THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS

Discrete components are the backbone of the electronics world, consisting of individually packaged, leaded devices, highly integrated circuits (IC), interconnects, terminators, switches, etc.

While discretes are rapidly being displaced by the smaller-form surface mount technology (SMT) package, the discrete component is still widely in use, especially in extreme environmental applications where the SMT device will not perform reliability and/or is unavailable.

GENERAL REQUIREMENTS

Components are installed per engineering documentation and are parallel to, and in contact with, the board surface. Component and board markings are clear and legible. Component leads exhibit proper bend radii and stress relief. Solder fillets are smooth and shiny with concave profiles.

PREFERRED
100% SOLDER FILL (PTH)

Populated plated through holes (PTH) should exhibit a vertical solder fill of 100%, with a fully formed fillet on the solder side, and evidence of 100% wetting on the component side lead, barrel and pad.

Best Workmanship Practice

PREFERRED
PWB COMPONENT SIDE FILLET (PTH)

The solder joint surface is smooth, nonporous and undisturbed, with a finish varying from satin to bright. The fillet completely wets all elements to the periphery of the connection and is concave.

NASA-STD-8739.3 [13.6.1.f.2]

PREFERRED
SOLDER SIDE FILLETS (PTH/NPTH)

The solder joint surfaces are smooth, nonporous and undisturbed, with a finish varying from satin to bright. The fillet completely wets all elements of the connection and is concave.

NASA-STD-8739.3 [13.6.1.f.1]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

PREFERRED
HEAT PRODUCING PARTS

Parts which dissipate heat in quantities of 1 Watt or greater, or in quantities sufficient to damage the laminate shall be mounted with sufficient standoff [≥ 1.5mm (0.060 in.)] and shall be mechanically restrained.

Best Workmanship Practice

PREFERRED
HIGH-MASS COMPONENTS

Components weighing in excess of 7 g (0.25 oz.) total, or 3.5 gm (0.12 oz.) per lead, shall be mechanically secured to the mounting surface by at least 4 evenly spaced bonds, when no other mechancial support is used.

Best Workmanship Practice

PREFERRED
WIRE/LEAD INSULATION GAP (MINIMUM)

The insulation shall not be imbedded in the solder joint. The contour of the conductor shall not be obscured at the termination end of the insulation.

NASA-STD-8739.3 [9.1.1]

PREFERRED
WIRE/LEAD INSULATION GAP (MAXIMUM)

The termination exhibits a gap of less than two (2) insulated wire diameters (<2d) between the end of the insulation and the first point of contact of the conductor to the termination/pad.

NASA-STD-8739.3 [9.1.2]

ACCEPTABLE
ADHESIVES

Adhesives may be used to temporarily hold discrete components in position during wave or reflow soldering. Adhesives shall not interfere with soldering, and residues shall be removed following soldering operations.

Best Workmanship Practice

UNACCEPTABLE
ADHESIVE INCLUSION

Adhesive material in the solder joint shall be cause for rejection.

NASA-STD-8739.3 [13.6.2.b.10]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

ACCEPTABLE
CLINCHED LEAD TERMINATION

Conductor/lead ends may be clinched, with the clinched length at least 1/2 the largest solder pad dimension, bent in the direction of the longest pad dimension. Clinched leads shall not violate minimum electrical spacing requirements.

NASA-STD-8739.3 [8.5.2]

UNACCEPTABLE
IMPROPERLY CLINCHED LEAD

Component leads shall not be clinched toward an electrically uncommon conductor.

NASA-STD-8739.3 [13.6.2.a.20]

ACCEPTABLE
CONDUCTIVE CASE PARTS

Parts having conductive cases, which are mounted over printed conductors or which are in close proximity to other conductive materials shall be separated by insulation of suitable thickness, or shall have an insulating jacket/sleeve.

NASA-STD-8739.3 [8.1.2.b]

ACCEPTABLE
DEWETTING

Slight solder dewetting around the periphery of the component side termination pad shall not be cause for rejection, provided the termination exhibits flow-through and bonding of the lead/conductor to the termination pad.

NASA-STD-8739.3 [11.2.3.c]

ACCEPTABLE
EXPOSED BASE METAL

Exposed ends of leads on straight-through termination shall not be cause for rejection if the PWA is to be conformally coated.

NASA-STD-8739.3 [13.6.1.k]

UNACCEPTABLE
EXPOSED BASE METAL

Defects or damage (cuts, nicks, gouges, scrapes, etc.) that result in exposed base metal (except for the vertical edges of circuit traces, lands and pads) shall be rejectable.

NASA-STD-8739.3 [13.6.2.a.8], [13.6.2.c.5]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

ACCEPTABLE
EXPOSED BASE METAL (SPECIAL EXCEPTION)

Exposed base metal on the vertical edge of printed wiring conductors, lands and pads is acceptable.

NASA-STD-8739.3 [13.6.2.c.5]

ACCEPTABLE
FILLER WIRE USE

Interfacial connections in double-sided PWBs require the use of filler wire if the PWB coupon is not evaluated by construction analysis.

NASA-STD-8739.3 [13.6.2.a.24]

ACCEPTABLE
GLASS ENCASED PARTS

Glass encased parts shall be covered with transparent/translucent resilient sleeving (or other approved material) when epoxy is used for staking, conformal coating, encapsulating or where damage from other sources is likely.

NASA-STD-8739.3 [8.1.4]

UNACCEPTABLE
UNSLEEVED GLASS ENCASED PARTS

Glass encased parts shall be covered with transparent/translucent resilient sleeving (or other approved material) when epoxy is used for staking, conformal coating, encapsulating or where damage from other sources is likely.

NASA-STD-8739.3 [8.1.4], [13.6.2.a.12]

ACCEPTABLE
LEAD PROTRUSION LENGTH

Leads terminated straight through the PWB shall extend 0.5 mm (0.020 in.) to 2.29 mm (0.0900 in.) beyond the pad surface. Leads may be bend up to 30° from the vertical plane to retain the part during soldering.

NASA-STD-8739.3 [8.5.3]

UNACCEPTABLE
INSUFFIENCT LEAD PROTRUSION

Leads terminated straight through the PWB shall extend a minimum of 0.5 mm (0.020 in.) beyond the pad surface.

NASA-STD-8739.3 [13.6.2.a.21]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

ACCEPTABLE
INTERFACIAL CONNECTIONS/VIAS (MULTILAYER PWBs)

Interfacial connections (vias) in multilayer PWBs do not require the use of filler wire, and shall not be solder filled.

NASA-STD-8739.3 [11.2.4.b]

ACCEPTABLE
SOLDER-FILLED INTERFACIAL CONNECTIONS (PTH/VIAS)

No dedicated effort shall be expended to remove solder from unpopluated plated through holes (PTH) and/or vias.

NASA-STD-8739.3 [11.2.4]

ACCEPTABLE
MEASLING

Whitish, discrete spots or crosses below the laminate surface - usually induced by thermal shock/stress. Measling that bridges uncommon conductors is unacceptable.

NASA-STD-8739.3 [13.6.1.l], [13.6.2.c.3]

UNACCEPTABLE
MEASLING

Measling that bridges uncommon conductors is unacceptable.

NASA-STD-8739.3 [13.6.2.c.3]

ACCEPTABLE
NON-UNIFORM/UNEVEN FLOW (DEMARCATION LINES/FILLET SWIRLS)

A solder fillet exhibiting a nonuniform/ uneven profile, demarcation lines or swirls is acceptable, provided the fillet is shiny and there is evidence of complete wetting with smooth fillets at the swirls.

Best Workmanship Practice

UNACCEPTABLE
UNEVEN FLOW/REFLOW

A solder fillet exhibiting nonuniform/ uneven flow lines/swirls with hard demarcation lines (no fillet at swirl interfaces), and a dull finish are typically caused by an inadequate/uneven application of heat during the fillet formation.

Best Workmanship Practice

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

ACCEPTABLE
PART MARKINGS

Parts shall be mounted in such a manner that, at a minimum, the markings are visible in the following order of precedence: polarity, traceability/lot code (if applicable), part value, part number/type.

NASA-STD-8739.3 [8.1.3]

UNACCEPTABLE
IDENTIFICATION MARKS MISSING

The component (capacitor C47) has been mounted with the identification marks on the underside of the component body (against the circuit board), preventing visual confirmation that the correct value part is installed.

NASA-STD-8739.3 [8.1.3]

ACCEPTABLE
PITS

A solder pit is acceptable, provided the bottom of the cavity can be seen from all angles of vision.

Best Workmanship Practice

ACCEPTABLE
SHRINK TUBING (TRANSLUCENT/TRANSPARENT)

Shrink tubing installed over components and/or soldered terminations shall be transparent (or translucent) to allow visual inspection.

NASA-STD-8739.3 [8.1.4]

ACCEPTABLE
SMOOTH TOOL IMPRESSION MARKS

Smooth tool impression marks (slight cuts, nicks, scratch or scrapes) on the conductor surface, which do not expose base metal or reduce cross-sectional area are acceptable.

NASA-STD-8739.3 [8.1.6.d]

ACCEPTABLE
SOLDER FILLET RECESS/SHRINKBACK

A slight recessing or shrinkback of the solder into the PTH below the solder pad is acceptable, providing the lead and pad exhibit wetting and the shrinkback is slight.

NASA-STD-8739.3 [13.6.1.f.2]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

ACCEPTABLE
SOLDER IN STRESS RELIEF BEND

Solder which extends into the stress relief bend of any leaded part shall not be cause for rejection if the topside bend radius is discernable, and if the solder does not extend within one (1) lead diameter of the part or end seal.

NASA-STD-8739.3 [13.6.2.b.6]

UNACCEPTABLE
SOLDER IN STRESS RELIEF BEND

Solder extends into the stress relief bend and contacts the part body end seal. The topside of the lead is not discernable.

NASA-STD-8739.3 [13.6.2.b.6]

ACCEPTABLE
TEMPERED LEADS

Tempered/hardened leads (sometimes referred to as pins) shall not be bent or formed for mounting purposes since body seals and connections internal to the part may be damaged.

NASA-STD-8739.3 [8.1.6.e]

UNACCEPTABLE
BENT TEMPERED LEADS

Tempered/hardened leads (sometimes referred to as pins) shall not be bent or formed.

NASA-STD-8739.3 [8.1.6.e]

UNACCEPTABLE
BLOWHOLE

Blowholes are typically caused by trapped gases or flux during the formation of the solder fillet, and are unacceptable.

NASA-STD-8739.3 [13.6.2.b.5]

UNACCEPTABLE
BRIDGING

Bridging is an indicator of poor process controls (i.e.: excess solder, smeared paste, improper placement, incorrect heat).

NASA-STD-8739.3 [13.6.2.c.4]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (CONT.)

UNACCEPTABLE
CHARRING

Charring of components and/or laminate is an indicator or poor process control (i.e.: excessive heat).

NASA-STD-8739.3 [13.6.2.a.7]

UNACCEPTABLE
CHIP-OUTS (NICKS)

The use of parts with chips in the component body, termination area or meniscus, is prohibited.

NASA-STD-8739.3 [13.6.2.a.7]

UNACCEPTABLE
COLD SOLDER JOINT

A cold solder joint is an indicator of incorrect process control (i.e.: inadequate heat).

NASA-STD-8739.3 [13.6.2.b.1]

UNACCEPTABLE
CONTAMINATION

Contamination is a reliability concern.

NASA-STD-8739.3 [13.6.2.b.10]

UNACCEPTABLE
COPLANARITY

Improper coplanarity of leaded parts will result in bridging, shorts, opens and/or misalignment. Part leads shall be reworked (if allowed) prior to installation.

NASA-STD-8739.3 [13.6.2.a.5]

UNACCEPTABLE
CRACKS (COMPONENT)

Cracks (especially in ceramic components) are an indicator of poor process control (i.e.: improper preheat, thermal/ mechanical shock, etc.).

NASA-STD-8739.3 [13.6.2.a.7]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

UNACCEPTABLE
CRACKS (LAMINATE)

Cracks in the laminate are cause for rejection.

Best Workmanship Practice

UNACCEPTABLE
CRACKS (SOLDER FILLET)

Cracks or fractures in the solder fillet are an indication of mechanical/thermal shock, or temperature coefficient mismatch.

NASA-STD-8739.3 [13.6.2.b.3]

UNACCEPTABLE
DAMAGED PART SEAL

Parts with damaged seals shall not be used.

NASA-STD-8739.3 [13.6.2.a.7]

UNACCEPTABLE
DEWETTING

Dewetting is caused when molten solder coats a surface and then recedes, leaving irregulary-shaped solder deposits separated by areas covered by a thin solder film.

NASA-STD-8739.3 [13.6.2.b.11]

UNACCEPTABLE
DISCOLORED LAMINATE (BURNS)

Burns that physically damage the laminate surface of the assembly are not allowed. Slight discoloration is allowable.

NASA-STD-8739.3 [13.6.2.c.2]

UNACCEPTABLE
DISCOLORED LAMINATE (OVERHEATING)

A browning/darkening of the laminate because of excess heat; an indicator of improper process control/ thermal design.

NASA-STD-8739.3 [13.6.2.c.3]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

UNACCEPTABLE
DISTURBED SOLDER

A disturbed solder joint is characterized by the appearance that there was motion between the metals being joined while the molten solder was solidifying.

NASA-STD-8739.3 [13.6.2.b.3]

UNACCEPTABLE
EXCESS SOLDER

The solder fillet shall exhibit a positive wetting angle and shall not contact the component body.

NASA-STD-8739.3 [13.6.2.b.6]

UNACCEPTABLE
EXCESS SOLDER/SOLDER FLOODING

Excess solder/Solder flooding is an indicator of improper/incorrect process controls, and is typically seen in wave soldering.

NASA-STD-8739.3 [13.6.2.b.6]

UNACCEPTABLE
EXCESSIVE LEAD PROTRUSION

Leads terminated straight through the PWB shall extend a maximum of 2.29 mm (0.090 in.) beyond the pad surface. Leads may not violate minimum electrical spacing requirements.

NASA-STD-8739.3 [13.6.2.a.21]

UNACCEPTABLE
EXPOSED DIE/CIRCUIT ELEMENTS

The unprotected exposure of die or circuit elements is not allowed unless specified in the engineering documentation.

NASA-STD-8739.3 [13.6.2.a.7]

UNACCEPTABLE
EYELETS

Eyelets shall not be used for interfacial terminations.

Best Workmanship Practice

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

UNACCEPTABLE
FLUX RESIDUE

Flux residue indicates improper/ incomplete cleaning.

NASA-STD-8739.3 [13.6.2.b.10]

UNACCEPTABLE
FLUX SPLATTER

Flux splatter is an indication of an improper process parameter (heat/moisture).

NASA-STD-8739.3 [13.6.2.b.8]

UNACCEPTABLE
FRACTURED SOLDER

A fractured solder joint is an indication that the joint has been subjected to extreme mechanical shock. A crack in an "as-received" assembly is unusual and cause for concern.

NASA-STD-8739.3 [13.6.2.b.3]

UNACCEPTABLE
GOLD INTERMETALLIC

Gold intermetallic is characterized by evidence of golden colored streaks in the solder fillets of gold plated leads that have not been properly tinned. Gold intermetallic can severly embrittle a solder joint.

Best Workmanship Practice

UNACCEPTABLE
GOLD PLATING

Gold plated surfaces that will become part of the finished solder connection shall be tinned prior to soldering to remove the gold plating.

NASA-STD-8739.3 [7.2.5.c],[13.6.2.a.3]

UNACCEPTABLE
HOLE OBSTRUCTION

The mounting pad has been installed upside down. Parts shall not be mounted such that they obstruct solder flow to the component-side termination area (pad) or prevent cleaning and inspection.

NASA-STD-8739.3 [8.4.4]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

UNACCEPTABLE
IMPROPER LEAD BENDING

The minimum distance from the part body/seal to the start of the bend shall be 2 lead diameters for round leads and 0.5 mm (0.020) for ribbon leads. The bend radius shall not be less than one lead diameter (1 d) or ribbon thickness (1 t).

NASA-STD-8739.3 [8.1.6.a]

UNACCEPTABLE
IMPROPER LEAD CUTTING

Leads shall be cut per engineering documentation and by methods, which do not impart stress to the lead seal or internal terminations.

NASA-STD-8739.3 [8.1.6.a]

UNACCEPTABLE
IMPROPER LEAD LENGTH

The clinched lead extends beyond the pad edge in excess of allowed limits and is bent over an uncommon electrical conductor.

NASA-STD-8739.3 [13.6.2.a.20]

UNACCEPTABLE
IMPROPER ORIENTATION

Parts shall be mounted parallel to the laminate surface, right side up and aligned to the lands within design and engineering specifications.

NASA-STD-8739.3 [13.6.2.a.5]

UNACCEPTABLE
IMPROPER TINNING

Tinned surfaces, which are to become part of the solder termination, shall exhibit 100% coverage.

NASA-STD-8739.3 [7.2.6],[13.6.2.a.3]

UNACCEPTABLE
INSUFFICIENT SOLDER

Insufficient solder is an indicator or improper process control, and may result in reduced reliability.

NASA-STD-8739.3 [13.6.2.b.7]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

UNACCEPTABLE
INSUFFICIENT STRESS RELIEF/LEAD BEND

Lead is improperly bent, placing strain on the weld bead. Conductors and part leads shall have sufficient stress relief to prevent damage to the solder termination and/or part.

NASA-STD-8739.3 [13.6.2.a.10]

UNACCEPTABLE
MENISCUS CONTACT

Parts exhibiting contact with, or embedment of the meniscus and the solder joint, shall be rejected.

NASA-STD-8739.3 [8.1.7], [13.6.2.b.13]

UNACCEPTABLE
NICKS

The use of parts with nicks in the component body or termination area is prohibited.

NASA-STD-8739.3 [13.6.2.a.7]

UNACCEPTABLE
NONWETTING

Nonwetting results in the solder forming a ball or beading on the termination surface. The fillet is convex; no feathered edge is apparent.

NASA-STD-8739.3 [13.6.2.b.12]

UNACCEPTABLE
NO FLOW/REFLOW

The lack of flow/reflow of solder is an indicator of poor process control or layout design (i.e.: inadequate heat, shadowing).

NASA-STD-8739.3 [13.6.2.b.1]

UNACCEPTABLE
NO SOLDER

The lack of solder is an indicator of poor process control.

NASA-STD-8739.3 [13.6.2.b.7]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

UNACCEPTABLE
OBSCURED SOLDER TERMINATIONS

The placement of a part, which obscures the inspectability of another part's terminations, is unacceptable, unless interim inspection is performed (part depicted is mounted over previously installed surface mount components).

NASA-STD-8739.3 [13.6.2.a.23]

UNACCEPTABLE
OPENS/VOIDS

Cavities (opens/voids) reduce the circumferential wetting of lead and barrel, land coverage and vertical solder fill below minimum acceptable requirements.

NASA-STD-8739.3 [13.6.2.b.5]

UNACCEPTABLE
OVERHEATED SOLDER

Overheated solder has a dull, gray, frosty and/or crystallized appearance and is the result of excessive exposure to heat.

NASA-STD-8739.3 [13.6.2.b.2]

UNACCEPTABLE
PART BODY CONTACT

Part bodies shall not be in contact with soldered terminations. The spacing between components is below recommended values, resulting in contact between the resistor body and the lead, which may eventually result in a short circuit.

NASA-STD-8739.3 [8.1.7], [13.6.2.b.13]

UNACCEPTABLE
PART LEADS USED AS TERMINALS

Part leads shall not be used as terminals, unless the part lead is designed to function as a terminal.

NASA-STD-8739.3 [13.6.2.a.18]

UNACCEPTABLE
PART MISALIGNMENT

Part misalignment is an indicator of improper process control.

NASA-STD-8739.3 [13.6.2.a.5]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

UNACCEPTABLE
PIGGYBACKED PARTS

The piggybacking of parts not designed specifically for that configuration is prohibited.

Best Workmanship Practice

UNACCEPTABLE
PINHOLE

Pinholes are typically small holes in the solder surface, leading to a void of indeterminate size within the solder termination.

NASA-STD-8739.3 [13.6.2.b.5]

UNACCEPTABLE
POOR WETTING

Poor wetting is an indicator of poor solderability, improper flux or contamination.

NASA-STD-8739.3 [13.6.2.b.4]

UNACCEPTABLE
POPCORNING

Popcorning is caused by the release of entrapped moisture during the soldering process.

Best Workmanship Practice

UNACCEPTABLE
POROUS SOLDER

Porous solder exhibits an uneven surface and a spongy appearance that may contain a concentration of small pinholes and voids.

Best Workmanship Practice

UNACCEPTABLE
ROSIN SOLDER JOINT

A rosin solder joint is similar in appearance to a cold solder joint, but exhibits evidence of entrapped flux in the fillet and at the surfaces to be joined.

NASA-STD-8739.3 [13.6.2.b.9]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

UNACCEPTABLE
SCRATCHES (SOLDER FILLET)

Scratches in the solder are prohibited.

NASA-STD-8739.3 [13.6.2.b.3]

UNACCEPTABLE
SOLDER BALLS

Solder balls are considered a contaminant and are an inedciation of improper process control (inadequate preheat) and/or the use of outdated solder/flux.

NASA-STD-8739.3 [13.6.2.b.10]

UNACCEPTABLE
SOLDER PEAKS, ICICLES, SHARP EDGES

Solder peaks, icicles and/or sharp edges are an indicator of an improper process parameter and are a reliability and short-circuit concern.

NASA-STD-8739.3 [13.6.2.c.4]

UNACCEPTABLE
SOLDER SKIPS

Solder skip is the random non-formation of solder fillets, and is an indicator of poor process control. Solder skip may be caused by insufficient solder, contamination, non-solderability (oxide), improper flux, solder thieving, etc.

NASA-STD-8739.3 [13.6.2.b.7]

UNACCEPTABLE
SOLDER SLIVERS

Solder slivers are an indication of improper process control.

NASA-STD-8739.3 [13.6.2.c.4]

UNACCEPTABLE
SOLDER SPLATTER

Solder splatter is typically caused by moisture contamination and is an indicator of poor process control.

NASA-STD-8739.3 [13.6.2.b.8]

THROUGH-HOLE SOLDERING GENERAL REQUIREMENTS (cont.)

UNACCEPTABLE
SOLDER WEBBING

Webbing is an indication of improper process control.

NASA-STD-8739.3 [13.6.2.c.4]

UNACCEPTABLE
SPLICED CONDUCTORS/LEADS

Splices shall not be used to repair broken or damaged conductors or part leads.

NASA-STD-8739.3 [8.1.8], [13.6.2.a.16]

UNACCEPTABLE
VOIDS

Voids are an indication of improper process control, and are typically caused by insufficient solder, solder wicking/thieving or contamination.

NASA-STD-8739.3 [13.6.2.b.5]

UNACCEPTABLE
WHISKER

A whisker is a slender needle-shaped metallic growth between a conductor and a land. Typically the result of mechanical stresses in high tin compounds, it is a reliability concern.

Best Workmanship Practice

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