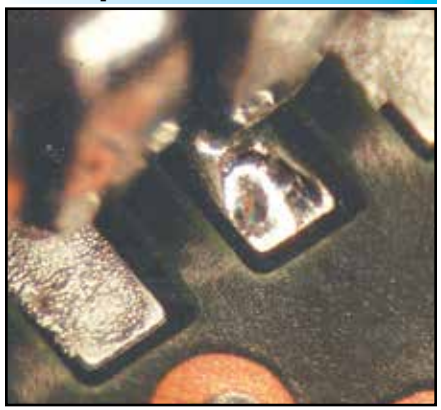


Incomplete Reflow

The solder paste had insufficient heat to reflow properly.

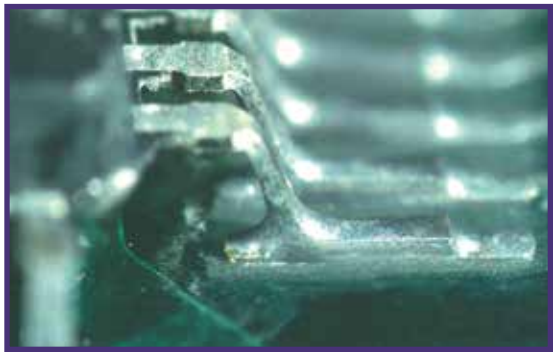
Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.3,
Fig. 5-14



Gull Wing Components • Class 1

Target Condition

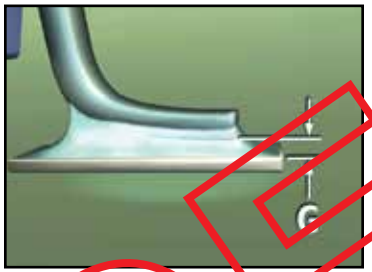


This photo represents an **ideal** surface mount solder joint for any class of Gull Wing component.

Notes: *Solder joints are semi-transparent to show relationship between land and lead. Side Overhang, Dimension* ***(A),*** *must not violate minimum electrical clearance. The references below are applicable to the dimensional criteria for Gull Wing components.*

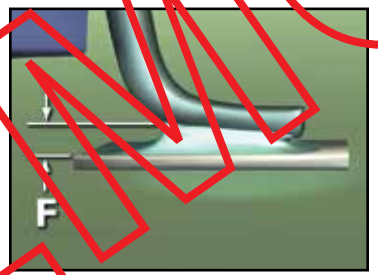
References: A-610F: 8.3.5, Table 8-5; 8.3.5.1 through 8.3.5.7

Acceptance Criteria



Solder Thickness (G)

The **minimum** distance between the land and component lead is **not specified**. Only a properly wetted fillet must be evident.



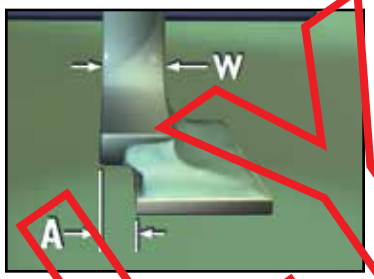
Heel Fillet Height (F)

There is no **minimum** fillet height requirement. Only a properly wetted fillet must be evident.

Acceptance Criteria

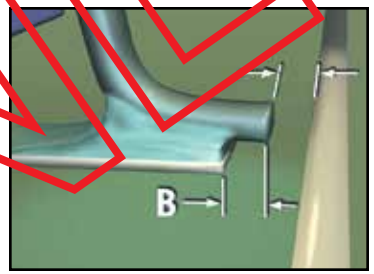
Side Overhang (A)

The component lead may overhang the side of the land a **maximum** of 50% lead width **(W)**, or 0.5 mm (0.02 in.), whichever is less.



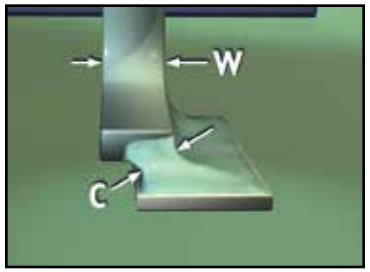
Toe Overhang (B)

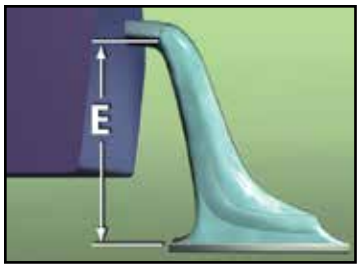
The end or tip of the lead extending over the edge of the land must not violate minimum electrical clearance as a **maximum** condition.



End Joint Width (C)

The width of the solder joint at its narrowest point needs to be at least 50% lead width **(W)**, as a **minimum** requirement.

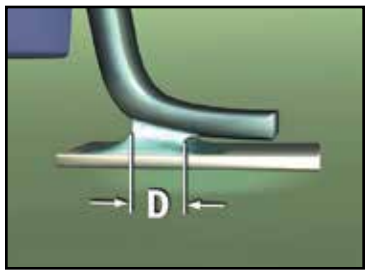




Heel Fillet Height (E)

Solder may extend to the top bend of the lead, or knee, but **not touch** the component body or end seal as a **maximum** fillet height.

Note: *Solder may touch the body of a plastic SOIC (family of components).*



Side Joint Length (D)

The length of the solder joint at its narrowest point, must be a **minimum** of the lead width **(W)**, or 0.5 mm (0.02 in.), whichever is less.

Gull Wing Components • Class 2

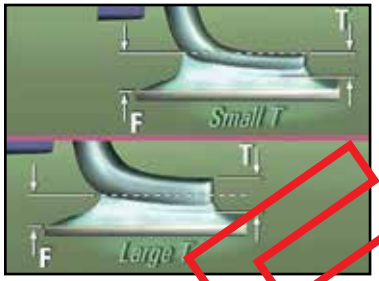
Target Condition

This photo represents an **ideal** surface mount solder joint for any class of Gull Wing component.

Notes: *Solder joints are semi-transparent to show relationship between land and lead. Side Overhang, Dimension* **(A),** *must not violate minimum electrical clearance. Solder Thickness, or Dimension* **(G)** *is not specified for Class 2, only a properly wetted fillet must be evident. Please see Gull Wing, Class 1, for Dim.* **(G)** *picture. The references below are applicable to the dimensional criteria for Gull Wing components.*

References: A-610F: 8.3.5, Table 8-5; 8.3.5.1 through 8.3.5.7

Acceptance Criteria

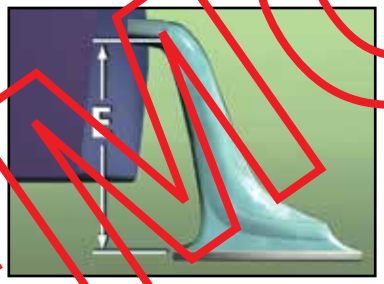


Heel Fillet Height (F)

Small T: Where lead thickness **(T)** is 0.4 mm or less, **minimum** heel fillet height is equal to **(T)*** measured at the toe.

Large T: Where **(T)** is greater than 0.4 mm, Dim. **F** is a **minimum** of 50% **(T)***.

Including any measurement for solder thickness* *(G)****.*



Heel Fillet Height (E)

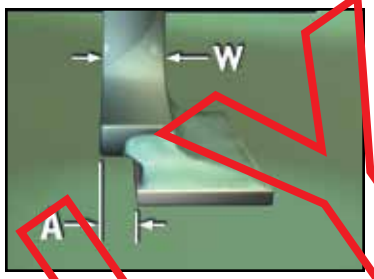
Solder may extend to the top bend of the lead, or knee, but **not touch** the component body or end seal as a **maximum** fillet height.

Note: *Solder may touch the body of a plastic SOIC (family of components).*

Acceptance Criteria

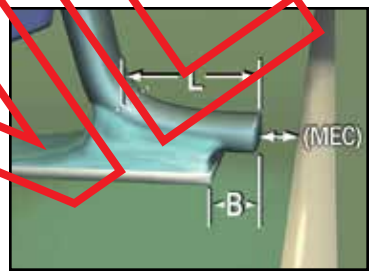
Side Overhang (A)

The component lead may overhang the side of the land a **maximum** of 50% lead width **(W)**, or 0.5 mm (0.02 in.), whichever is less.



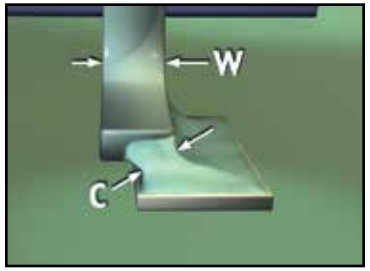
Toe Overhang (B)

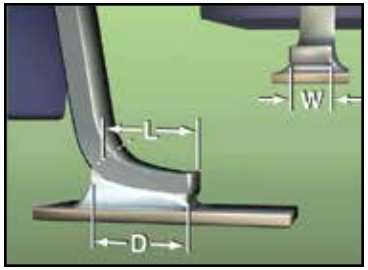
If foot length **(L)** is greater than 3 land widths **(W)**, then the tip of the lead extending over the edge of the land must not violate minimum electrical clearance **(MEC)** as a **maximum** condition. If **(L)** is less than 3 **(W)**, any amount of toe overhang is a defect.



End Joint Width (C)

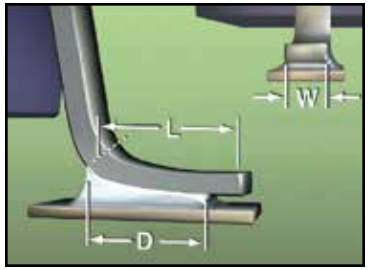
The width of the solder joint at its narrowest point needs to be at least 50% lead width **(W)**, as a **minimum** requirement.





Side Joint Length (D)

Short Foot—If foot length **(L)** is less than 3 **(W)**, then **minimum (D)** is 100% **(L)**.

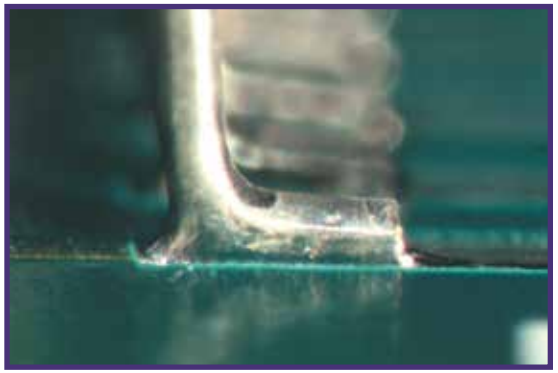


Side Joint Length (D)

Long Foot—When foot length **(L)** is equal to or greater than three lead widths **(W)**, side joint length **(D)** must be a **minimum** of 3 **(W)** or 75% **(L)**, whichever is longer.

Gull Wing Components • Class 3

Target Condition

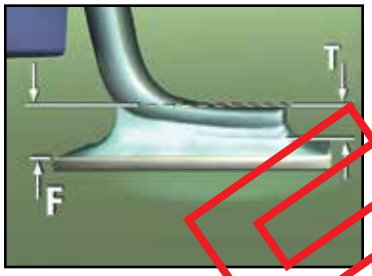


This photo represents an **ideal** surface mount solder joint for any class of Gull Wing component.

Notes: *Solder joints are semi-transparent to show relationship between land and lead. Side Overhang, Dimension* **(A),** *must not violate minimum electrical clearance. Solder Thickness, or Dimension* **(G)** *is not specified for Class 3, only a properly wetted fillet must be evident. Please see Gull Wing, Class 1, for Dim.* **(G)** *picture. The references below are applicable to the dimensional criteria for Gull Wing components.*

References: A-610F: 8.3.5, Table 8-5; 8.3.5.1 through 8.3.5.7

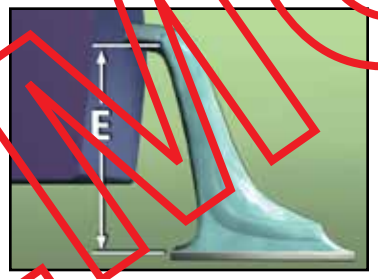
Acceptance Criteria



Heel Fillet Height (F)

The **minimum** heel fillet height must be at least as high as Lead Thickness **(T)*** at connection side.

Including any measurement for solder thickness **(G).*



Heel Fillet Height (E)

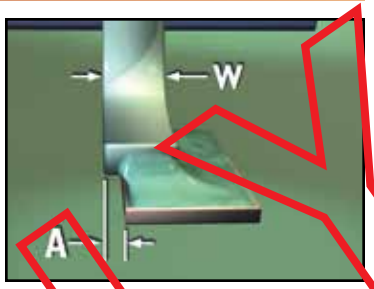
Solder may extend to the top bend of the lead, or knee, but **not touch** the component body or end seal as a **maximum** fillet height.

Note: *Solder may touch the body of a plastic SOIC (family of components).*

Acceptance Criteria

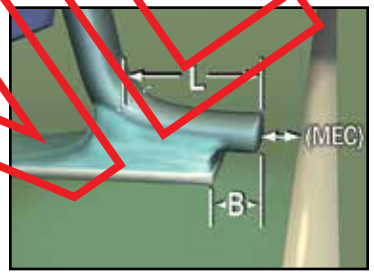
Side Overhang (A)

The component lead may overhang the side of the land a **maximum** of 25% lead width **(W)**, or 0.5 mm (0.02 in.), whichever is less.



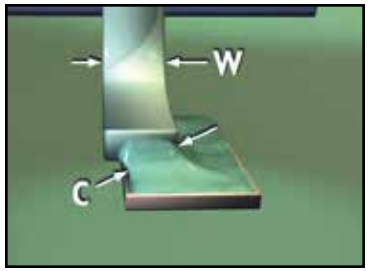
Toe Overhang (B)

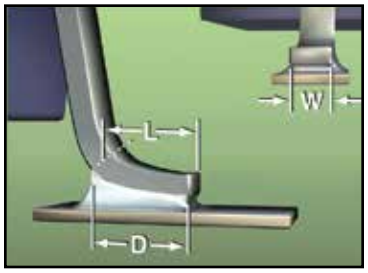
If foot length **(L)** is greater than 3 land widths **(W)**, then the tip of the lead extending over the edge of the land must not violate minimum electrical clearance **(MEC)** as a **maximum** condition. If **(L)** is less than 3 **(W)**, any amount of toe overhang is a defect.



End Joint Width (C)

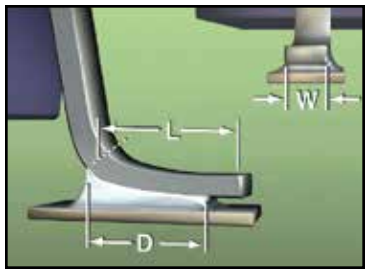
The width of the solder joint at its narrowest point needs to be at least 75% lead width **(W)**, as a **minimum** requirement.





Side Joint Length (D)

Short Foot—If foot length **(L)** is less than 3 **(W),** then **minimum (D)** is 100% **(L)**.



Side Joint Length (D)

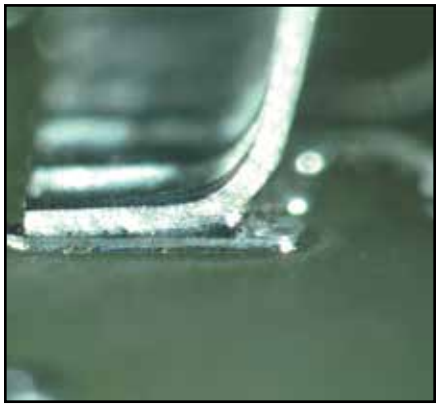
Long Foot—When foot length **(L)** is equal to or greater than three lead widths **(W)**, side joint length **(D)** must be a **minimum** of 3 **(W)** or 75% **(L)**, whichever is longer.

Gull Wing Solder Conditions

The following pages show photographs of some of the major solder defects and process indicators for surface mounted Gull Wing components.

These examples each contain a description as well as a reference to the appropriate section in the IPC-A-610F.

Insufficient Solder

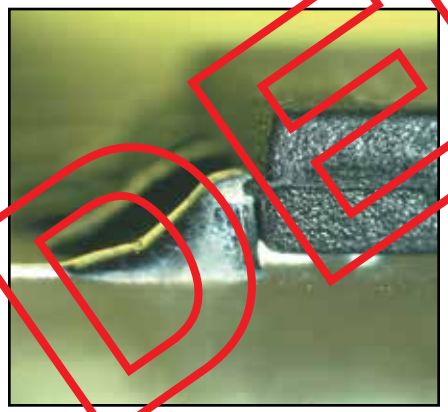


Solder fails to meet minimum heel fillet height. No evidence of properly wetted fillet.

Defect, Class 1, 2, 3

Reference
A-610: Section 8.3.5.6

Excess Solder



Solder touches body of plastic SOIC (family of components).

Acceptable, Class 1, 2, 3

Notes: *Solder that touches the body of a ceramic or metal component is a Defect Class 1, 2, 3. Solder that touches the body of a plastic component outside the SOIC family, is Acceptable Class 1, Defect Class 2, 3.*

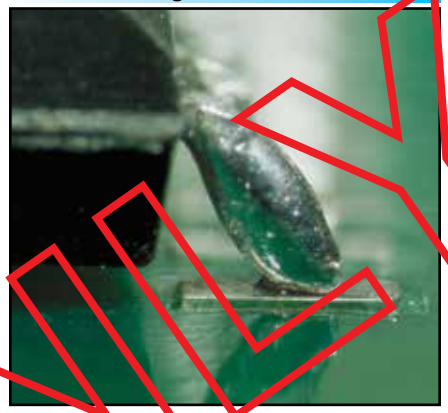
Reference
A-610: Section 8.3.5.5

Nonwetting

Solder has not adhered to the land or termination. No metallic bond.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.4

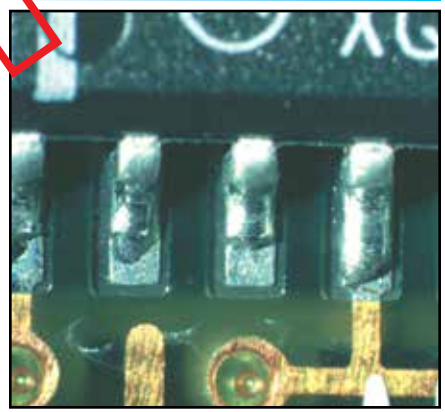


Dewetting

Molten solder coats surface then pulls back, leaving only a thin film of solder covering the land in some areas, and irregular mounds of solder in others.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.6



Disturbed Joint

Characterized by uneven surface from movement in the joint while cooling.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.8

Lead Free Joint

Lead free solder joints typically have a grainy or dull appearance.

Acceptable, Class 1, 2, 3

Reference
A 610: Section 5.1

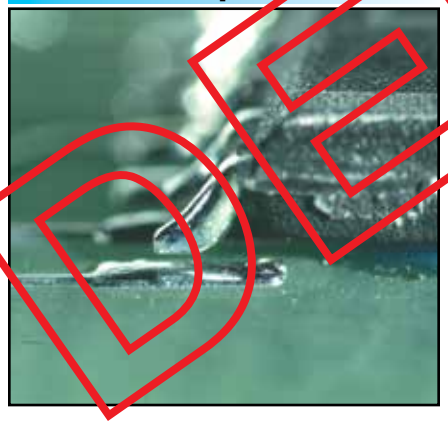
Fractured/Cracked Joint

Fractured or cracked solder joint.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.9

Open Connection

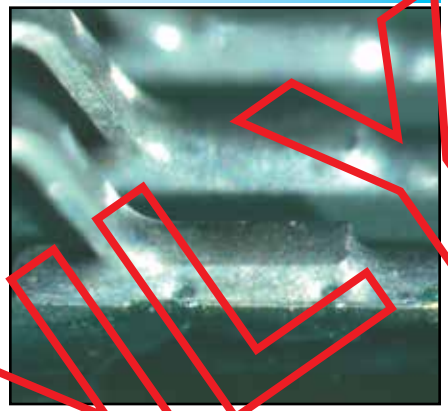


One lead, or series of leads on a component, is out of alignment (coplanarity), and prevents formation of a proper solder joint.

Defect, Class 1, 2, 3

Reference
A-610: Section 8.3.5.8

Pinholes

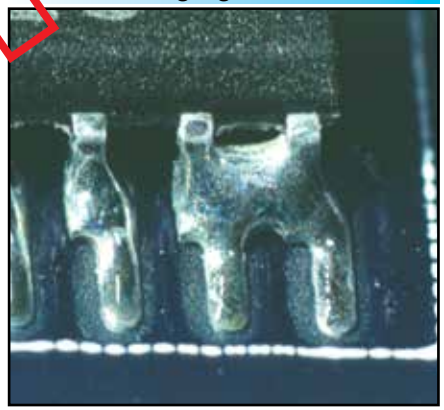


An escape of air or gas (outgassing) during the soldering process through tiny "pin" holes. Allowable condition as long as minimum soldering requirements have been met.

Acceptable Class 1
Process Indicator
Class 2, 3

Reference
A-610: Section 5.2.2, Fig. 5-12

Solder Bridging

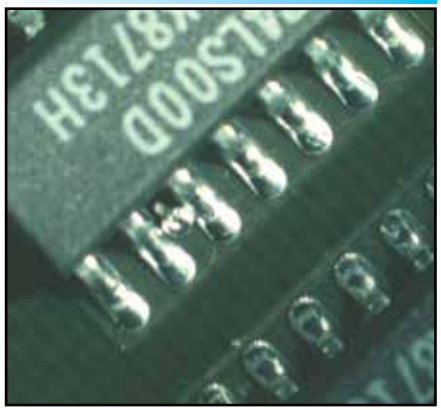


A connection of solder across conductors that should not be joined.

Defect, Class 1, 2, 3

Reference
A-610: Section 5.2.7.2

Solder Balls



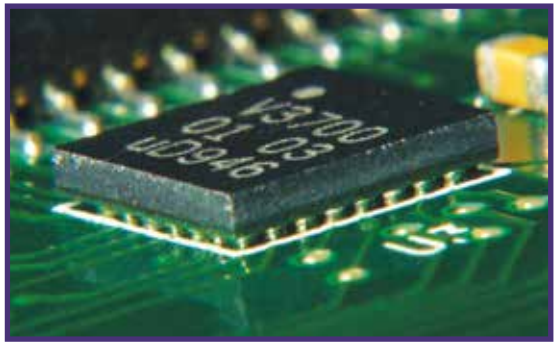
Any balls of solder that are not entrapped in a permanent coating, or attached to a metal contact, or violate minimum electrical clearance requirements.

Defect, Class 1, 2, 3

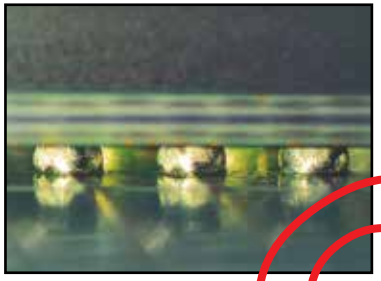
Reference
A-610: Section 5.2.7.1, Fig. 5-31

Ball Grid Arrays (BGA) • Class 1, 2, 3

Target Condition



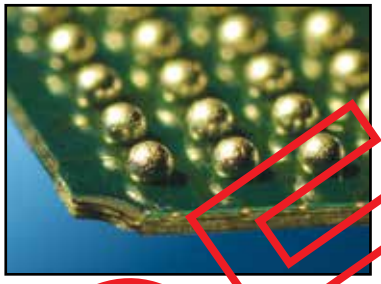
Shows **target** solder connections along the perimeter (visible) row underneath a BGA.



Note the complete wetting of the solder balls to the land, forming continuous, evenly rounded and evenly spaced connections.

References:
A-610F: 8.3.12 See Table 8-13 for Collapsing Balls. For Non-Collapsing Balls: Table 8-14, and the latest amendment to A-610F.

Acceptance Criteria



Solder Balls

BGA components come with various land patterns, but all include circular solder balls that are pre-formed onto the lands of the BGA. Once soldered onto the board only the external row of solder balls may be visible.

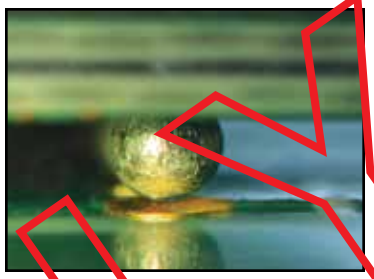
Misalignment

Visual registration between existing *legends* on the surface of the board and the BGA component outline should not be uneven or misaligned. This is only a **defect** if the solder ball *offsets* violate minimum electrical clearance.

Acceptance Criteria

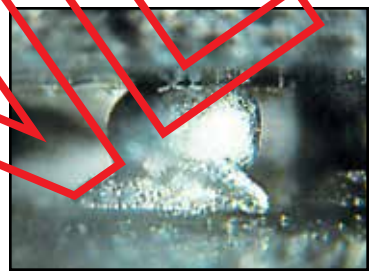
Non-wetting

Solder joints that are not wetted to either the lands on the board or the component are considered a **defect** for Classes 1-3.



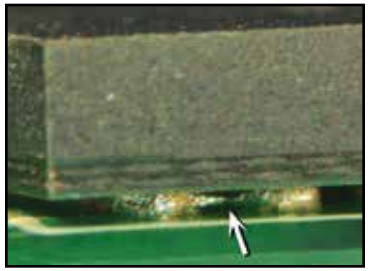
Incomplete Wetting

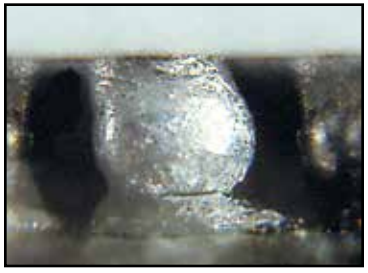
Solder balls that have reflowed but are not wetted to the land are considered a **defect** for all classes of products. This is also called "head in pillow" because of the visual similarity.



Solder Bridging

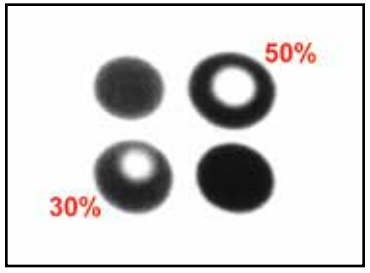
Visual or X-Ray evidence of solder bridging is a **defect** for any class of product.





Fractures

Complete or partial cracks in the solder balls are considered a **defect** for all three classes.



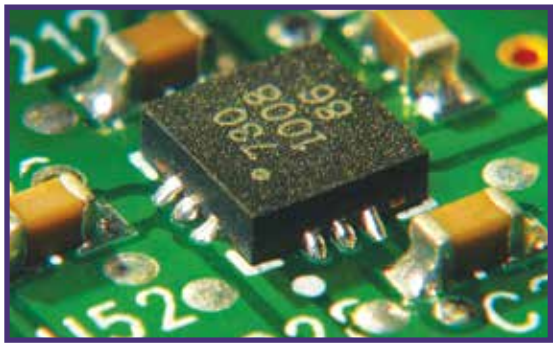
Voids

Light areas on X-Rays within an individual ball indicate voiding. More than 30% voiding of any collapsable solder ball in the X-Ray image is a **defect** for Classes 1-3.

Photos
Class 3
Class 2
Class 1
Gull Wing Components
J-Lead Components
Chip Components
Area Array Components

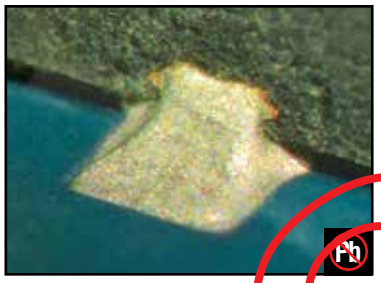
Bottom Termination (BTC) • Class 1, 2, 3

Target Condition



Wetting of QFN terminations and lands is evident.

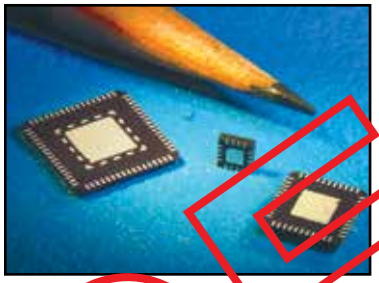
Alignment is accurate and evenly spaced.



Shows **target** solder connection for BTC. Note concave solder fillet with complete wetting to the top of the toe termination.

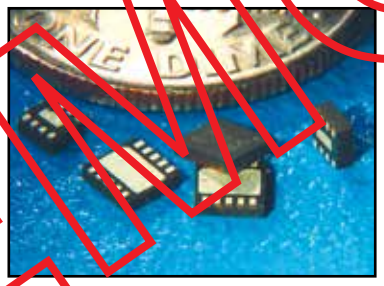
References:
A-610F: 8.3.13, Table 8-16

Component Types



QFN Components

Commonly called QFN or Quad Flat No Lead. Terminations typically extend from underneath the component to the outside perimeter on all four sides.



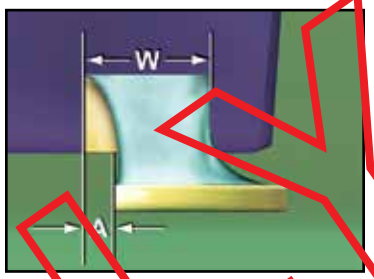
DFN Components

Commonly called DFN or Dual Flat No-Lead. Terminations typically extend from underneath the component to the outside perimeter — projecting from two sides only.

Acceptance Criteria

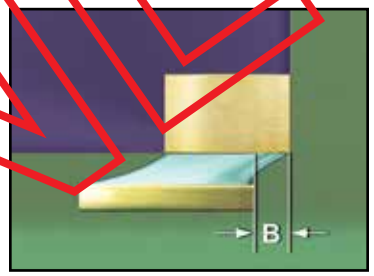
Side Overhang (A)

Overhang is a **maximum** of 50% the width of the toe/termination **(W)** for Class 1, and 25% **(W)** as a **maximum** for Class 2, 3 (as shown).



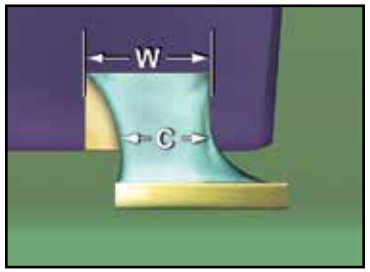
Toe Overhang (B)

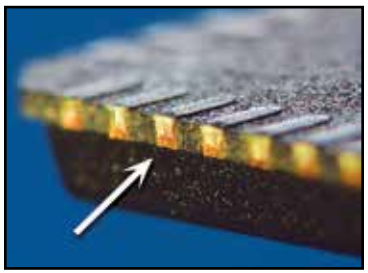
Any amount of toe overhang **(B)** is a **defect** for Class 1, 2, 3 (as shown in cross section view).



End Joint Width (C)

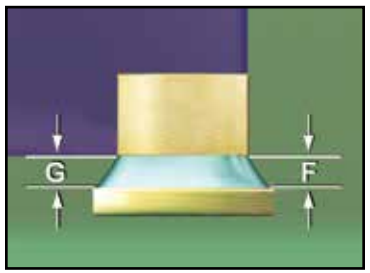
The **minimum** width of the solder joint **(C)** must be at least 50% of the termination width **(W)** for Class 1. 75% of the toe width **(W)** is the **minimum** for Class 2-3 (as shown).





Toe Terminations

Both QFN and DFN components typically have a *toe termination* that extends out to the edge of the component.



Toe (End) Fillet Height (F)

The solder fillet **(F) does not** need to extend up onto the face of the toe or end of the termination. Evidence of wetting between the land and termination **(G)** is the **minimum** requirement for fillet height.

Photos
Class 3
Class 2
Class 1
Gull Wing Components
J-Lead Components
Chip Components
Area Array Components

This reference guide does not take precedence over, or replace the requirements from any IPC Standard or Specification. While every effort has been made to represent applicable portions of the IPC-A-610F document, this guide may not cover all related requirements and is not intended for use as an industry consensus standard. IPC disclaims any warranties or guarantees, expressed or implied, and shall not be held liable for damages of any kind in connection with the information set forth in DRM-SMT-F.

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