INTERNATIONAL STANDARD

IEC 60748-23-2

QC 165000-2

First edition
2002-05

Semiconductor devices –
Integrated circuits –

Part 23-2:
Hybrid integrated circuits and film structures –
Manufacturing line certification –
Internal visual inspection and special tests

Dispositifs à semiconducteurs –
Circuits intégrés –

Partie 23-2:
Circuits intégrés hybrides et structures par films –
Certification de la ligne de fabrication –
Contrôle visuel interne et essais spéciaux

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES – INTEGRATED CIRCUITS –

Part 23-2: Hybrid integrated circuits and film structures – Manufacturing line certification – Internal visual inspection and special tests

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60748-23-2 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

The text of this standard is based on the European standard EN 165000-2 and the following documents:

FDIS	Report on voting
47A/639/FDIS	47A/650/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

IEC 60748-23-2 should be read in conjunction with Parts 23-1, 23-3 and 23-4.

The QC number that appears on the front cover of this publication is the specification number in the IEC Quality Assessment System for Electronic Components (IECQ).

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

This set of specifications prescribes a set of procedures to be used by users and manufacturers for the production and delivery of high-quality, special requirement hybrid integrated circuits and film structures with a specified level of quality and reliability.

This set of specifications prescribes reference criteria for the establishment, control, maintenance and development of a certified manufacturing line and represents a manufacturing line certification methodology.

The targeted level of quality and reliability is to be achieved by using best design and manufacturing practices. Examples of quality and reliability best practices for elimination of potential failure mechanisms and achievement of a targeted quality and reliability level include: material characterization for derivation of process design rules, in-process control, continuous improvement, etc.

Assessment (estimation) of the targeted quality and reliability level may be accomplished by:

a) using data obtained from the material characterization, design and process control and improvement activities; or

b) through the use of product assessment level schedule (PALS) tests.

Part 23-1 of this set of specifications provides general information.

Part 23-3 of this set of specifications provides a framework for use as an assessment/audit tool to assist the suppliers, customers or an independent organization to carry out an assessment of a certified manufacturing line of a hybrid manufacturing company.

Part 23-4 of this set of specifications provides a blank detail specification, which provides guidance to 'users' of hybrids for procurement purposes.

Part 23-5 of this set of specifications provides a means of quality assessment on the basis of qualification approval.

SEMICONDUCTOR DEVICES – INTEGRATED CIRCUITS –

Part 23-2: Hybrid integrated circuits and film structures – Manufacturing line certification – Internal visual inspection and special tests

1 Scope

This part of IEC 60748 applies to high quality approval systems for hybrid integrated circuits and film structures.

The purpose of the tests is to perform visual inspections on the internal materials, construction and workmanship of hybrid, multichip and multichip module microcircuits and passive elements used for microelectronic applications including r.f./microwave.

These tests are for both Class H and Class K quality levels, SAW and film hybrid/multichip/ multichip module microcircuits using substrates such as ceramic and silicon. Class K is applicable to all microcircuits released to product assessment level schedule 11 (e.g. for space applications – see IEC 60748-23-1). Class H is applicable to all other microcircuits released to this standard. The following types of microcircuits may be inspected:

a) passive thin and thick film networks;

b) active thin and thick film circuits;

c) multiple circuits, including combinations, stacking or other interconnections of 1 a) and 1 b).

Where the deposited film has geometric features larger than 25 µm, the inspection criteria defined in clause 5 apply. In cases where deposited features are smaller than this (e.g. deposited integrated circuits) the inspection requirements of IEC 60747 shall be applied.

These tests will normally be used on microelectronic devices prior to capping or encapsulation to detect and eliminate devices with internal non-conformances that could lead to device failure in normal application. They may also be employed on a sampling basis to determine the effectiveness of the manufacturers' quality control and handling procedures.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary*

IEC 60747-1:1983, *Semiconductor devices – Discrete devices – Part 1: General* [1]

Amendment 3 (1996)

IEC 60748-1, *Semiconductor devices – Integrated circuits – Part 1: General* [1]

IEC 60748-23-1:2002, *Semiconductor devices – Integrated circuits – Part 23-1: Hybrid integrated circuits and film structures – Manufacturing line certification – Generic specification*

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[1] Together with any other part of IEC 60747 or IEC 60748 relevant to the specific hybrid application, including terminology.

IEC 60748-23-3:2002, *Semiconductor devices – Integrated circuits – Part 23-3: Hybrid integrated circuits and film structures – Manufacturing line certification – Manufacturers' self-audit checklist and report*

IEC 60748-23-4:2002, *Semiconductor devices – Integrated circuits – Part 23-4: Hybrid integrated circuits and film structures – Manufacturing line certification – Blank detail specification*

IEC 61191-2:1998, *Printed board assemblies – Part 2: Sectional specification – Requirements for surface mount soldered assemblies*

IEC 61340-5-1:1998, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

EN 100012:1995, *Basic Specification: X-ray inspection of electronic components*

3 Definitions

For the purpose of this part of IEC 60748, the definitions given in IEC 60050, IEC 60747, IEC 60748-1 and IEC 60748-23-1, as well as the following definitions, shall apply.

3.1
active circuit area
includes all areas of functional circuit elements, operating metallization or connected combinations thereof excluding beam leads; in the case of resistors, includes all resistor material that forms a continuous path between two metallized areas (usually bonding pads)

3.2
add-on substrate
supporting structural material into and/or upon which glassivation, metallization and circuit elements are placed and the entire assembly is in turn placed on and attached to the main substrate

3.3
attachment medium
material used to effect the attachment of an element to an underlying surface (e.g. adhesive, solder, alloy)

3.4
blister, metallization
hollow bump that can be flattened

3.5
block resistor
solid, rectangularly shaped resistor, which, for purposes of trimming, is designed to be much wider than would be dictated by power density requirements

3.6
bonding pad
metallized area (usually located along the periphery of the element) at which an electrical connection is to be made by the user of the element

3.7
bonding site
metallized area on a substrate or element intended for a wire or ribbon interconnecting bond

3.8
bridging
complete connection between circuit features not intended to be connected

3.9
cold solder joint
solder joint whose appearance is "grainy" or "dull"

NOTE Where a "grainy" or "dull" appearance is characteristic of certain solder materials (e.g. AuSn, etc.), this criterion should not cause these materials to be rejected.

3.10
compound bond
one bond on top of another

3.11
conductive attach
process and materials used for the attachment that also provides an electrical contact or thermal dissipation path (e.g. solder, eutectic, solder-impregnated epoxy)

3.12
conductive substrate
substrate that can conduct electricity

NOTE Copper or doped silicon, for example, are conductive substrates while alumina and quartz are non-conductive (insulating) substrates.

3.13
contact window
opening (usually square) through the oxide (or insulating) layer for the purpose of allowing contact by deposited material to the substrate

3.14
controlled environment
environment that is in accordance with the requirements of the appropriate product assessment level schedules (PALS) in Annex A of IEC 60748-23-1 and with respect to cleanroom class and (where specified) temperature and relative humidity

3.15
corrosion
gradual wearing away of metal, usually by chemical action, with the subsequent production of a corrosion product

3.16
coupling (air) bridge
raised layer of metallization used for interconnection that is isolated from the surface of the element by an air gap or other insulating material

3.17
crazing
presence of numerous, minute, interconnected surface cracks

3.18
crossover
transverse crossing of metallization paths, without mutual electrical contact, achieved by the deposition of an insulating layer between the metallization paths in the area of crossing

3.19
detritus
fragments of original or trim-modified resistor or conductor material

3.20
dielectric
insulating material that does not conduct electricity but may be able to sustain an electric field

NOTE It can be used in crossovers, as a passivation or a glassivation, or in capacitors.

3.21
dielectric attach
process and materials used for attachment that does not provide electrical contact or thermal dissipation

3.22
edge metallization
metallization that electrically connects the metallization from the top surface to the opposite side of the substrate

3.23
element
constituent of a hybrid microcircuit; such as integral deposited or screened passive elements, substrates, discrete or integrated electronic parts including dies, chips and other microcomponents; also mechanical piece parts such as cases and covers; all contributing to the operation of a hybrid microcircuit

3.24
electrically common
satisfied when two or more conductive surfaces or interconnects are of equal d.c. voltage/signal potential

3.25
end terminated or wrap-around elements
those elements which have electrical connections on the ends (sides) and/or base of their bodies

3.26
foreign material
any material that is foreign to the element or microcircuit or any non-foreign material that is displaced from its original or intended position in the element or microcircuit package

NOTE It is considered attached when it cannot be removed by a nominal gas blow (approximately 138 kN/m^2) (20 psig) or by an approved cleaning process. Conductive foreign material is any substance that appears opaque under those conditions of lighting and magnification used in routine visual inspection. Particles are considered to be embedded in glassivation when there is evidence of colour fringing around the periphery of the particle.

3.27
glassivation
top layer(s) of transparent insulating material that covers the active circuit area, including metallization, but not bonding pads

NOTE Crazing is the presence of numerous minute cracks in the glassivation. Cracks are fissures in the glassivation layer resulting from stress release or poor adhesion. The cracks can form loops over metallized areas.

3.28
insulating layer
dielectric layer used to isolate single or multilevel conductive and resistive material or to protect top level conductive resistive material

3.29
intermetallics (purple plague)
one of several gold-aluminium compounds formed when bonding gold to aluminium and activated by re-exposure to moisture and high temperature (> 340 °C)

NOTE Purple plague is purplish in colour and is very brittle, potentially leading to time-based failure of the bonds. Its growth is highly enhanced by the presence of silicon to form ternary compounds.

3.30
kerf
clear area in a trimmed resistor resulting from the removal of resistor material by the trimming operation

NOTE In laser trimming, the kerf is bounded by the reflow zone (which is characterized by adherent, melted resistor material), the scorched heat-affected zone (which is characterized by discoloration of the resistor film without alteration of its physical form), and the undisturbed zone (see figure 1).

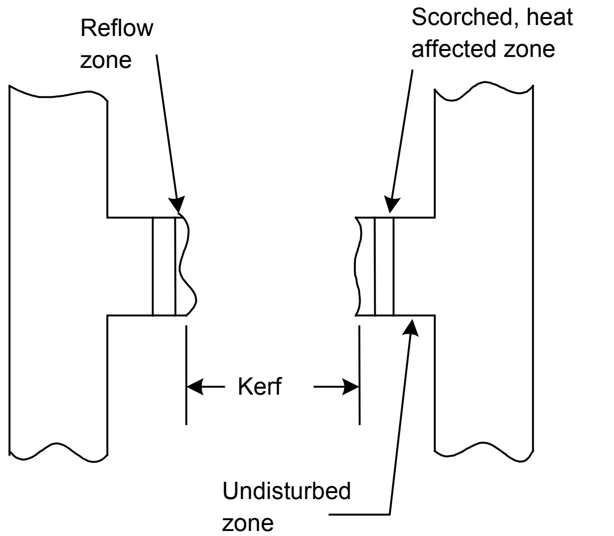


Figure 1 – Class H – Metallization scratch criteria

3.31
mar
non-tearing surface disturbance such as an indentation or a buff mark

3.32
mechanical strength tests
tests, such as mechanical shock or constant acceleration, which demonstrate adequate attachment processes and materials

3.33
metallization, multilevel (conductors)
alternate layers of metallization, or other material used for interconnection, that are isolated from each other by a grown or deposited insulating material. The term "overlaying metallization" refers to any metallization layer on top of the insulating material

3.34
metallization, multilayered (conductors)
two or more layers of metallization, or other material used for interconnection, that are not isolated from each other by a grown or deposited insulating material

NOTE The term "underlying metallization" refers to any metallization layer below the top layer of metallization.

3.35
metallization, operating (conductors)
all metallization (gold, aluminium, or other material) used for interconnection

NOTE Bonding pads are considered to be operating metallization. Alignment markers, test patterns, and identification markings are not considered to be operating metallization.

3.36
narrowest resistor width
narrowest portion of a given resistor prior to trimming; however, the narrowest resistor width for a block resistor may be specified in the approved manufacturer's design documentation

3.37
neck-down
tapering of a resistor line at a metallization interface

NOTE Resistor material taper is typically equal on both sides of the line and is less abrupt than a void.

3.38
nicking (partial cut)
incomplete or inadvertent trimming of a resistor adjacent to the one being trimmed or of the next ladder rung of the same resistor

3.39
nodule, metallization
solid bump that cannot be flattened

3.40
non-monometallic compound bond
two lead bonds, made of dissimilar metals, which are stacked one on top of the other, i.e. the interface between the two lead bonds is made up of dissimilar metals such as an aluminium lead bond stacked on top of a gold lead bond or vice-versa

3.41
non-planar element
element that is essentially three-dimensional

3.42
operating metallization (conductors)
metal or any other material used for interconnections except metallized scribe lines, test patterns, unconnected functional circuit elements, unused bonding pads and identification markings

3.43
original design separation
separation dimension or distance that is intended by design

3.44
original width
width dimension or distance that is intended by design (e.g. original metal width, original diffusion width, original beam width, etc.)

3.45
oxide non-conformance
irregularly shaped non-conformance in the oxide characterized by two or three coloured fringes at its edges

3.46
passivation
silicon oxide, nitride, or other insulating material that is grown or deposited directly on the die prior to the deposition of the final metal layers

3.47
passivation step
change in thickness of the passivation layer by design

3.48
passive elements
planar resistors, capacitors, inductors, and patterned substrates (both single-layer and multilayer), and non-planar chip capacitors, chip resistors, chip inductors, and transformers

3.49
patterned substrate
substrate on which conductors, and components such as resistors or capacitors, are formed using thick or thin film manufacturing techniques

3.50
pit
depression produced in a substrate surface typically by non-uniform deposition of metallization or by non-uniform processing such as excessively powered laser trim pulses

3.51
planar element
element that is essentially two-dimensional with all points in a common plane

3.52
protrusion
jutting-out of a circuit feature

NOTE Protrusion is typically caused by a photolithographic or screening non-conformance.

3.53
resistor ladder
resistor structure resembling a ladder in appearance that can be trimmed in incremental steps

NOTE A coarse ladder structure is one in which trimming of a rung results in a large incremental resistance change (one that can cause an out-of-tolerance condition to occur). A fine ladder structure is one in which trimming of a rung results in a small incremental resistance change (one that cannot cause an out-of-tolerance condition to occur).

3.54
resistor ladder rung
portion of a resistor ladder structure intended to be laser trimmed to result in an incremental change in resistance

3.55
resistor loop
resistor structure resembling a loop in appearance that can be trimmed

NOTE A coarse loop structure is one in which trimming results in a large resistance change (one that can cause an out-of-tolerance condition to occur). A fine loop structure is one in which trimming results in a small resistance change (one that cannot cause an out-of-tolerance condition to occur).

3.56
resistor material, self passivating
material on which a conformal insulating layer can be thermally grown (such as tantalum nitride on which tantalum pentoxide is grown)

3.57
scorching
discoloration of laser trimmed thin film resistor material without alteration of its physical form

3.58
scratch, metallization
any tearing non-conformance, including probe marks on the surface of the metallization

NOTE A mar on the metallization surface is not considered to be a scratch.

3.59
scratch, resistor
any tearing non-conformance in the resistor film

NOTE A mar on the resistor surface is not considered to be a scratch.

3.60
sidebar
portion of a resistor ladder structure to which rungs are attached

NOTE Sidebars are not intended to be laser trimmed.

3.61
string
filamentary run-out or whisker of polymer material

3.62
surface acoustic wave (SAW) element
planar element fabricated typically using thin film manufacturing techniques on various substrate materials

NOTE Size varies as a function of frequency and design features include interdigitated fingers.

3.63
thick film
conductive, resistive or dielectric material screen printed onto a substrate and fired at temperature to fuse into its final form

3.64
thin film
conductive, resistive or dielectric material, usually less than 50,000 Å in thickness, that is deposited onto a substrate by vacuum evaporation, sputtering, or other means

3.65
tine
individual lead of an edge connector lead frame that makes contact with an edge of a substrate

3.66
tuning
adjustment of signals from an r.f./microwave circuit by altering lines or pads; adding, deleting or manipulating wires/ribbons; and/or changing resistance, inductance or capacitance values to meet specific electrical specifications

3.67
through-hole metallization
metallization that electrically connects the metallization on the top surface of the substrate to the opposite surface of the substrate

3.68
underlying material
any layer of material below the top-layer metallization. This includes metallization, resistor, passivation or insulating layers, or the substrate itself

3.69
unused component or unused deposited element
one not connected to a circuit or one connected to a circuit path at one, and only one, point

NOTE A connection may be made by design or by visual anomaly.

3.70
via
opening in the insulating material in which a perpendicular conductive electrical connection from one metallization layer to another in a multilayer substrate is made

3.71
visible line
defined as 12,5 µm at 60× magnification

3.72
vitrification
conversion into glass or a glassy substance by heat and fusion

3.73
void
any region in the material (interconnects, bonding sites, etc.) where underlying material is visible that is not caused by a scratch

3.74
void, metallization
any missing metallization where the underlying material is visible (exposed)

NOTE Voids typically are caused by photolithographic, screen, or mask related non-conformances, not by scratches.

3.75
void, resistor
any missing resistor material where the underlying material is visible (exposed)

NOTE Voids typically are caused by photolithographic, screen, or mask related non-conformances, not by scratches.

3.76
wrap-around conductor
conductor which extends around the edge of the substrate by design

4 Apparatus

The apparatus for this test shall include optical equipment capable of the specified magnification(s) and visual standards/aids (gauges, drawings, photographs, etc.) necessary to perform an effective examination and enable the operator to make objective decisions as to the acceptability of the device being examined. Adequate means shall be provided for handling devices during examination to promote efficient operation without inflicting damage to the units.

5 Procedure

5.1 General

The device shall be examined in a suitable sequence of observations within the specified magnification range to determine compliance with the specified test condition. If a specified visual inspection requirement is in conflict with element design, topology or construction, it shall be documented and specifically approved by the acquiring activity. Inspection for all of the visual non-conformance criteria in this test shall be performed on all elements to which they are applicable. Where a criterion is intended for a specific element type, process, or technology, it has been so indicated.

5.2 Sequence of inspection

The order in which criteria are presented is not a required order of examination and may be varied at the discretion of the manufacturer. Where obscuring mounting techniques (e.g. beam lead devices, stacked substrates, components mounting in holes or cutaways, flip chip devices, packaged devices, etc.) are employed, the inspection criteria contained herein that cannot be performed after mounting shall be conducted prior to mounting the element or substrate. The inspection criteria of clause 7 may be performed at the option of the manufacturer prior to element attachment.

5.3 Inspection control

In all cases, examination prior to final pre-seal inspection shall be performed under the same conditions that are required at the final pre-seal inspection station. If a microcircuit is electrostatic discharge (ESD) sensitive, then appropriate precautions shall be taken in accordance with IEC 61340-5-1. Devices examined according to the criteria of clauses 5 to 17 shall be inspected and prepared for sealing under the environmental conditions specified in the appropriate product assessment level schedules in annex A of IEC 60748-23-1, under “Process and packaging requirements”.

5.4 Re-inspection

When inspection for product acceptance or quality verification of the visual requirements herein is conducted subsequent to the manufacturer's successful inspection, the additional inspection may be performed at any magnification specified by the applicable test condition, unless a specific magnification is required by the acquisition document. Where sample inspection is used rather than 100 % re-inspection, the sampling plans defined in IEC 60748-23-1 shall apply.

5.5 Exclusions

Where conditional exclusions have been allowed, specific instruction as to the location and conditions for which the exclusion can be applied shall be documented in the assembly inspection drawing.

5.6 Magnification

The magnification ranges to be used for inspection are specified at the start of each clause and are defined at the start of each major criteria grouping. "High magnification" inspection shall be performed perpendicular to the element with illumination normal to the element surface. Other angles at which the inspection can be performed, and at which the element can be illuminated, may be used at the option of the manufacturer if the visual presentation is the same as used in the originally specified conditions. "Low magnification" inspection shall be performed with either a monocular, binocular, or stereo microscope with the element under suitable illumination.

5.7 Format and conventions

For ease of understanding and comparison, visual criteria are presented side-by-side in a columnar format. Class H criteria are presented in the left column and class K criteria are presented in the right column. When there are differences, the applicable parts of the class H criterion are underlined, for ease of comparison and clarity, and the differences only are shown in the class K column. When there are similarities, the phrase "same as class H" is used with no underlining of the class H criterion. If a requirement is not applicable to either product class, this is indicated by "N/A". A note in the class H column is applicable to class K, unless otherwise specified in the class K column. A note in the class K column is applicable to class K only.

Two kinds of notes are used herein, regular notes (NOTE) and precautionary notes (PRECAUTIONARY NOTE). A regular note is an integral part of a criterion. A precautionary note is not an integral part of the criterion but serves to alert the user to a requirement of IEC 60748-23, Parts 1 to 5.

The phrases "except by design," "intended by design," "by design," or "unless otherwise specified by design" require that the element drawing be referenced to determine intent. For inspections performed at 100×, the criterion of "2,5 µm of passivation, separation, or metal" is satisfied by a "line of passivation, separation or metal." In the figures, cross-hatched areas represent metallization, blank areas represent resistor material and shaded areas represent exposed underlying material. The letters "x", "y", or "z" represent the dimension of interest and the letter "d" represents the original dimension. Most figures show the reject condition only.

5.8 Interpretations

References herein to "that exhibits" shall be considered satisfied when the visual image or visual appearance of the device under examination indicates that a specific condition is present and shall not require confirmation by any other method of testing. When other methods of test are to be used to confirm that a reject condition does not exist, they shall be approved by the acquiring activity.

6 Thin film element inspection

Inspection for visual non-conformances described in this clause shall be conducted on each planar thin film passive element. The "high magnification" inspection shall be within the range of 100× to 200× for both class H and class K. The "low magnification" inspection shall be within the range of 30× to 60× for both class H and class K. Patterned substrates that have geometries of 50 µm or greater shall be inspected at 10× to 60× magnification.

6.1 Operating metallization non-conformances – "high magnification"

NOTE The metallization non-conformance criteria contained in this subclause apply to operating metallization only.

No element shall be acceptable that exhibits:

6.1.1 Metallization scratches

Class H	Class K
a) A scratch or probe mark in the metallization, excluding bonding pads, that both exposes underlying material anywhere along its length and leaves less than 50 % of the original metallization width undisturbed (see figure 2).	a) Same as Class H.
NOTE 1 This criterion does not apply to capacitors (see 6.1.1 e)).	
NOTE 2 Underlying material does not have to be exposed along the full length of the scratch.	

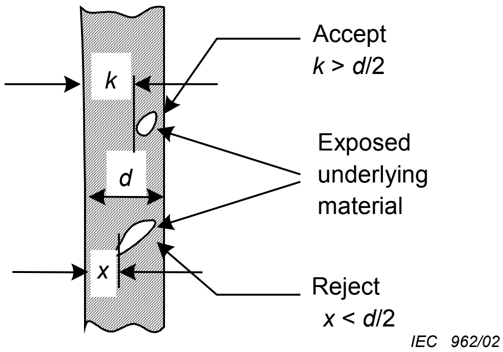


Figure 2 – Class H – Metallization scratch criterion

Class H

b) Scratch in the bonding pad area that both exposes underlying material and reduces the metallization path width, where it enters the bonding pad, and leaves less than 50 % of its original metallization width. If two or more metallization paths enter a bonding pad, each shall be considered separately (see figure 3).

Class K

b) Less than 75 % (see figure 4).

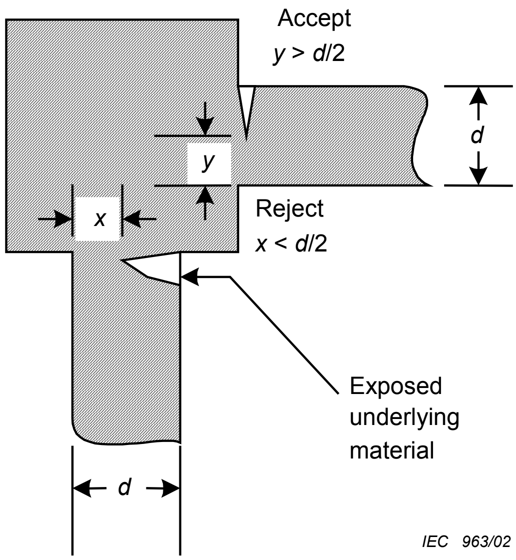


Figure 3 – Class H – Metallization width reduction at bonding pad criterion

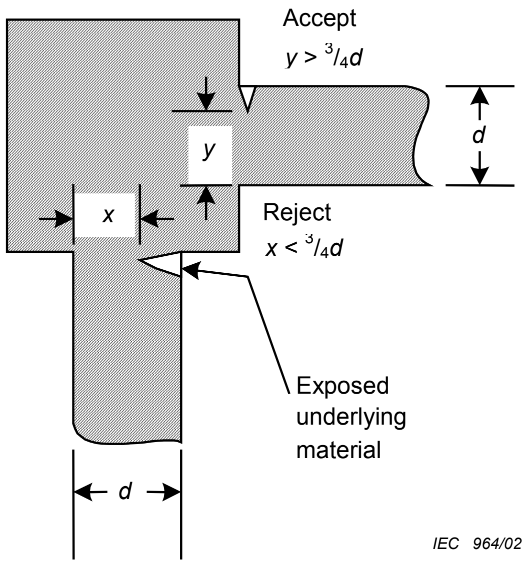


Figure 4 – Class K – Metallization width pad reduction at bonding pad criterion

Class H

c) Scratch that completely crosses metallization and damages the metallization on either side.

d) Scratches or probe marks in the bonding pad area that expose underlying material over more than 25 % of the original unglassivated metallization area.

Class K

c) Not applicable.

d) Same as Class H.

e) For capacitors only, a scratch in the metallization, other than in the bonding pad area, that exposes the dielectric material.

e) Same as Class H.

6.1.2 Metallization voids

Class H

Class K

a) Void(s) in the metallization, excluding bonding pads, that leave less than 50 % of the original metallization width undisturbed (see figure 5).

a) Same as Class H.

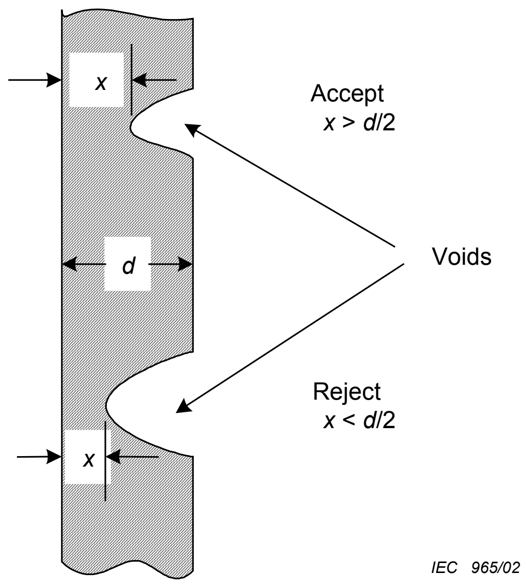


Figure 5 – Class H – Metallization void criterion

b) Void(s) in the bonding pad area that reduce the metallization path width, where it enters the bonding pad, to less than 50 % of its original metallization width. If two or more metallization paths enter a bonding pad, each shall be considered separately.

NOTE Figures 3 and 4 illustrate metallization width reduction at bonding pad criteria for scratches. Void criteria are similar.

b) Less than 75 %.

c) Scratch that completely crosses void(s) in the bonding pad area that expose underlying material over more than 25 % of the original unglassivated metallization area.

NOTE For r.f./microwave elements on non-conductive substrates, a void created in the bonding pad area as a result of wire bond removal for performance optimization or tuning, is not rejectable provided that the void remains entirely visible.

c) Same as Class H.

d) For capacitors only, void(s) in metallization, other than in the bonding pad area, that reduce the metallization to an extent greater than an area equivalent to 25 % of the capacitor metallization.

d) Same as Class H.

e) For interdigitated capacitors only, void(s) in the metallization that leaves less than 50 % of the original metallization width undisturbed (see figure 6).

e) Less than 75 % (see figure 7).

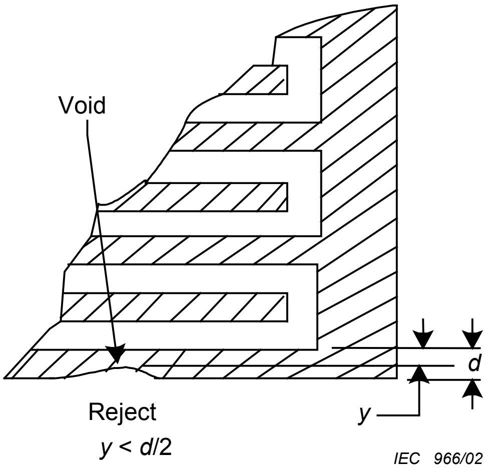


Figure 6 – Class H – Interdigitated capacitor metallization void criterion

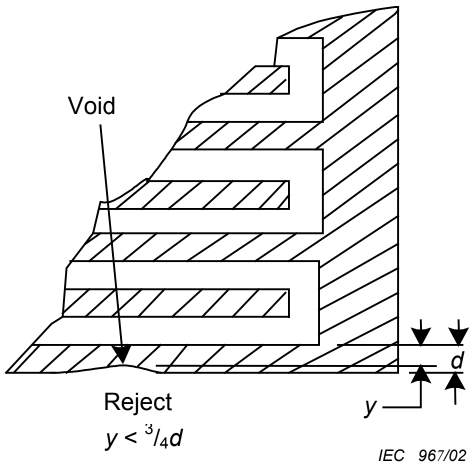


Figure 7 – Class K – Interdigitated capacitor metallization void criterion

6.1.3 Metallization corrosion

Class H

a) Any metallization corrosion

Class K

a) Same as Class H.

Metallization having any localized discoloured area shall be closely examined and rejected unless it is demonstrated to be a harmless film, glassivation interface, or other obscuring effect.

6.1.4 Metallization adherence

a) Any metallization lifting, peeling, or blistering.

NOTE 1 Nodules are acceptable. In order to determine if a bump in the metallization is a blister or a nodule, attempt to flatten the bump with a non-metallic instrument. If the bump flattens, then it is a blister.

NOTE 2 These criteria are not applicable to undercutting or separation induced anomalies (for example, metallization lifting due to scribe and break or diamond sawing) since these are not indicative of adhesion problems.

a) Same as Class H.

6.1.5 Metallization protrusion

Class H

a) Protrusion of metallization that reduces the original separation between adjacent operating metallization by more than 50 % (see figure 8).

Class K

a) Same as Class H.

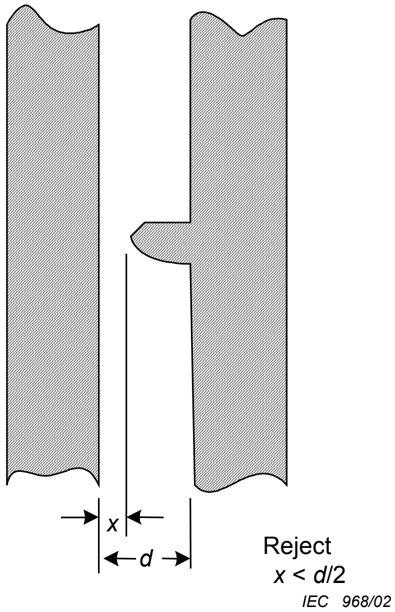


Figure 8 – Class H – Operating metallization protrusion criterion

Class H

b) For interdigitated capacitors only, protrusion of metallization that reduces the original separation by more than 50 % (see figure 9).

Class K

b) Same as Class H.

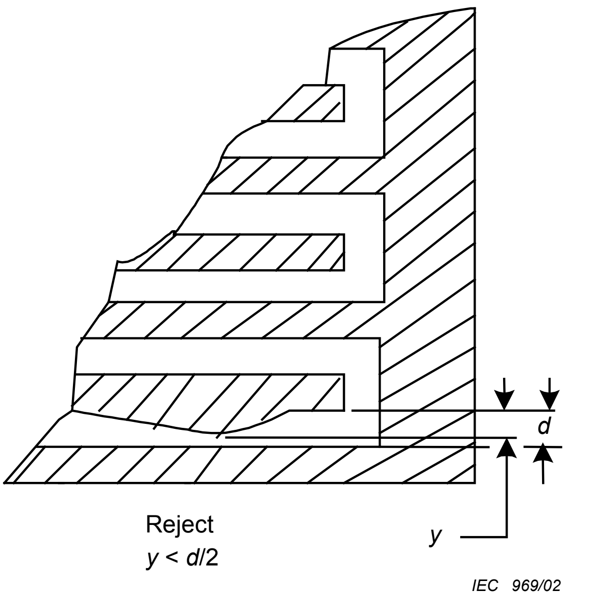


Figure 9 – Class H – Interdigitated capacitor metallization protrusion criterion

6.1.6 Metallization alignment

Class H	Class K
a) A contact window that has less than 50 % of its area covered by metallization.	a) Less than 75 %.
b) A contact window that has less than a continuous 40 % of its perimeter covered by metallization (see figure 10).	b) 50 % of its perimeter (see figure 11).

NOTE When, by design, metallization is completely contained in a contact window, or does not cover the entire contact perimeter, 6.1.6 a), area coverage, or 6.1.6 b), perimeter coverage, can be deleted as applicable provided that the design criteria are satisfied.

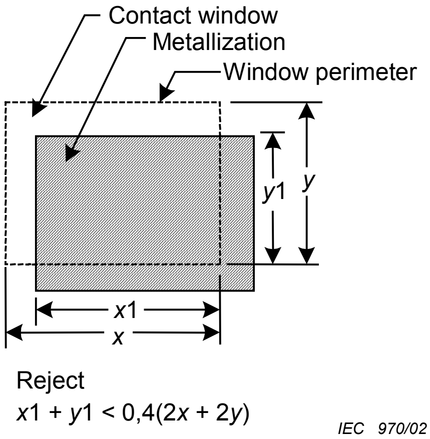


Figure 10 – Class H – Metallization alignment criterion

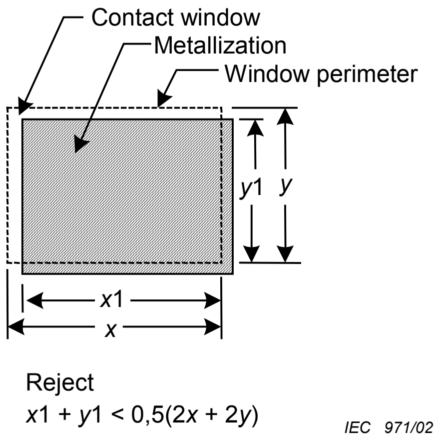


Figure 11 – Class K – Metallization alignment criterion

Class H	Class K
c) A metallization path not intended to cover a contact window that is separated from the window by less than 2,5 µm unless by design.	c) Same as Class H.

6.1.7 Metallization bumps or indentations

Class H	Class K
a) For capacitors only, a bump or indentation in the overlaying metallization.	a) Same as Class H.

6.1.8 Metallized through-hole non-conformances – "high magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) Through-hole metallization that is not perpendicularly continuous or that does not cover at least a continuous 50 % of the inside, circumferential surface area unless by design.	a) Same as Class H.

6.1.9 Wrap-around connection non-conformances – "high magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) Unmetallized area in the edges of wrap-around connections greater than 50 % of the largest dimension of the edge metallization (see figure 12).	a) Same as Class H.

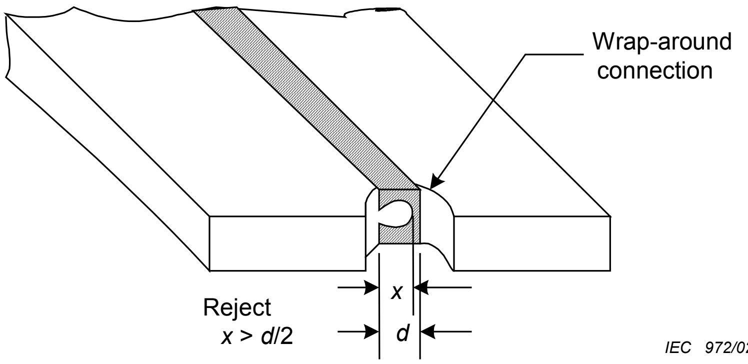


Figure 12 – Class H – Wrap-around connection unmetallized area criterion

6.2 Passivation non-conformances - "high magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) Either multiple lines (colour fringing) or a complete absence of passivation visible at the edge and continuing under the metallization (see figure 13). A passivation non-conformance that exhibits a line of separation from the metallization is acceptable.	a) Same as Class H.

NOTE 1 These criteria apply to conductive substrate elements only.

NOTE 2 Double or triple lines at the edge of the passivation non-conformance indicate it can have sufficient depth to penetrate down to the bare substrate.

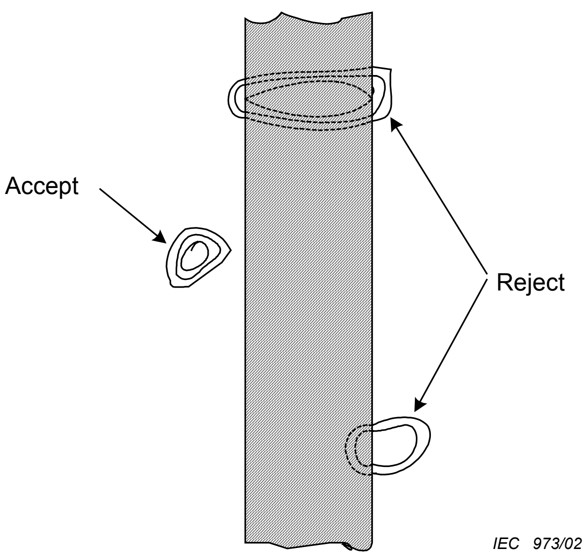


Figure 13 – Class H – Passivation non-conformance criteria

6.3 Glassivation non-conformances - "high magnification"

Class H

Criteria of 6.1.3 can be excluded when the non-conformances are due to laser trimming. In this case, the non-conformances outside the kerf due to laser trimming shall not be more than one half the remaining resistor width and shall leave a primary resistor path free of glassivation non-conformances, equal to or greater than 50 % of the narrowest resistor width, (see figure 14).

No device shall be acceptable that exhibits:

Class K

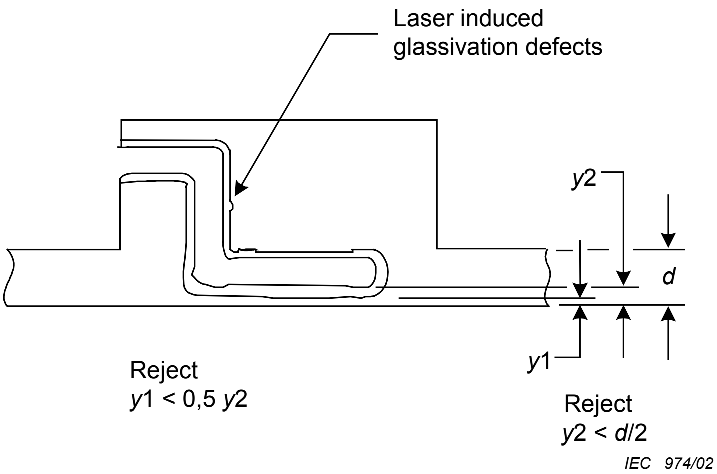


Figure 14 – Class H – Laser trimmed glassivation non-conformance criteria

Class H	Class K
a) Glass crazing or damage that prohibits the detection of visual criteria contained herein.	a) Same as Class H.
b) Any lifting or peeling of the glassivation.	b) Same as Class H.
NOTE Lifting or peeling of the glassivation is acceptable when it does not extend more than 25 µm from the designed periphery of the glassivation, provided that the only exposure of metallization is of adjacent bonding pads or of metallization leading from those pads.	
c) A void in the glassivation that exposes two or more adjacent operating metallization paths, excluding bonding pad cut-outs, unless by design.	c) Same as Class H.
d) Unglassivated non-active circuit areas greater than 125 µm in any dimension, unless by design.	d) Same as Class H.
e) Unglassivated areas at the edge of a bonding pad exposing the conductive substrate.	e) Same as Class H.

Class H	Class K
f) Glassivation covering more than 25 % of a bonding pad area.	f) Same as Class H.
g) Crazing in glassivation over a resistor.	g) Same as Class H.
h) Misalignment of the glassivation that results in incomplete coverage of a resistor, unless by design.	h) Same as Class H.
i) Glassivation scratches or voids that expose any portion of a resistor or fusible link except for polycrystalline silicon links where the glassivation is opened by design.	i) Same as Class H.
j) Scratches in the glassivation that disturb metallization and bridge metallization paths.	j) Same as Class H.
k) Cracks (not crazing) in the glassivation that form a closed loop over adjacent metallization paths.	k) Same as Class H.

6.4 Substrate non-conformances - "high magnification"

No element shall be acceptable that exhibits:

a) Less than 2,5 µm of separation between the operating metallization and the edge of the element unless by design (see figure 15). For elements containing wrap-around conductors or for bonding pads of r.f./microwave elements that are co-incident with the element edge (as documented on the design drawing) this criterion does not apply. When bond pad metallization is coincident with the element edge, a minimum separation of 25 µm shall exist between the bonding pad metallization at the element edge and any non-common conductive surface.	a) Same as Class H.
b) A chipout that extends into the active circuit area (see figure 15).	b) Same as class H.

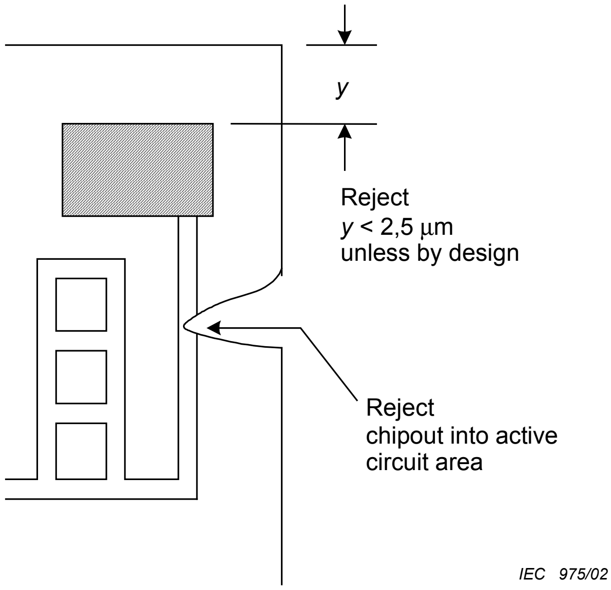


Figure 15 – Class H – Separation and chipout criteria

Class H

c) Any crack that exceeds 125 µm in length (see figure 16).

NOTE For fused quartz or crystalline substrates, no cracking is allowed.

d) Any crack that does not exhibit 2,5 µm of separation from any active circuit area or operating metallization (see figure 16).

e) Any crack exceeding 25 µm in length extending from the element edge directly towards the active circuit area or operating metallization (see figure 16).

Class K

c) Same as Class H.

d) 0,7 µm (see figure 16).

e) Same as Class H.

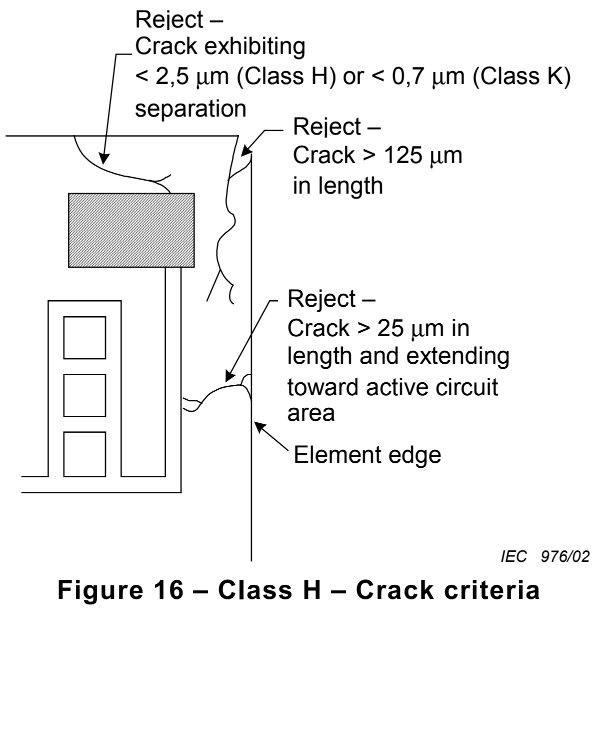


Figure 16 – Class H – Crack criteria

Class H	Class K
f) N/A.	f) Semicircular crack or combination of cracks along the element edge whose total length is equal to or greater than 75 % of the narrowest separation between any two bonding pads (see figure 17).

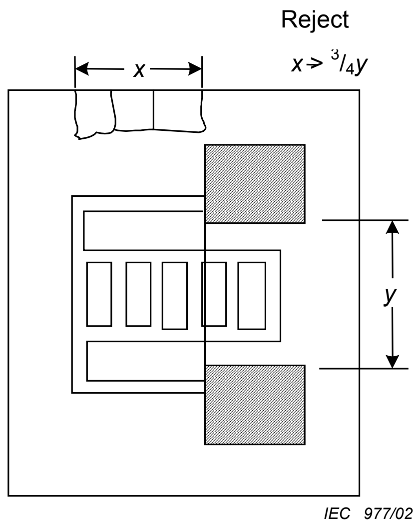


Figure 17 – Class K – Semicircular crack criterion

Class H	Class K
g) An attached portion of an active circuit. area from an adjacent element.	g) Same as Class H.
h) Any crack that does not originate at an edge.	h) Same as Class H.
i) Holes through the substrate, unless by design.	i) Same as Class H.

6.5 Foreign material non-conformances - "low magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) For mounted elements, unattached, conductive foreign material on the surface of the elements. For unmounted elements, unattached, conductive foreign material on the surface of the element that is large enough to bridge operating metallization paths, active circuitry, or any combination of these.	a) Same as Class H.

NOTE 1 If an element has an insulating layer (such as glassivation or self-passivation) that covers operating metallization paths, active circuitry, or any combination of these, then the presence of unattached, conductive foreign material, that is large enough to bridge these features, is acceptable since the features are protected by the insulating layer.

Class H	Class K
All foreign material shall be considered to be unattached unless otherwise verified to be attached. Verification of attachment shall be accomplished by a light touch with an appropriate mechanical device (e.g. needle, probe, pick, etc.), or by a suitable cleaning process approved by the acquiring activity, or by a blow-off with a nominal gas blow (approximately 150 kN/m^2). NOTE 2 Removal of unattached foreign material may be attempted using the techniques for verification of attachment discussed above. NOTE 3 Semiconductor particles are considered to be foreign material.	
b) Attached, conductive foreign material that bridges metallization paths, active circuitry, or any combination of these.	b) Same as Class H.
c) Liquid droplets, ink drops, or chemical stains that appear to bridge any unglassivated or unpassivated active circuit areas.	c) Same as Class H.
d) Attached foreign material that covers more than 25 % of a bonding pad area.	d) Same as Class H.

6.6 Thin film resistor non-conformances - "high magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) Voids at the terminal that reduce the resistor width to less than 50 % of the original resistor width (see figure 18).	a) Same as Class H.

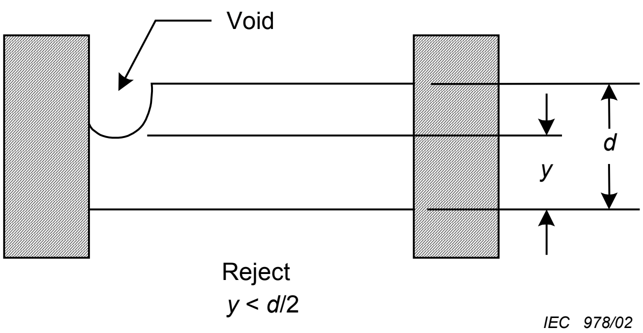


Figure 18 – Class H – Film resistor width reduction at terminal by voids criterion

Class H

b) Neck-down at the terminal that reduces the resistor width to less than 75 % of the original resistor width (see figure 19).

Class K

b) Same as Class H.

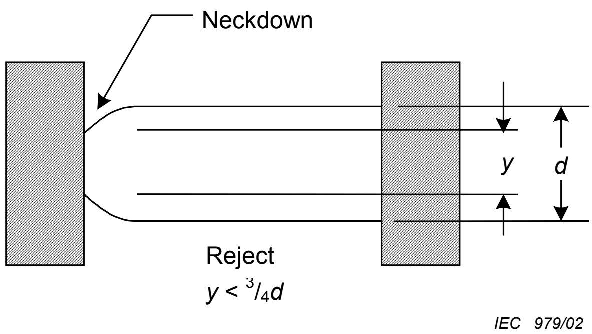


Figure 19 – Class H – Film resistor width reduction at terminal by necking criterion

Class H

c) Any sharp (clearly defined) colour change within 2,5 µm of the terminal.

NOTE A sharp colour change close to the terminal usually indicates an abrupt reduction of resistor film thickness. This colour change usually occurs in a straight line parallel to the terminal. A gradual colour change, or a non-uniform or mottled colour anywhere in the resistor, is not cause for rejection.

d) Any resistor film lifting, peeling or blistering.

e) Reduction of resistor width, resulting from voids, scratches, or a laser trim kerf or a combination of these, that leaves less than 50 % of the narrowest resistor width (see figure 20).

PRECAUTIONARY NOTE The maximum allowable current density requirement must not be exceeded.

Class K

c) Same as Class H.

d) Same as Class H.

e) Same as Class H.

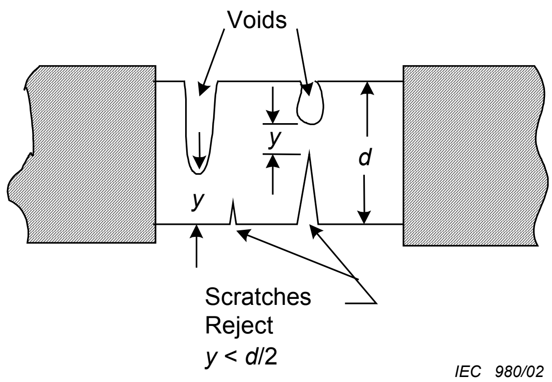


Figure 20 – Class H – Film resistor width reduction by voids and scratches criteria

Class H	Class K
f) Contact overlap between the metallization and the resistor in which the width dimension "*y*" is less than 50 % of the original resistor width (see figure 21).	f) Same as Class H.

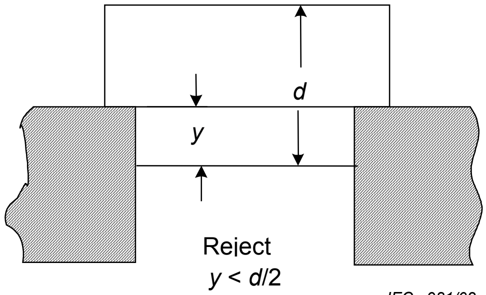


Figure 21 – Class H – Metal/resistor overlap criterion

g) Contact overlap between the metallization and the resistor in which the length dimension "*x*" is less than 5 µm (see figure 22).	g) Same as Class H.

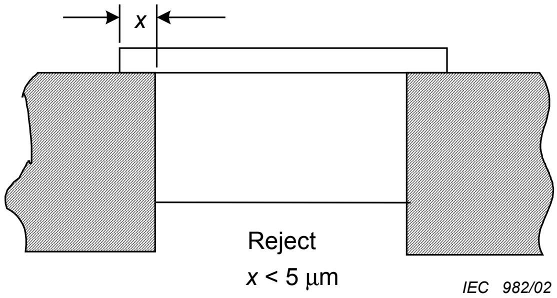


Figure 22 – Class H – Contact overlap criterion

h) More than a 50 % reduction of the original separation, between any two different resistors, or a resistor and metallization not associated with it (see figure 23).	h) Same as Class H.

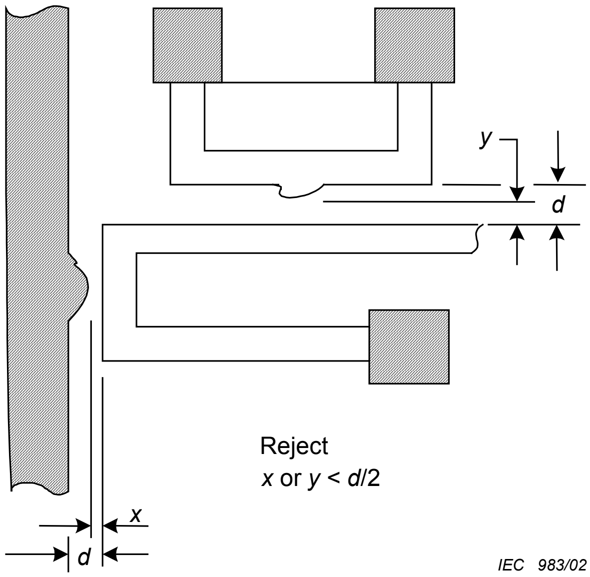


Figure 23 – Class H – Resistor separation criteria

Class H

i) Any resistor that crosses a substrate irregularity (such as a void or scratch) (see figure 24).

NOTE This criterion is applicable to conductive substrates only.

Class K

i) Same as Class H.

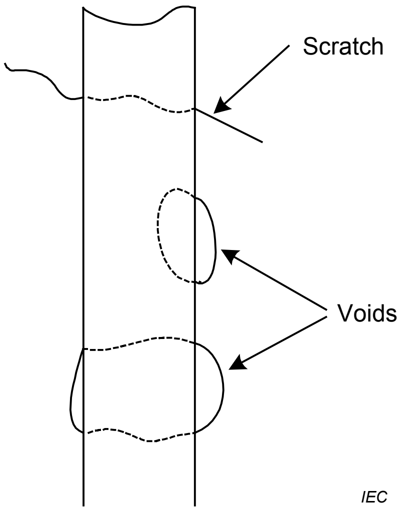


Figure 24 – Class H – Substrate irregularity criterion

Class H

j) Any increase in resistor width of a block resistor greater than 25 % of the original resistor width (see figure 25).

Class K

j) Same as Class H.

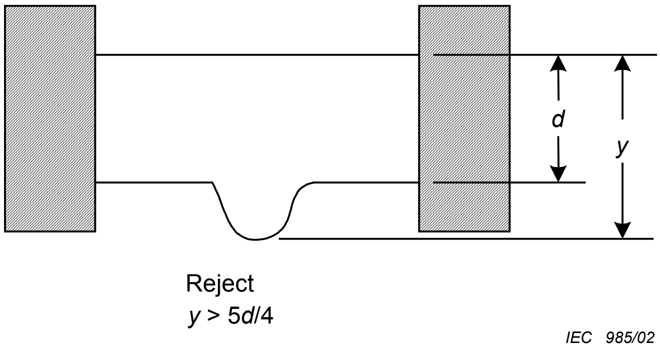


Figure 25 – Class H – Resistor width increase criterion

Class H

k) Protruding resistor material within the same resistor structure that reduces the original separation to less than 50 % (see figure 26).

NOTE This criterion applies to protrusion of resistor material resulting from a photolithographic non-conformance.

Class K

k) Same as Class H.

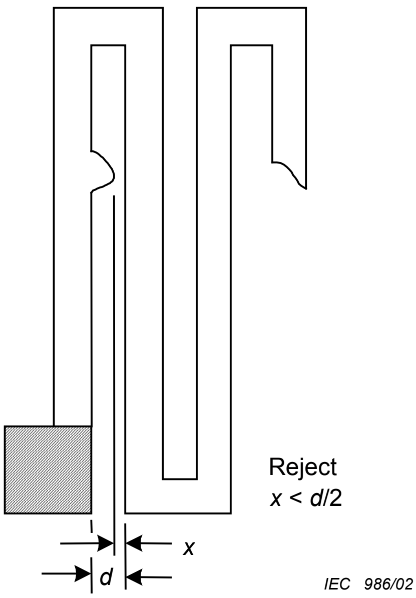


Figure 26 – Class H – Protrusion of resistor material criterion

Class H

l) Bridging within the same resistor pattern where the width of the bridge is less than 50 % of the narrowest line being bridged (see figure 27).

Class K

l) Same as class H.

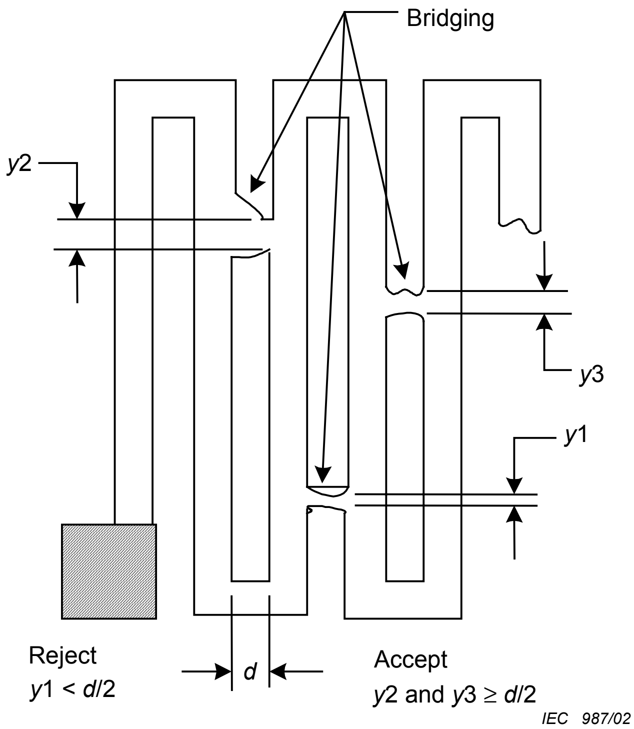


Figure 27 – Class H – Bridging of resistor material criteria

6.7 Laser trimmed thin film resistor non-conformances - "high magnification"

NOTE The laser trim non-conformance criteria contained in this subclause apply to active resistor areas only.

No element shall be acceptable that exhibits:

Class H

a) A kerf width less than 2,5 µm (see figure 28).

NOTE This does not apply to edge trimming.

Class K

a) Same as Class H.

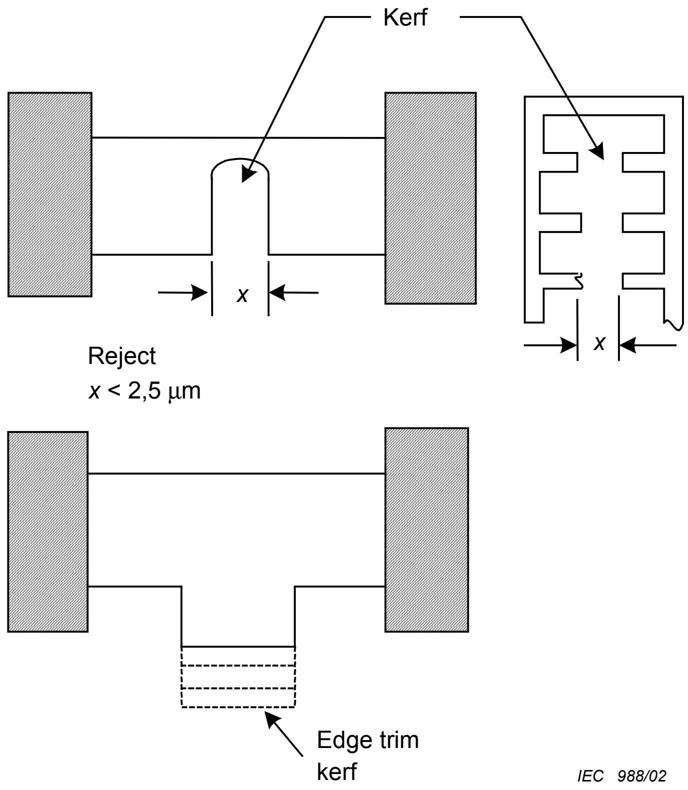


Figure 28 – Class H – Kerf width criteria

b) A kerf containing particles of detritus.

For resistor materials that are self-passivating (such as tantalum nitride), detritus in the kerf is allowed provided that a clear path of at least 2,5 µm in width exists in the kerf. Such detritus shall be attached. Verification of attachment shall be accomplished using the techniques described in 6.5 a) (see figure 29).

NOTE This does not apply to edge trimming.

b) Same as Class H.

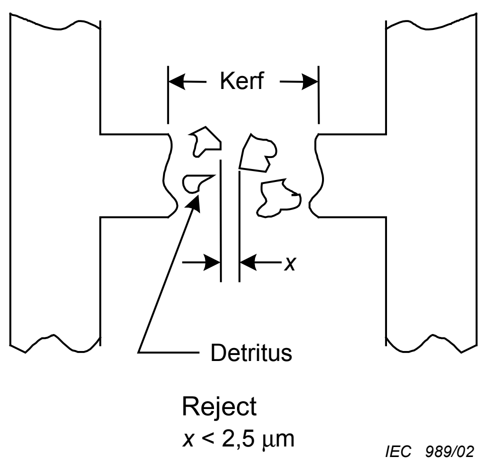


Figure 29 – Class H – Detritus criterion for self-passivating resistor materials

Class H

In the case of a resistor loop made with self-passivating resistor material which is similar in configuration to the one shown in figure 30, there shall be at least one kerf that contains a clear path of at least 2,5 µm in width; otherwise, the element shall be rejected.

Class K

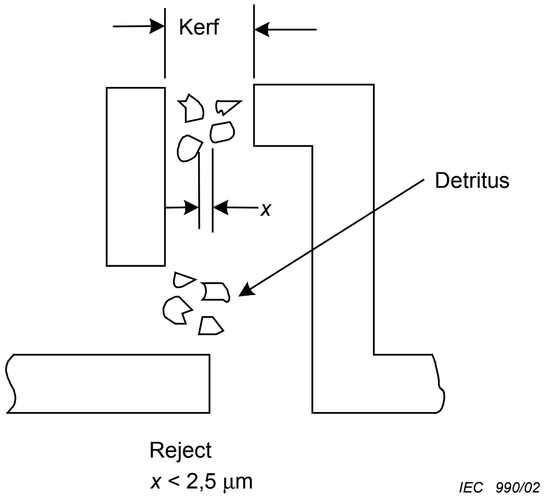


Figure 30 – Class H – Resistor loop element detritus criterion for self-passivating resistor materials

c) Bridging of detritus between rungs in the active area of a resistor ladder structure (see figure 31).

NOTE Bridging of detritus in inactive areas is acceptable.

c) Same as Class H.

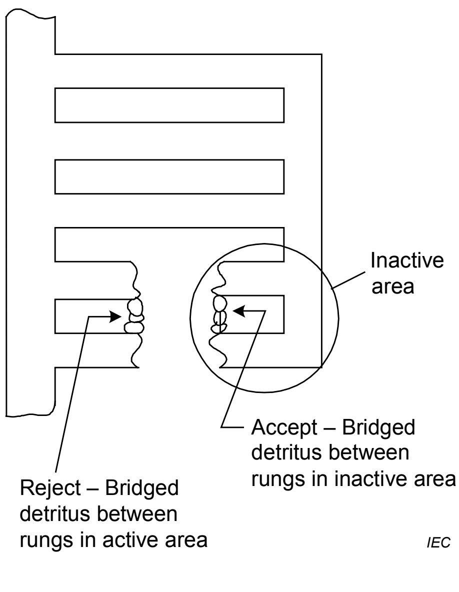


Figure 31 – Bridging of detritus between rungs in the active area of a resistor ladder structure criterion

Class H

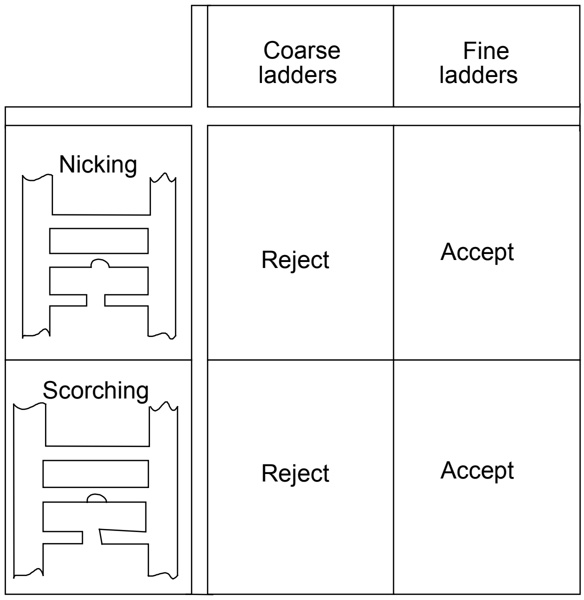
d) No nicking or scorching is allowed except as permitted below.

NOTE 1 This does not apply to rungs in a fine resistor ladder structure (see figure 32).

NOTE 2 See 3.53 for a definition of coarse and fine resistor ladder structures. The element drawing must be referenced to determine if a given resistor ladder structure is coarse or fine.

Class K

d) Same as Class H.

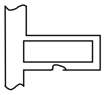
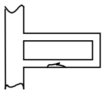
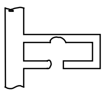
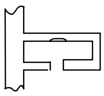


IEC 992/02

Figure 32 – Class H – Resistor ladder structure nicking and scorching criteria exceptions

NOTE 3 These criteria do not apply to the second rung of a resistor loop since the second rung is inactive. These criteria do not apply to a fine loop or to a resistor structure that consists of fine loops (see figure 33).

NOTE 4 See 3.55 for a definition of coarse and fine resistor loop structures. The element drawing must be referenced to determine if a given resistor loop structure is coarse or fine.

		Course loops	Fine loops
Nick in first (Active) rung		Reject	Accept
Scorch in first (Active) rung		Reject	Accept
Nick in second (Inactive) rung		Accept	Accept
Scorch in second (Inactive) rung		Accept	Accept

IEC 993/02

Figure 33 – Class H – Resistor loop nicking and scorching criteria exceptions

NOTE This criterion does not apply to the last rung of a resistor ladder if the last rung is inactive (see figure 34).

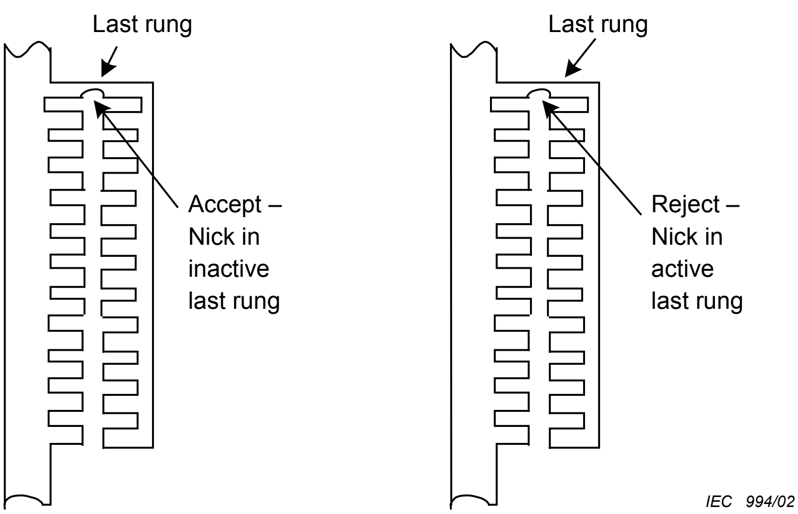


Figure 34 – Class H – Laser nicking criteria exception for the last rung of a resistor ladder

Class H

e) A kerf or scorch which extends into a resistor ladder sidebar (see figure 35).

Class K

e) Same as Class H.

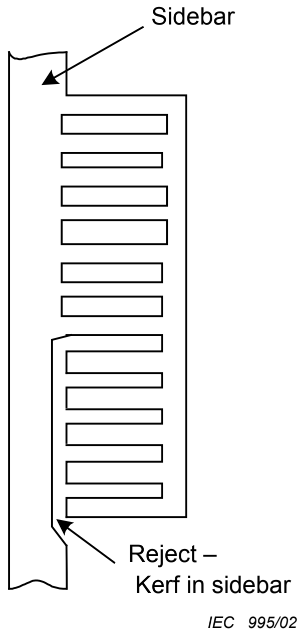


Figure 35 – Class H – Resistor ladder sidebar trim criterion

f) Kerf or scorch misalignment (see figure 36).

f) Same as Class H.

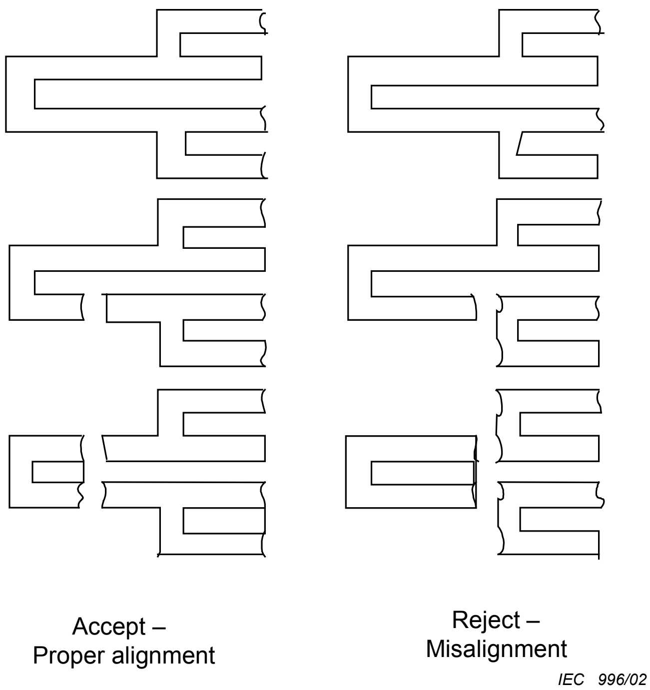


Figure 36 – Class H – Laser trim misalignment criteria

Class H

g) A kerf which extends into metallization and leaves less than 75 % of the metallization width undisturbed (see figure 37).

NOTE Opening a metallization link by design is acceptable.

Class K

g) Same as Class H.

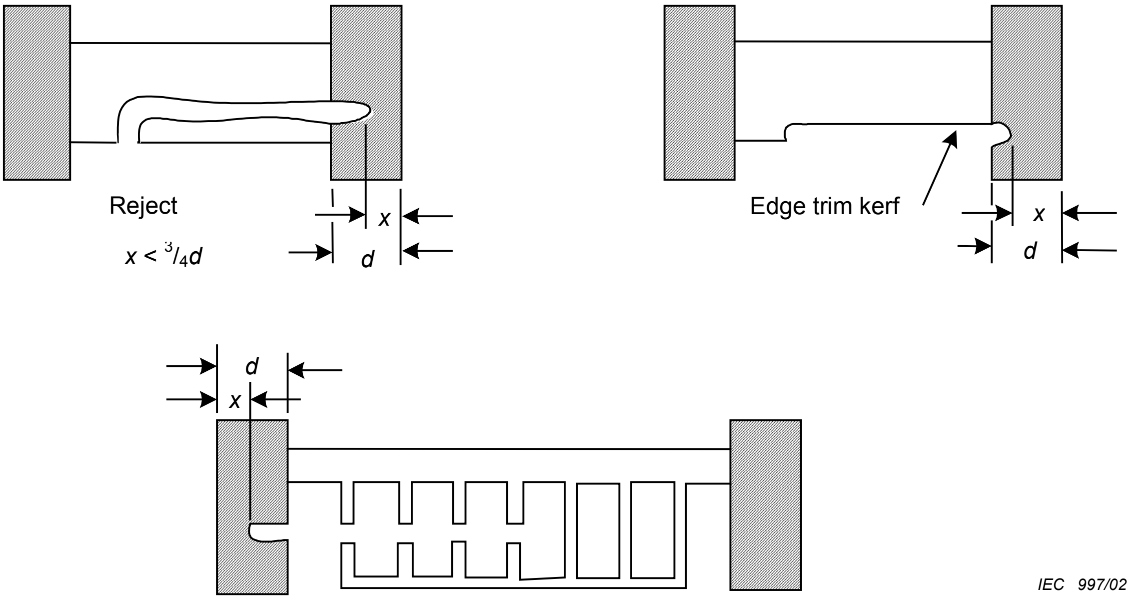


Figure 37 – Class H – Laser trim kerf extension into metallization criteria

Class H

h) A kerf in a resistor, at the interface of the resistor material with the metallization, that leaves less than 50 % of the original resistor width, unless by design.

PRECAUTIONARY NOTE The maximum allowable current density requirement must not be exceeded. (see figure 38).

Class K

h) Same as Class H.

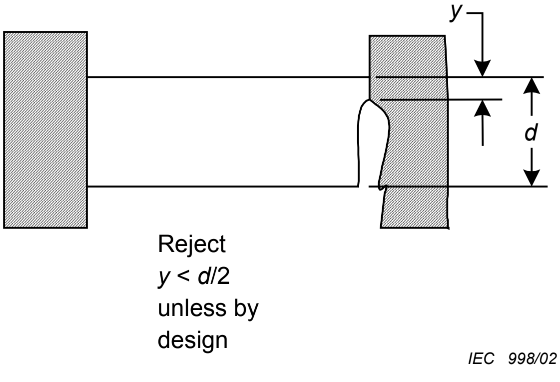


Figure 38 – Class H – Resistor width reduction at metallization interface criteria

Class H

i) A kerf in a resistor that leaves less than 50 % of the original resistor width, unless by design.

PRECAUTIONARY NOTE The maximum allowable current density requirement must not be exceeded (see figure 39).

Class K

i) Same as Class H.

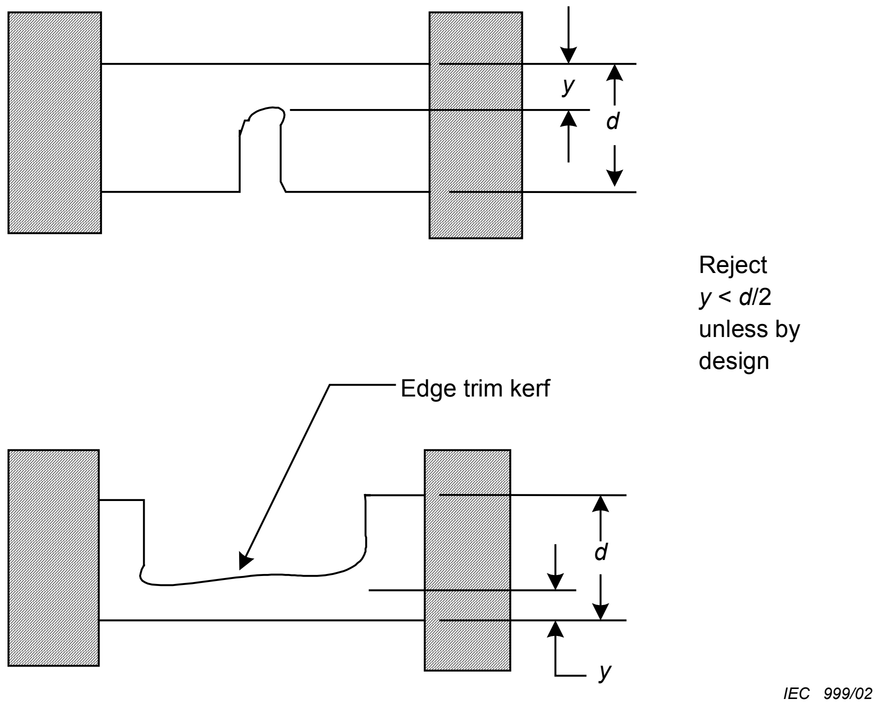


Figure 39 – Class H – Resistor width reduction by trimming criteria

j) A kerf in a resistor that leaves less than 50 % of the narrowest resistor width unless by design (see figure 40).

NOTE A floating kerf (one that is completely contained within the resistor) must meet this criterion.

PRECAUTIONARY NOTE The maximum allowable current density requirement must not be exceeded.

j) Same as Class H.

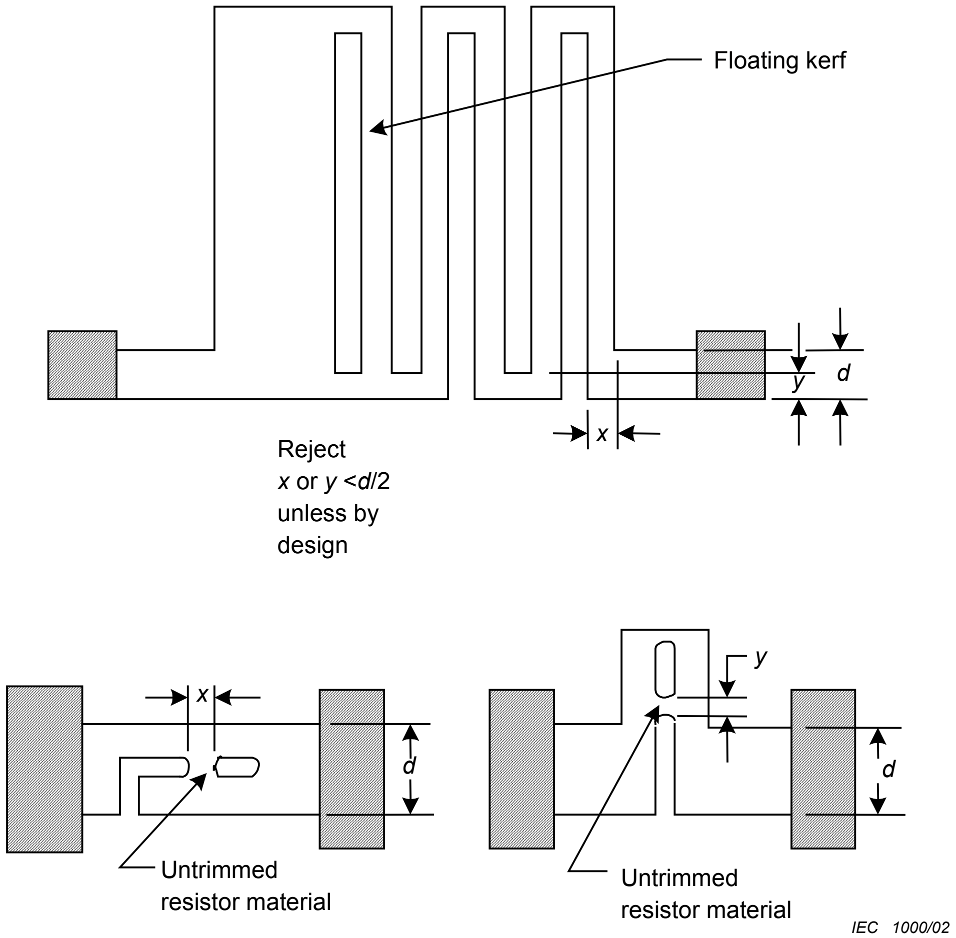


Figure 40 – Class H – Resistor width reduction and untrimmed resistor material criteria

k) Pits into the silicon dioxide of conductive substrate elements in the kerf which does not show a line of separation between the pit and the resistor material (see figure 41).

k) Same as Class H.

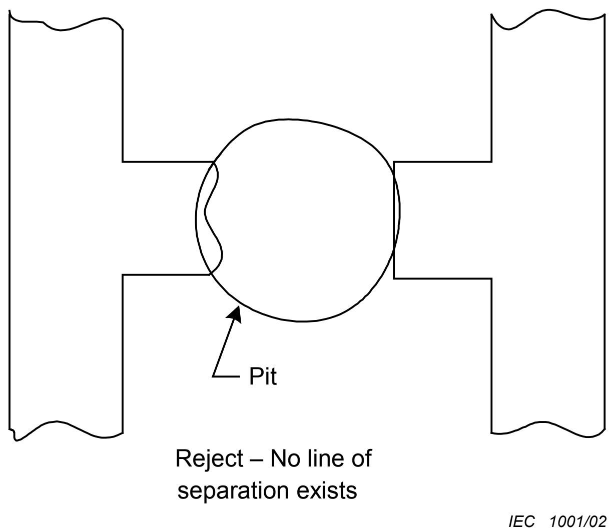


Figure 41 – Class H – Laser trim pitting criterion

6.8 Multilevel thin film non-conformances - "high magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) Insulating material that does not extend beyond the width of the upper and lower metallization by 7,5 μm minimum (see figure 42).	a) Same as Class H.

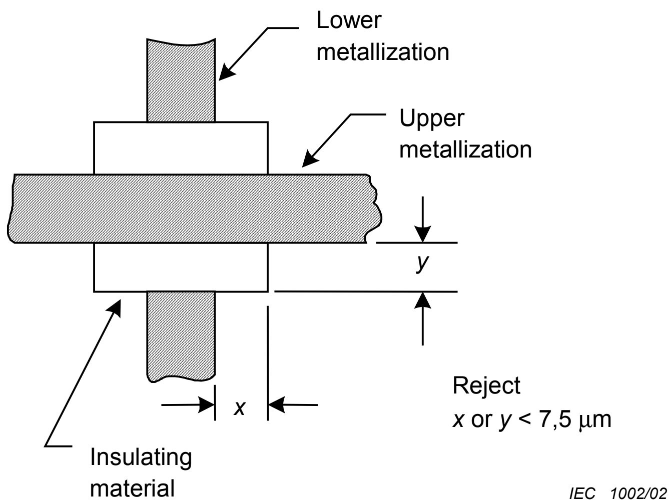


Figure 42 – Class H – Insulating material extension criteria

Class H	Class K
b) Voids in the insulating material.	b) Same as Class H.
c) A bump or indentation in the upper (overlaying) metallization. NOTE This criterion is not applicable to coupling (air) bridges.	c) Same as Class H.
d) Scratch that completely crosses the metallization and damages the insulating material surface on either side.	d) Same as Class H.

6.9 Coupling (air) bridge non-conformances - "high magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) A void in the coupling (air) bridge metallization that leaves less than 50 % of the original metallization width undisturbed (see figure 43).	a) Same as Class H.
b) Nodules or bumps that are greater, in any dimension, than the original coupling (air) bridge metallization width (see figure 43).	b) Same as Class H.
c) Coupling (air) bridge that contacts underlying operating metallization (see figure 43).	c) Same as Class H.

Class H

d) Attached, conductive foreign material that is greater, in any dimension, than 50 % of the original coupling (air) bridge metallization width.

e) No visible separation between the coupling (air) bridge and the underlying operating metallization.

NOTE This criterion is not applicable when an insulating material is used between the coupling (air) bridge and the underlying metallization (see figure 43).

f) Coupling (air) bridge metallization overhang over adjacent operating metallization, not intended by design, that does not exhibit a visible separation (see figure 43).

g) Mechanical damage to a coupling (air) bridge that results in depression (lowering) of coupling (air) bridge metallization over underlying operating metallization.

Class K

d) Same as Class H.

e) Same as Class H.

f) Same as class H.

g) Same as class H.

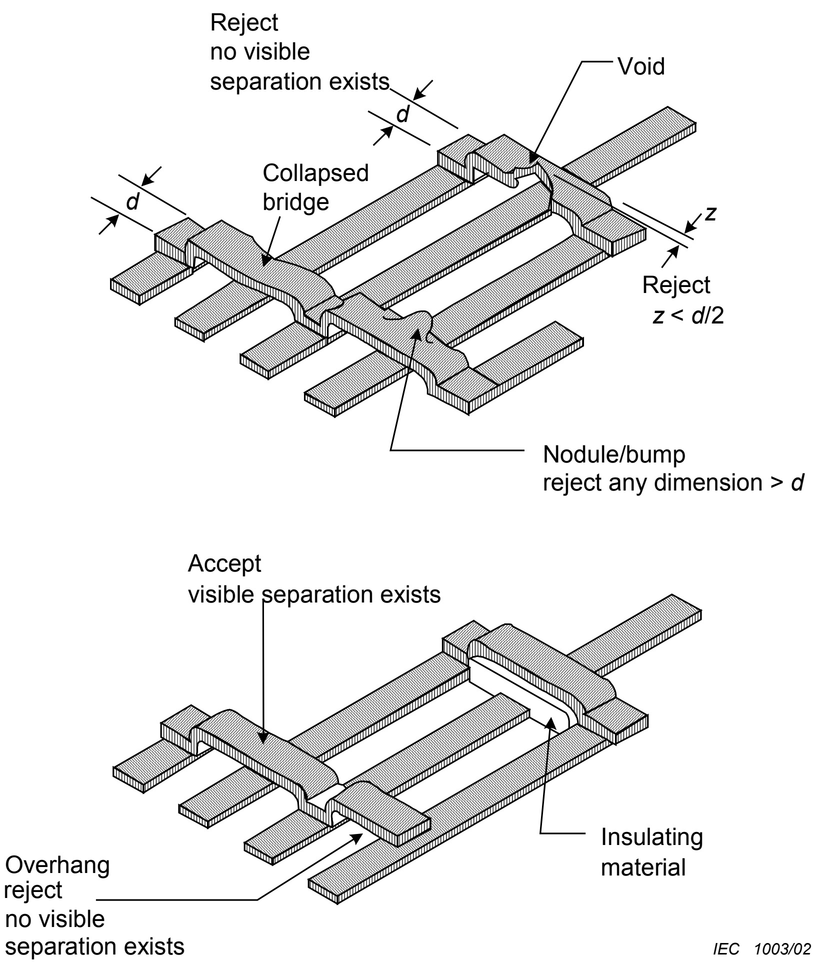


Figure 43 – Class H and Class K – Coupling (air) bridge criteria

7 Planar thick film element inspection

Inspection for visual non-conformances described in this clause shall be conducted on each planar thick film passive element. All inspection shall be performed at "low magnification" within the range of 10× to 60× magnification for both class H and class K.

7.1 Operating metallization non-conformances - "low magnification"

NOTE The metallization non-conformance criteria contained in this subclause apply to operating metallization only.

No element shall be acceptable that exhibits:

7.1.1 Metallization scratches

Class H

a) A scratch or probe mark in the metallization, excluding bonding pads, that both exposes underlying material anywhere along its length and leaves less than 50 % of the original metallization width undisturbed (see figure 44).

NOTE 1 Underlying material does not have to be exposed along the full length of the scratch.

NOTE 2 This criterion does not apply to capacitors.

Class K

a) Same as Class H.

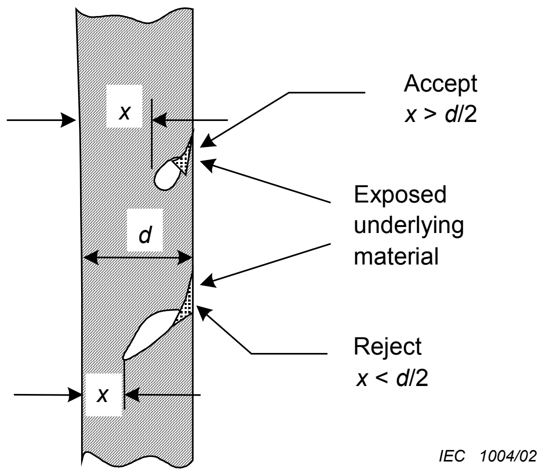


Figure 44 – Class H – Metallization scratch criteria

Class H

b) Scratch in the bonding pad area that both exposes underlying material and reduces the metallization path width, where it enters the bonding pad, to less than 50 % of its original metallization width. If two or more metallization paths enter a bonding pad, each shall be considered separately (see figure 45).

Class K

b) Less than 75 % (see figure 46).

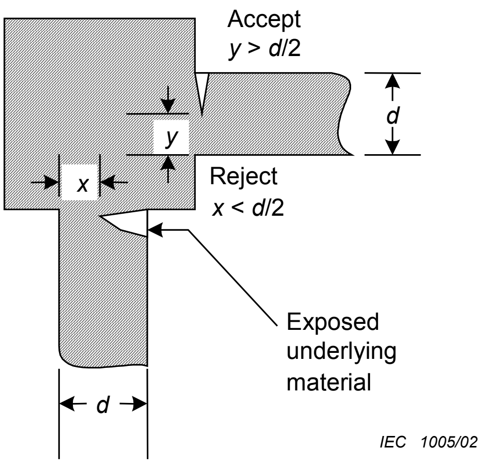


Figure 45 – Class H – Metallization width reduction at bonding pad criteria

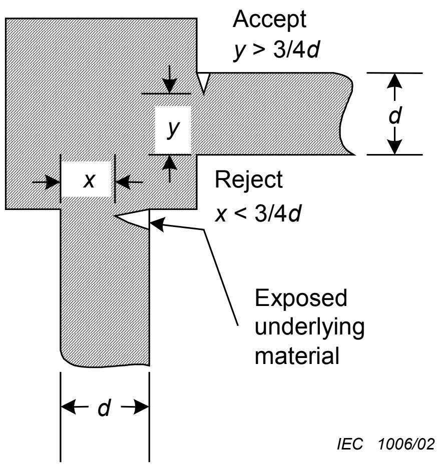


Figure 46 – Class K – Metallization width reduction at bonding pad criteria

c) Scratch or probe marks in the bonding pad area that expose underlying material over more than 25 % of the original metallization area.

c) Same as Class H.

7.1.2 Metallization voids

Class H

a) Void(s) in the metallization, excluding bonding pads, that leaves less than 50 % of the original metallization width undisturbed (see figure 47).

Class K

a) Same as Class H.

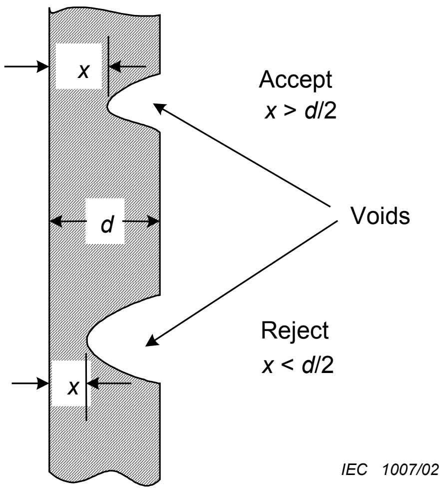


Figure 47 – Class H – Metallization void criteria

Class H

b) Void(s) in the bonding pad area that reduce the metallization path width, where it enters the bonding pad, to less than 50 % of its original metallization width. If two or more metallization paths enter a bonding pad, each shall be considered separately.

NOTE Figures 45 and 46 illustrate metallization width reduction at bonding pad criteria for scratches. Void criteria are similar.

c) Void(s) in the bonding pad area that expose underlying material over more than 25 % of the original metallization area.

NOTE For r.f. microwave elements on non-conductive substrates, a void created in the bonding pad area as a result of wire bond removal for performance optimization or tuning, is not rejectable provided that the void remains entirely visible.

Class K

b) Less than 75 %.

c) Same as Class H.

7.1.3 Metallization corrosion

Class H

a) Any metallization corrosion.

Class K

a) Same as Class H.

7.1.4 Metallization adherence

Class H

a) Any metallization lifting, peeling, or blistering.

NOTE 1 Nodules are acceptable. In order to determine if a bump in the metallization is a blister or a nodule, attempt to flatten the bump with a non-metallic instrument. If the bump flattens, then it is a blister.

NOTE 2 These criteria are not applicable to separation induced anomalies (for example, metallization lifting due to scribe and break or diamond sawing) since these are not indicative of adhesion problems.

Class K

a) Same as Class H.

7.1.5 Metallization protrusion

Class H

a) More than 50 % reduction of the original design separation, between any protruding metallization and adjacent metallization paths (see figure 48).

Class K

a) Same as Class H.

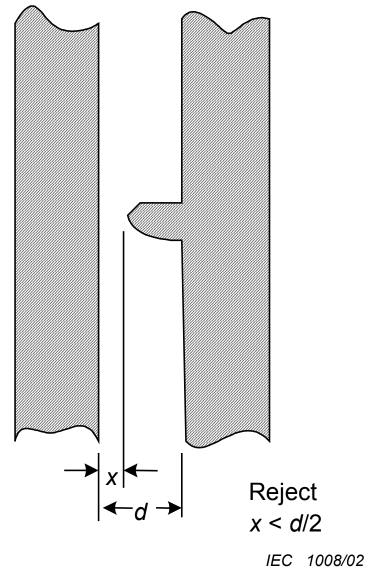


Figure 48 – Class H – Metallization protrusion criterion

7.1.6 Metallization overlap

Class H

a) Contact overlap between the upper and lower metallizations that is less than 50 % of the designed contact overlap area (see figure 49).

NOTE The overlap area is that area in which the upper metallization actually contacts the lower metallization.

Class K

a) Same as Class H.

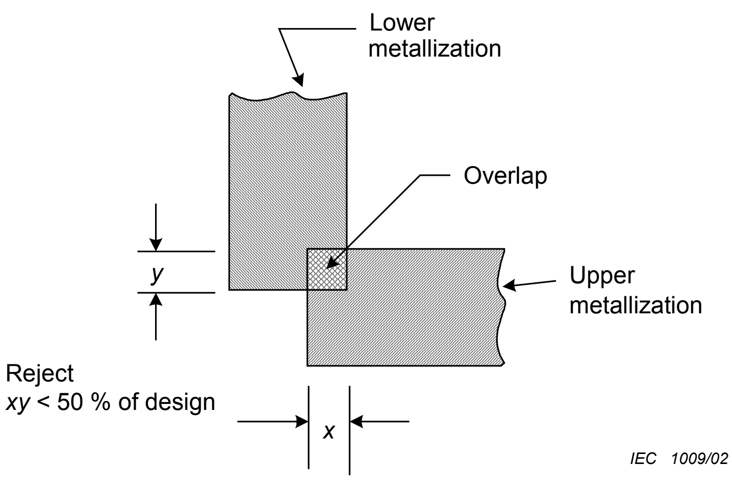


Figure 49 – Class H – Metallization overlap criterion

7.1.7 Metallized through-hole non-conformances - "low magnification"

No element shall be acceptable that exhibits:

Class H

a) Through-hole metallization that is not perpendicularly continuous or that does not cover at least a continuous 50 % of the inside, circumferential surface area unless by design.

Class K

a) Same as Class H.

7.1.8 Wrap-around connection non-conformances - "low magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) Unmetallized area in the edges of wrap-around connections greater than 50 % of the largest dimension of the edge metallization (see figure 50).	a) Same as Class H.

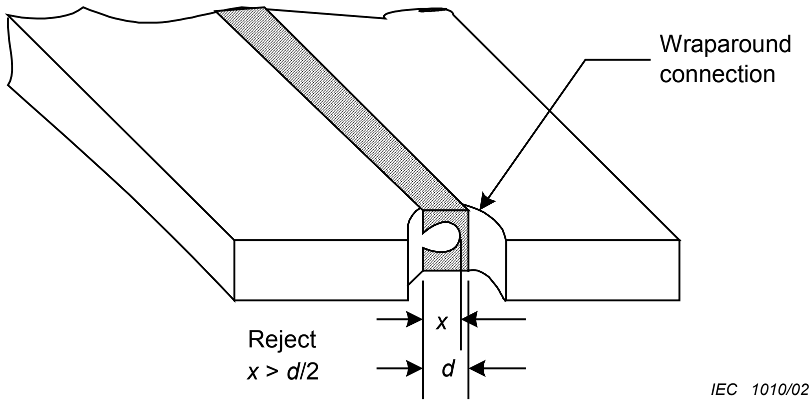


Figure 50 – Class H – Wrap-around connection unmetallized area criterion

7.2 Substrate non-conformances - "low magnification"

No element shall be acceptable that exhibits:

a) Less than 2,5 µm separation between the operating metallization and the edge of the element unless by design (see figure 51). NOTE This criterion does not apply to substrates designed for wrap-around conductors.	a) Same as Class H.
b) A chipout that extends into the active circuit area (see figure 51).	b) Same as Class H.

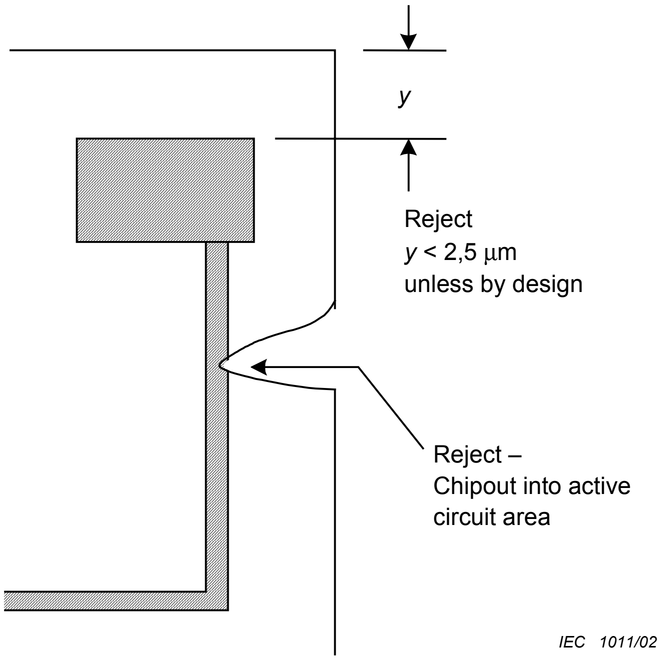


Figure 51 – Class H – Separation and chipout criteria

c) Any crack that exceeds 125 µm in length (see figure 52). NOTE For fused quart or crystalline substrates, no cracking is allowed.	c) Same as Class H.
d) Any crack that does not exhibit 25 µm of separation from any active circuit area or operating metallization (see figure 52).	d) Same as Class H.

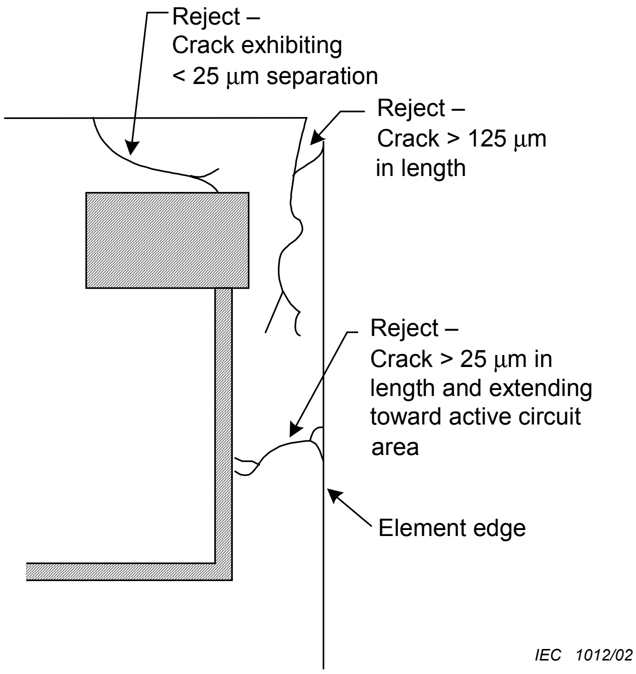


Figure 52 – Class H – Additional crack criteria

Class H

e) Any crack exceeding 25 µm in length extending from the element edge directly towards the active circuit area or operating metallization (see figure 52).

f) N/A

Class K

e) Same as Class H.

f) Semicircular crack or combination of cracks along the element edge whose total length is equal to or greater than 75 % of the narrowest separation between any two bonding pads (see figure 53).

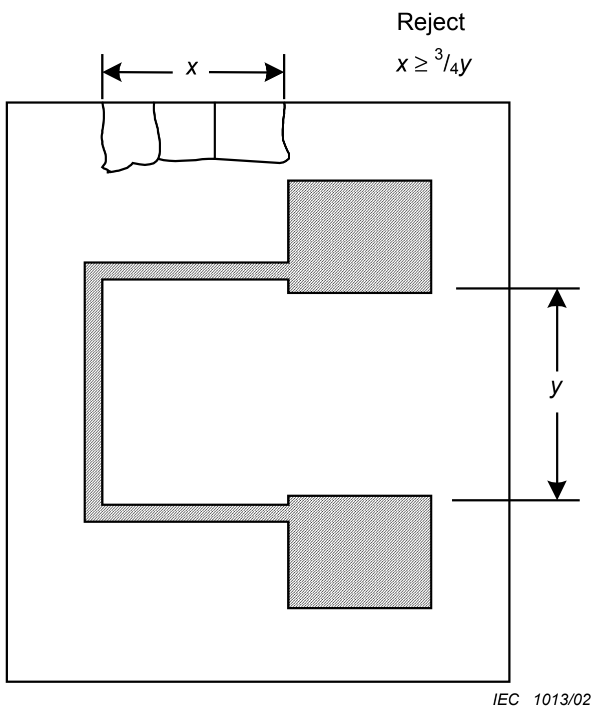


Figure 53 – Class K – Semicircular crack criterion

Class H

g) An attached portion of a circuit area from an adjacent element.

h) Any crack that does not originate at an edge.

i) Holes through the substrate, unless by design.

j) Patterned substrates having a section broken out around a substrate mounting hole(intended for substrate-to-post attachment) that is greater than 25 % of the mounting hole circumference.

Class K

g) Same as Class H.

h) Same as Class H.

i) Same as Class H.

j) Same as Class H.

7.3 Thick film resistor non-conformances - "low magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) A reduction due to voids of the resistor at the terminal to less than 50 % of the original resistor width (see figure 54).	a) Same as Class H.

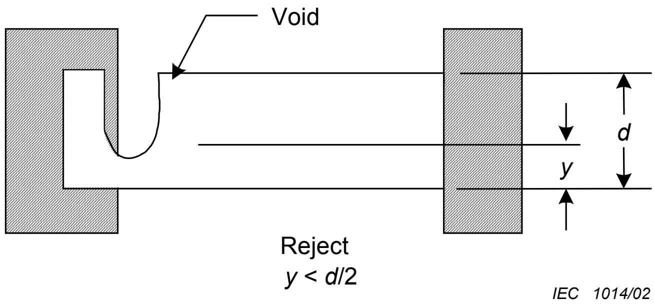


Figure 54 – Class H – Resistor width reduction at terminal caused by voids criterion

Class H	Class K
b) Reduction due to neck-down of the resistor at the terminal, to less than 50 % of the original resistor width (see figure 55).	b) Same as Class H.

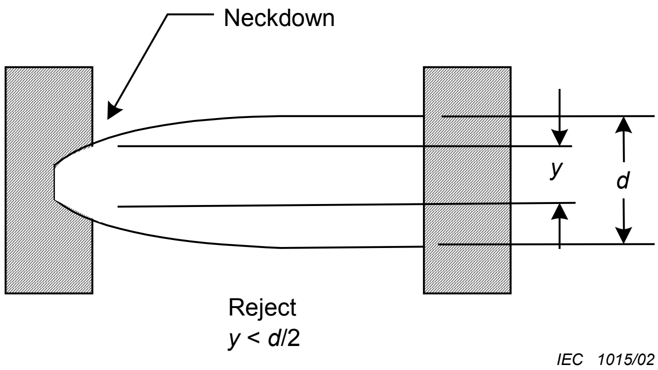


Figure 55 – Class H – Resistor width reduction at terminal by neck-down criterion

Class H	Class K
c) Any resistor film lifting, peeling, or blistering.	c) Same as Class H.
d) Crack in the resistor greater than 25 µm in length.	d) Same as Class H.
NOTE Irregularities such as fissures in resistor material that are created during firing, and that do not expose the underlying material, are not considered to be cracks.	
e) Evidence of resistor repair by over-printing or any other means.	e) Same as Class H.

Class H	Class K
f) Separation between any two resistors that is less than 50 % of the original separation.	f) Same as Class H.
g) Separation between any resistor and conductor combination that is less than 50 % of the original separation.	g) Same as Class H.
h) Increase in resistor width greater than 25 % of the original design width.	h) Same as class H.
i) Resistor that is closer than 25 µm to the edge of the substrate.	i) Same as Class H.
j) Reduction of resistor width resulting from voids, scratches, or chipouts, or a combination of these, that leaves less than 50 % of the narrowest resistor width (see figure 56).	j) Same as Class H.

PRECAUTIONARY NOTE The maximum allowable current density requirement must not be exceeded.

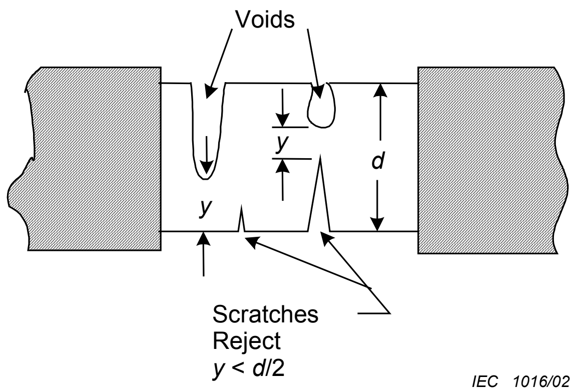


Figure 56 – Class H – Resistor width reduction criteria

Class H	Class K
k) Contact overlap between the metallization and the resistor in which the actual width dimension "*y*" is less than 50 % of the original resistor width (see figure 57).	k) Less than 75 % (see figure 58).

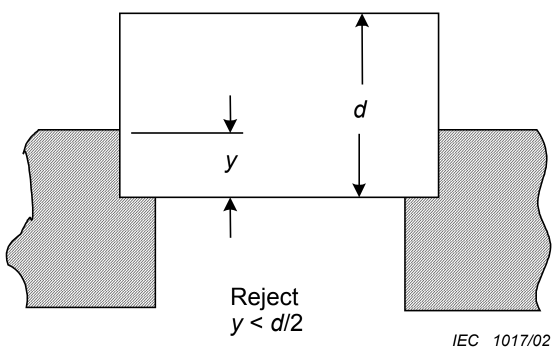


Figure 57 – Class H – Resistor overlap criterion

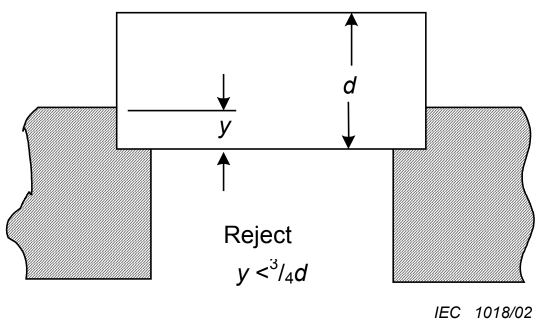


Figure 58 – Class K – Resistor overlap criterion

Class H	Class K
l) Contact overlap between the metallization and the resistor in which the length dimension "x" is less than 75 µm (see figure 59).	l) Same as Class H.

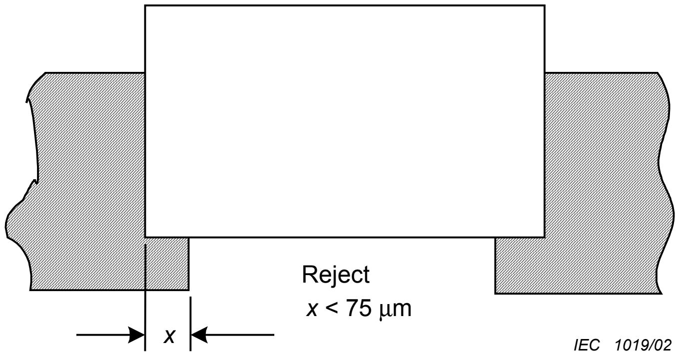


Figure 59 – Resistor overlap criterion

m) Voids or misalignment of glassivation that results in less than 90 % coverage of the resistor area, unless by design.	m) Same as Class H.
n) Crazing of glassivation over a resistor.	n) Same as Class H.
o) Glassivation scratches, lifting, or peeling that expose any portion of a resistor.	o) Same as Class H.

7.4 Trimmed thick film resistor non-conformances - "low magnification"

NOTE The trim non-conformance criteria contained in this subclause apply to active resistor areas only.

No element shall be acceptable that exhibits:

a) A kerf width less than 12,5 µm (see figure 60).	a) Same as Class H.

NOTE This does not apply to edge trimming.

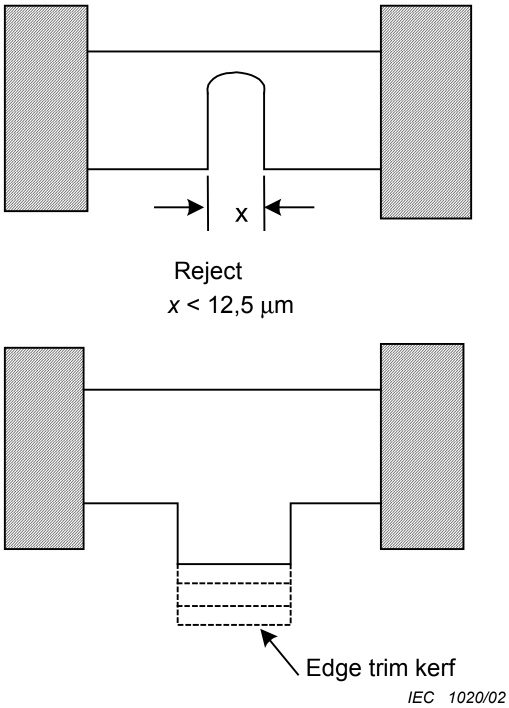


Figure 60 – Class H – Kerf width criteria

Class H

b) A kerf containing detritus.

c) A kerf which extends into metallization and leaves less than 75 % of the metallization width undisturbed (see figure 61).

NOTE Opening a metallization link by design is acceptable.

Class K

b) Same as Class H.

c) Same as Class H.

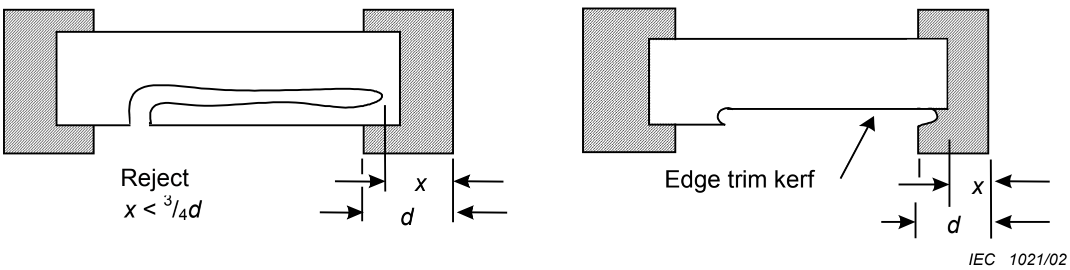


Figure 61 – Class H – Laser trim kerf extension into metallization criteria

Class H

d) A kerf that leaves less than 50 % of the original width of a resistor, unless by design (see figure 62).

PRECAUTIONARY NOTE The maximum allowable current density requirement must not be exceeded.

Class K

d) Same as class H.

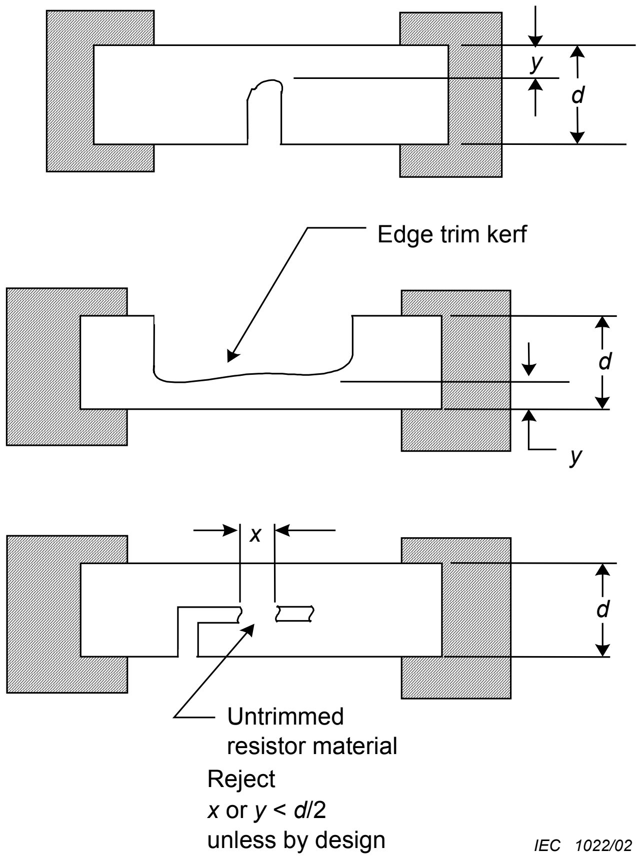


Figure 62 – Class H – Resistor width reduction and untrimmed resistor material criteria

Class H	Class K
e) A trim that does not originate from the edge of the resistor.	e) Same as Class H.

7.5 Multilevel thick film non-conformances - "low magnification"

No element shall be acceptable that exhibits:

a) Any insulating material that does not extend beyond the width of the upper and lower metallization by 75 µm minimum (see figure 63).	a) Same as Class H.
b) Voids in the insulating material that expose underlying metallization.	b) Same as Class H.
c) Vias that are less than 50 % of the original design area.	c) Same as Class H.
d) Scratch that completely crosses the metallization and damages the insulating material surface on either side.	d) Same as Class H.

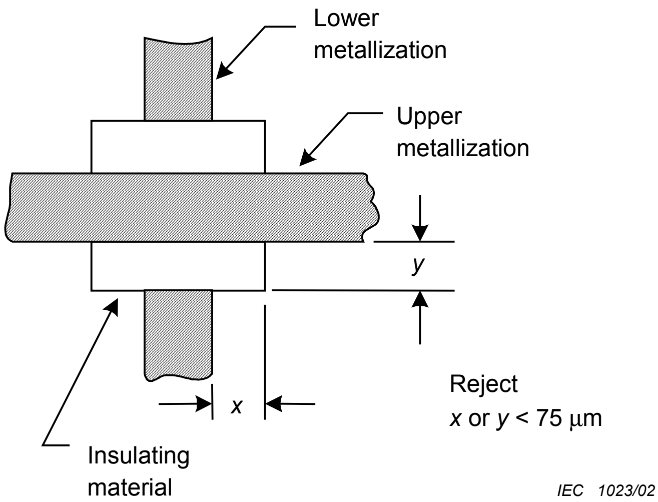


Figure 63 – Class H – Dielectric extension criteria

7.6 All thin film capacitors and overlay capacitors used in GaAs microwave devices - "low magnification"

No element shall be acceptable that exhibits:

a) scratches that expose an underlying material;
b) any peeling or lifting of the metallization;
c) excess top metal which extend beyond the capacitor bottom metal;
d) voids in the capacitor bottom metal which extend under the capacitor top metal;
e) voids in the top metallization which leaves less than 75 % of the metallization area undisturbed.

8 Active and passive elements

All integrated circuit, transistor and semiconductor diode elements shall be examined in accordance with the visual inspection requirements of IEC 60747.

Passive elements (including substrates) shall be examined in accordance with clauses 5 and 6.

Soldered surface mounted assemblies shall be examined in accordance with IEC 61191-2.

9 Element attachment (assembly) - "magnification 10× to 60×"

9.1 Solder connections (general appearance)

No device will be acceptable that exhibits:

Soldered connections with poor wetting to either the film solder pad or the component termination. Good wetting is defined as when the wetting angle is less than 90° (see figure 64).

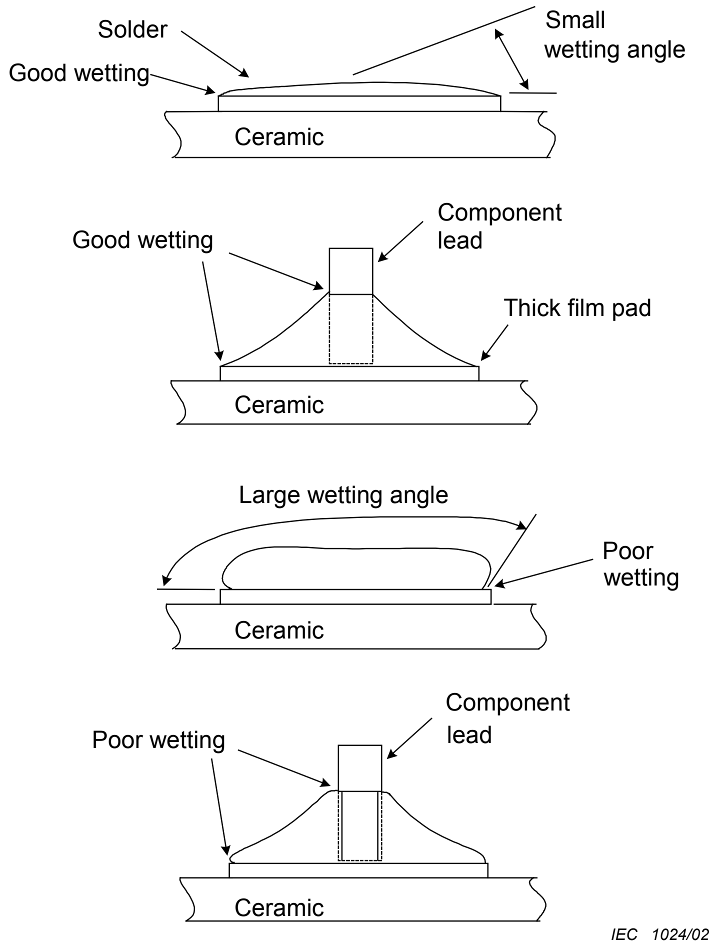


Figure 64 – Solder wetting criteria

The degree of wetting of solder to a conductor is assessed by the contact angle between the two at their common interface perimeter. Contact angles greater than 90° shall be the cause of rejection (see figure 65).

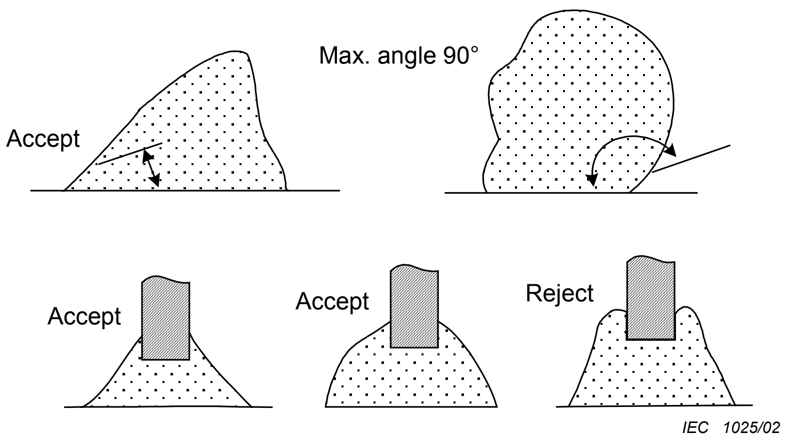


Figure 65 – Solder wetting contact angle

9.2 Element attachment requirements

Figure 66 gives examples of visual representations of attachment media types.

NOTE 1 Rejection criteria are not to be derived from these examples but rather from the specific criteria descriptions that follow.

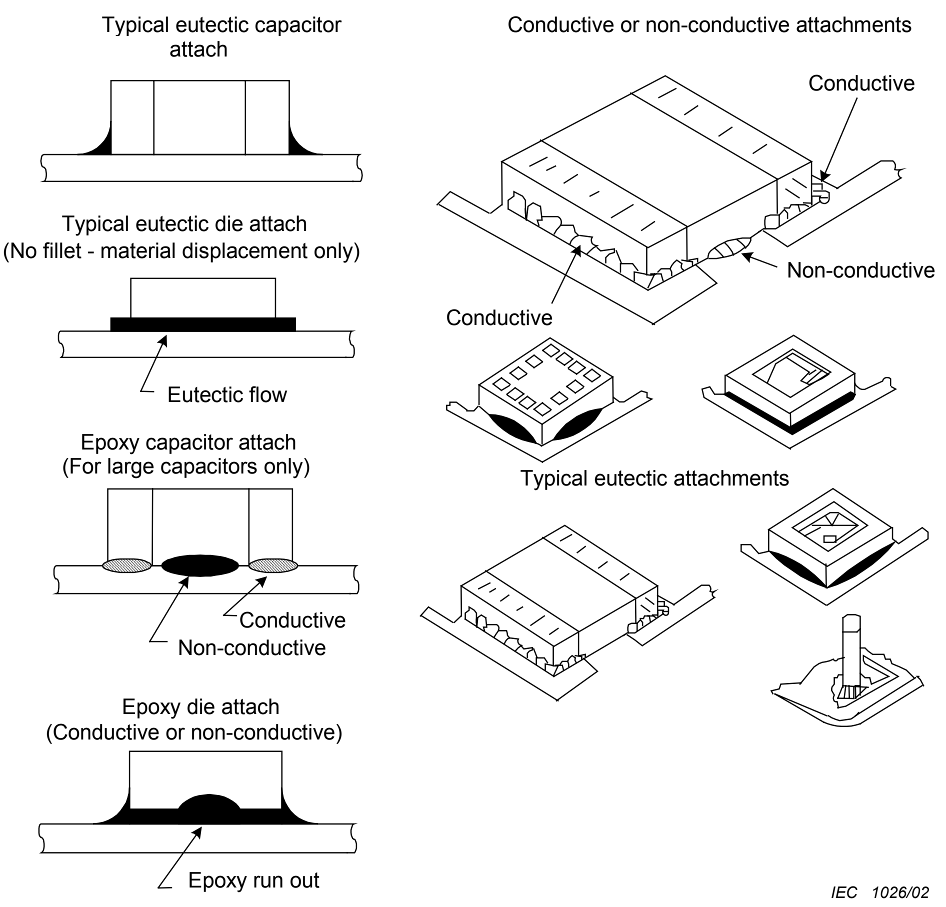


Figure 66 – Element attachments

Class H

NOTE 2 Mechanical strength or radiography may be used to verify attachment in lieu of visual criteria.

Class K

Dielectric attachment may be assessed through mechanical strength testing. For conductive attachment, the qualifying activity may approve alternative methods for verifying attachment integrity.

No device shall be acceptable that exhibits:

a) For non-end-terminated elements, attachment media not visible around at least 50 % of the perimeter unless it is continuous on two full non-adjacent sides of the element.

NOTE 3 The criterion of 9.2 a) does not apply when attachment material is applied directly to more than 50 % of the element attach area by use of a method such as preforms or printing.

Class H:

b) End-terminated elements that do not have conductive attachment media visible around at least 50 % of the visible bonding pad perimeter on each end termination. For dielectric attachment of end–terminated elements (i.e. where the body of the element between the end terminations is attached), the criterion of a) above applies.

Class K:

b) End terminated elements that do not have conductive attachment media visible around at least 75 % of the visible bonding pad perimeter on each end termination. For dielectric attachment of end terminated elements (i.e. where the body of the element between the end terminations is attached), the criterion of a) above applies.

NOTE 4 These criteria do not apply when attachment material is applied directly to more than 50 % of the substrate attach area by use of a method such as printing. Mechanical strength of the attachment may be verified in lieu of visual criteria.

Class H Class K

c) Glass substrates or transparent die, when viewed from the bottom, which exhibit attach area less than 50 %.

NOTE 5 This criterion may be employed in lieu of that of 8.2 a).

d) Flaking of the attachment media material.

e) Balling of the solder or alloy material that does not exhibit a fillet (see figure 67).

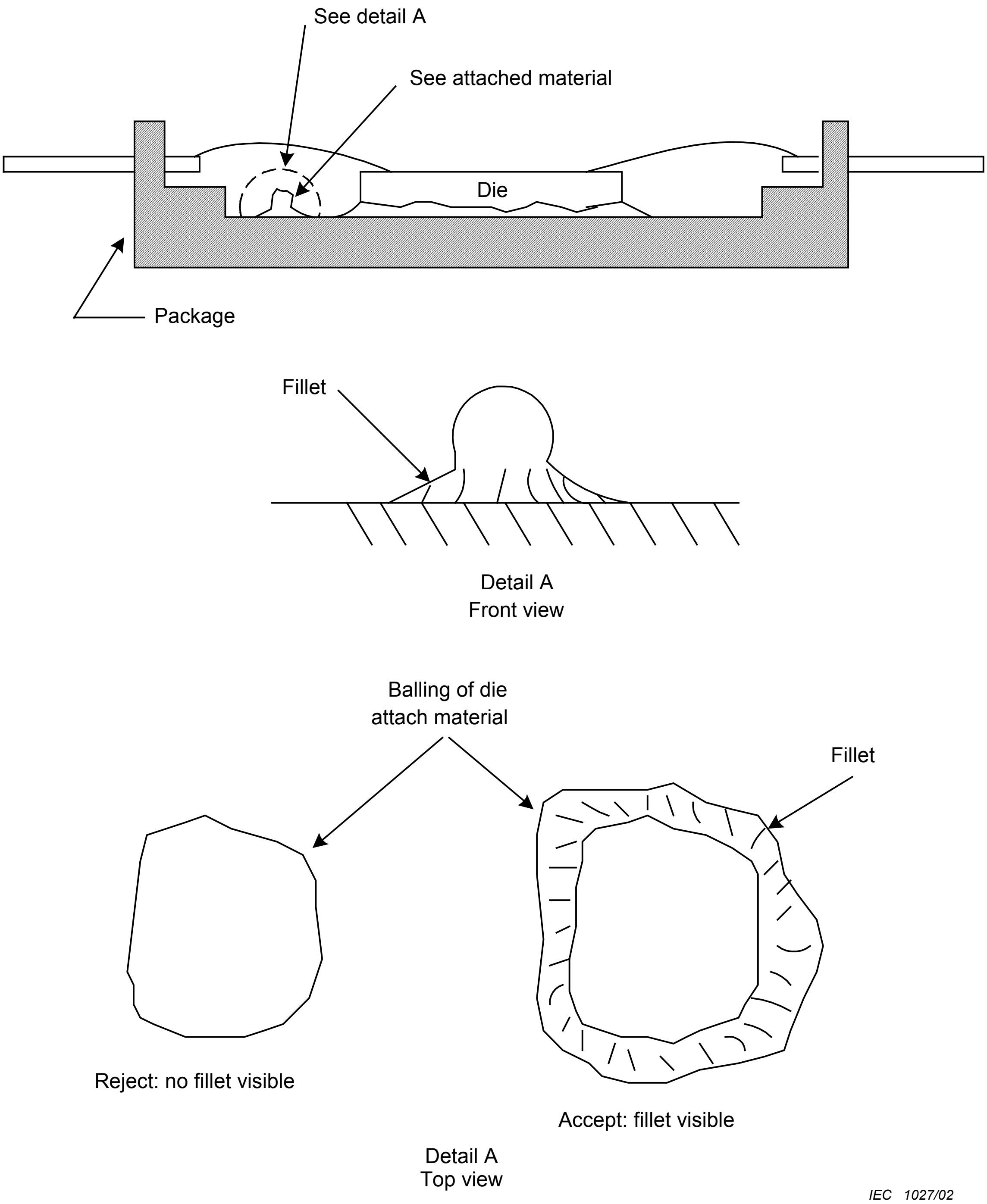


Figure 67 – Balling of die attach material

f) Conductive attachment media which comes closer than 25 µm to any functional metallization or element which is not electrically common.

g) Cracks in the surface of the attachment media greater than 125 µm in length or 10 % of the contact periphery, whichever is greater.

NOTE 6 Irregularities such as fissures or pullback at the edges of the adhesive are not considered cracks (see figure 68).

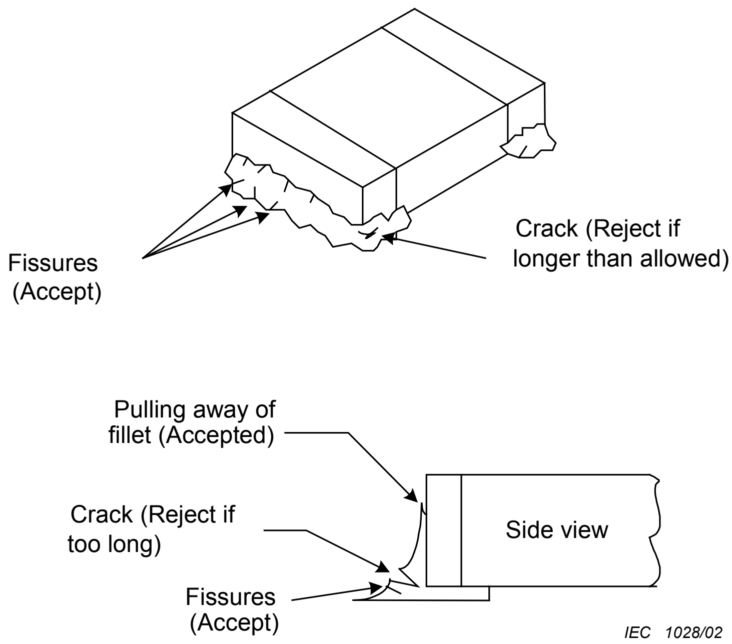


Figure 68 – Adhesive irregularities and cracks

h) Adhesive strings where the diameter of the string at the point of attachment is less than 50 % of the maximum length of the string (see figure 69).

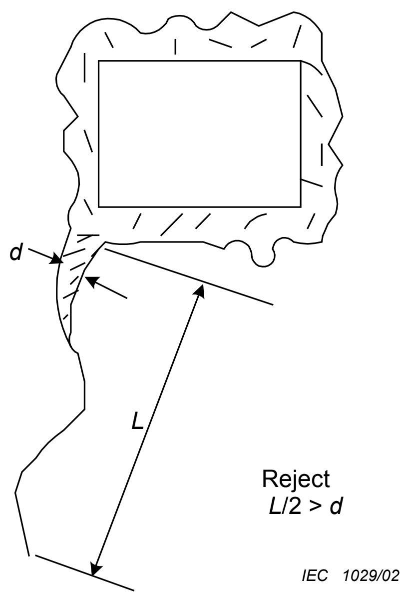


Figure 69 – Adhesive string criterion

i) For element connection to a package post lead, attachment media visible for less than 25 % of the post perimeter. When the post also serves for substrate attachment, media shall be visible for no less than 50 % of the post perimeter (see figure 70).

j) Cold solder joints.

k) The width of a conductor shall not be reduced to less than 50 % of design through leaching or contamination.

l) The area of a solder pad shall not be reduced more than 25 % of its designed area through leaching or contamination.

m) Presence of any residual flux or flux residues (except, by design, ionically neutral flux).

n) For thin film NiCr only, non-conductive adhesive material that covers more than 10 % of the active area of deposited resistor material.

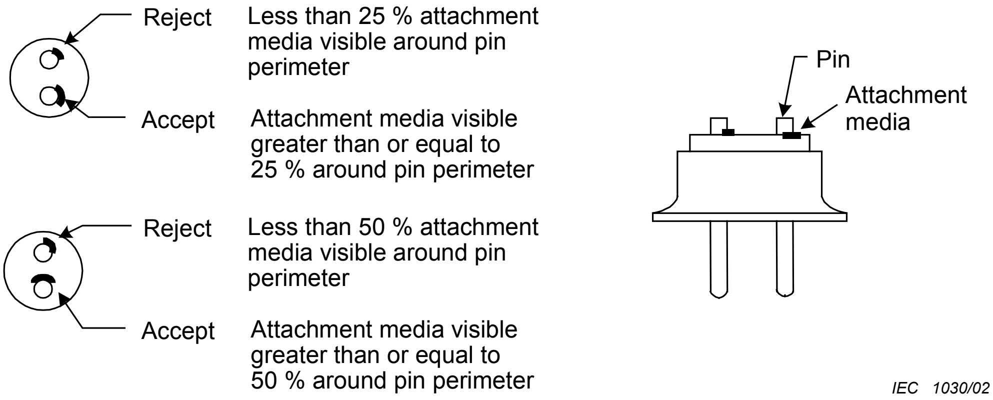


Figure 70 – Package post criteria

9.3 Leaded and leadless element attachment

Soldered surface mount components, pre-assembly, shall be examined in accordance with IEC 61191-2. Subclauses 9.4 to 9.6 give additional requirements.

9.4 Dual-in-line integrated circuit attachment (butt joints)

The following requirements apply to any component housed in a dual-in-line package (e.g. transistor/diode arrays, diode bridges) and other components, such as relays, connectors and transformers which do not have feet formed at the end of the leads and so make butt joints to the thick film pad.

No device shall be acceptable that exhibits:

Class H

a) A fillet of solder with inadequate wetting (see 9.1) of either lead or pad to less than 50 % of the available wetted area of a round or flat lead (see figure 71).

Class K

a) A fillet of solder with inadequate wetting (see 9.1) of either lead or pad to less than the available wetted area of a round or flat lead (see figure 71).

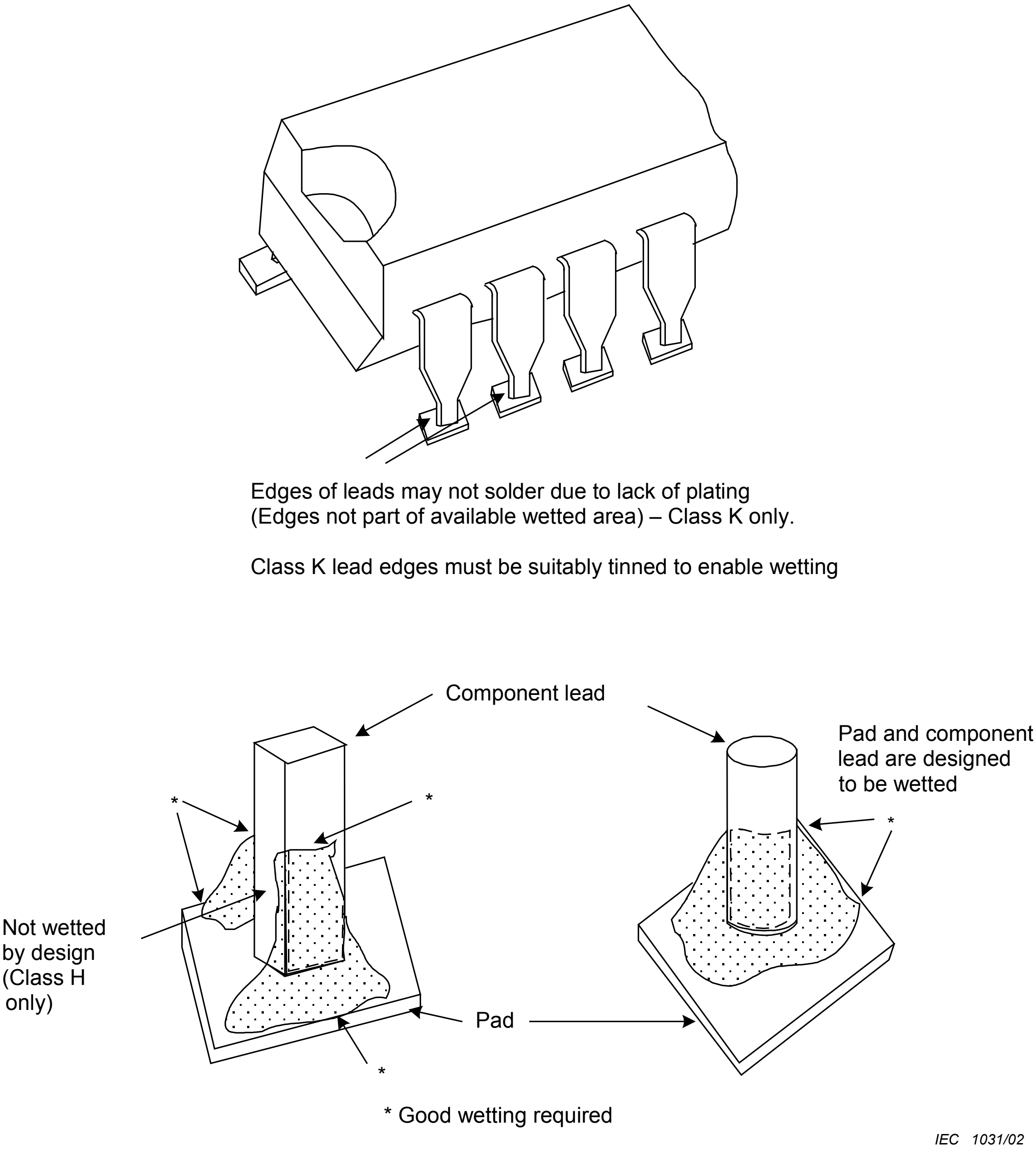


Figure 71 – Dual-in-line package leads solder wetting

Class H

b) Less than 50 % registration of the lead to pad (the requirements of 9.1 shall nevertheless be met) (See figure 72).

Class K

b) Less than 100 % registration of the lead to pad (the requirements of 9.1 shall nevertheless be met) (see figure 72).

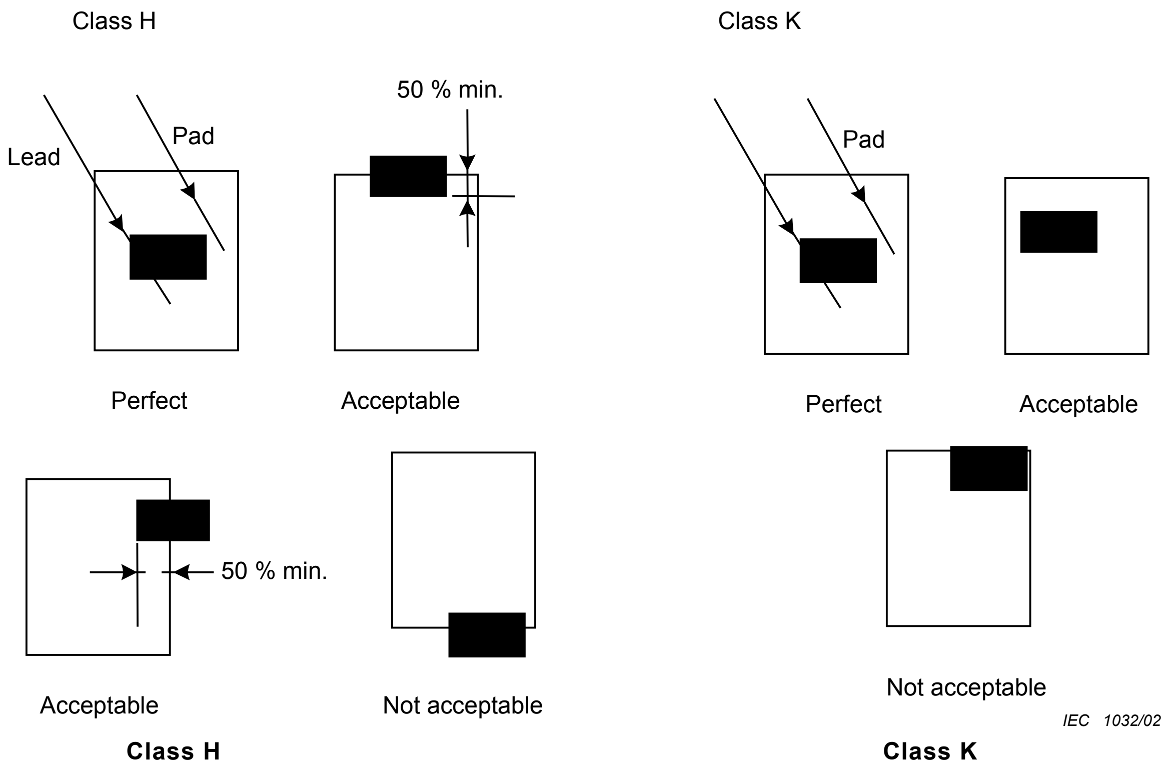


Figure 72 – Lead to pad registration

9.5 Axial and radial leaded components (lap joints)

The following requirements apply to any component or flying leads that are attached by lap joints.

No device shall be acceptable that exhibits:

a) Solder wetting of less than four wire diameters on both sides of the length of circular cross-section leaded components adding together the visible length down each side but not including the end which does not need to be wetted. (Each side shall have at least one wire diameter's length of good wetting). The profile of the component termination shall be visible through the solder coating (see figure 73).

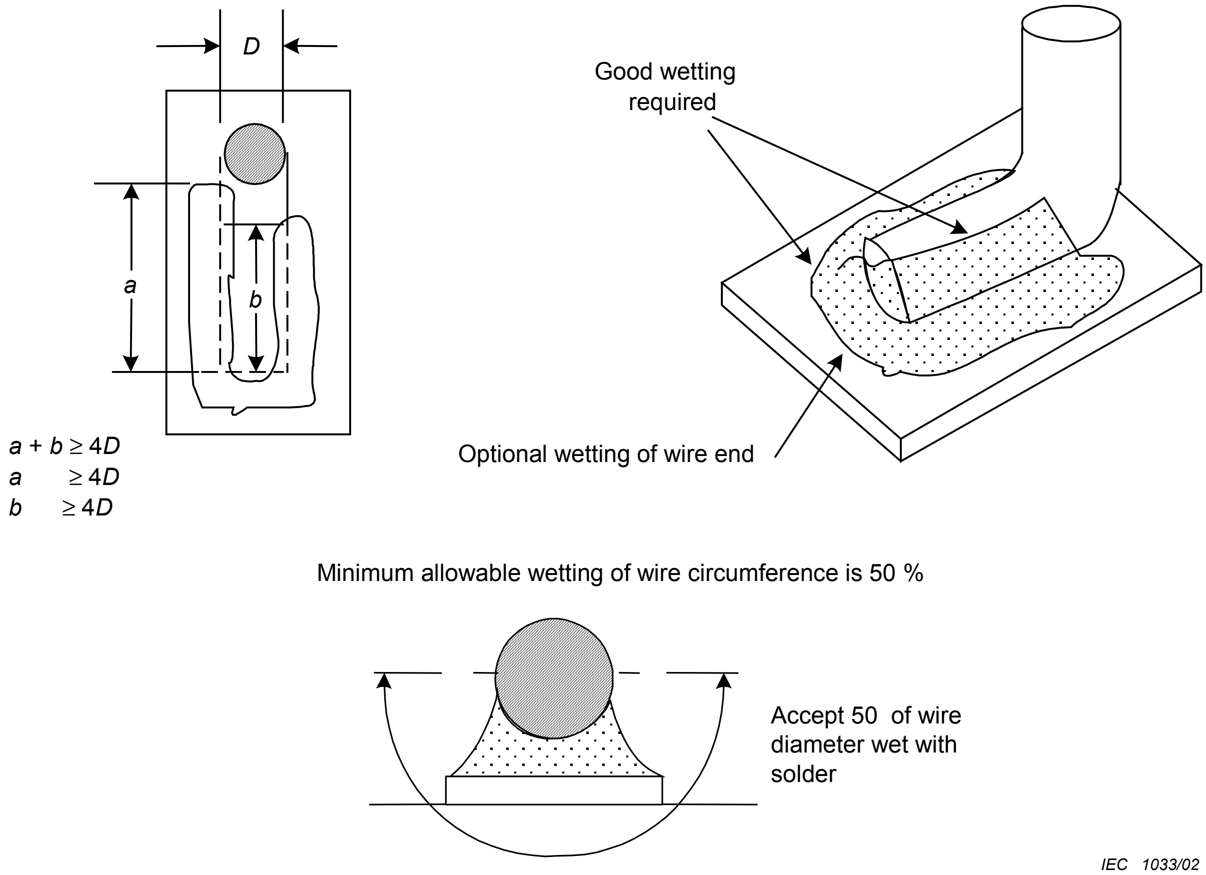


Figure 73 – Lap joint solder wetting

9.6 Components with feet (combined butt and lap joints)

The following requirements apply to components with ribbon tracks with formed feet such as SOT23 transistors, SO packaged ICs and leaded chip carriers. They also apply to larger components such as connectors and relays which have had feet formed on the end of their leads.

No device shall be acceptable that exhibits:

a) The fillet criteria depicted in figure 74 (acceptable joints are shown in figure 75).

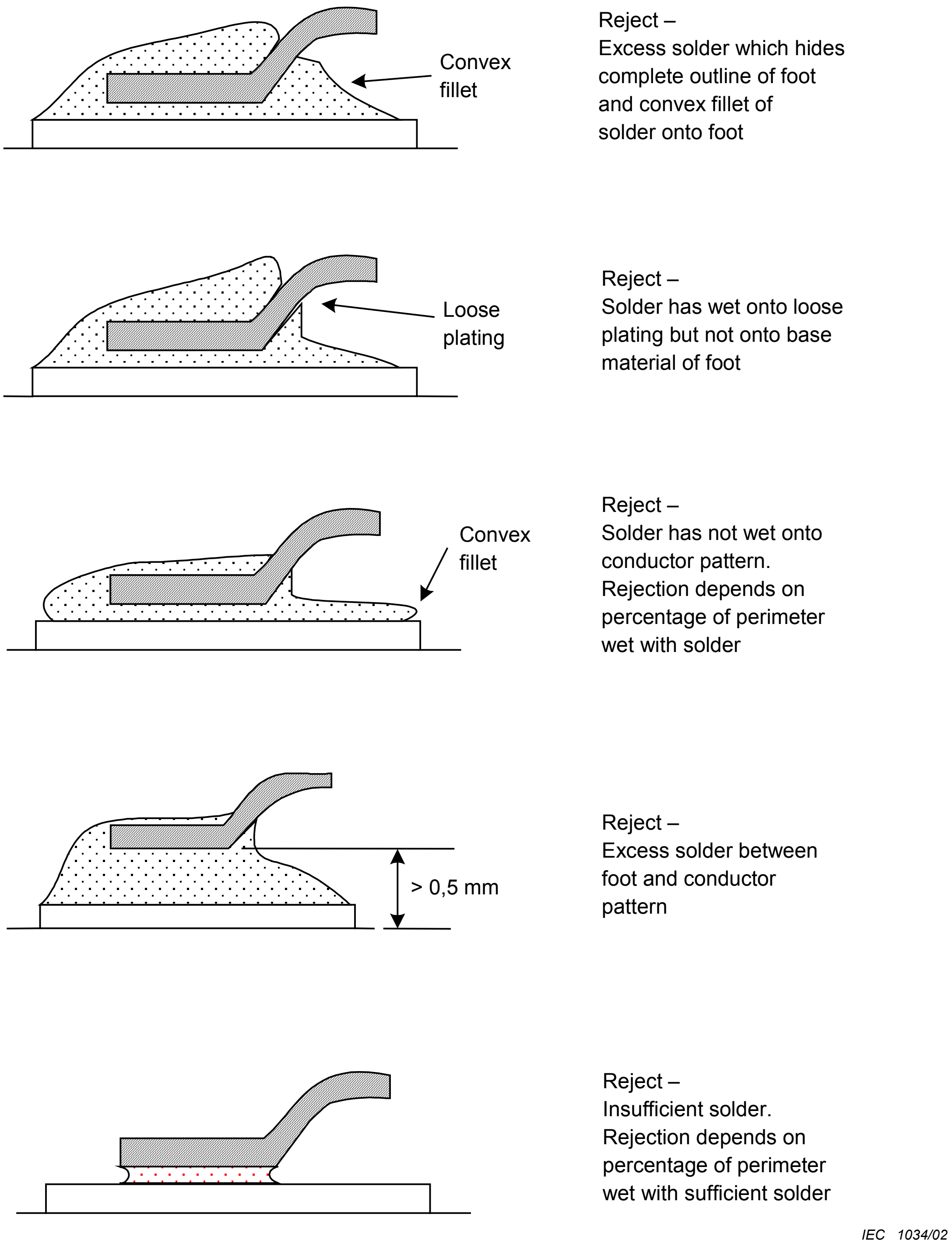


Figure 74 – Combined butt and lap joints solder wetting – Reject

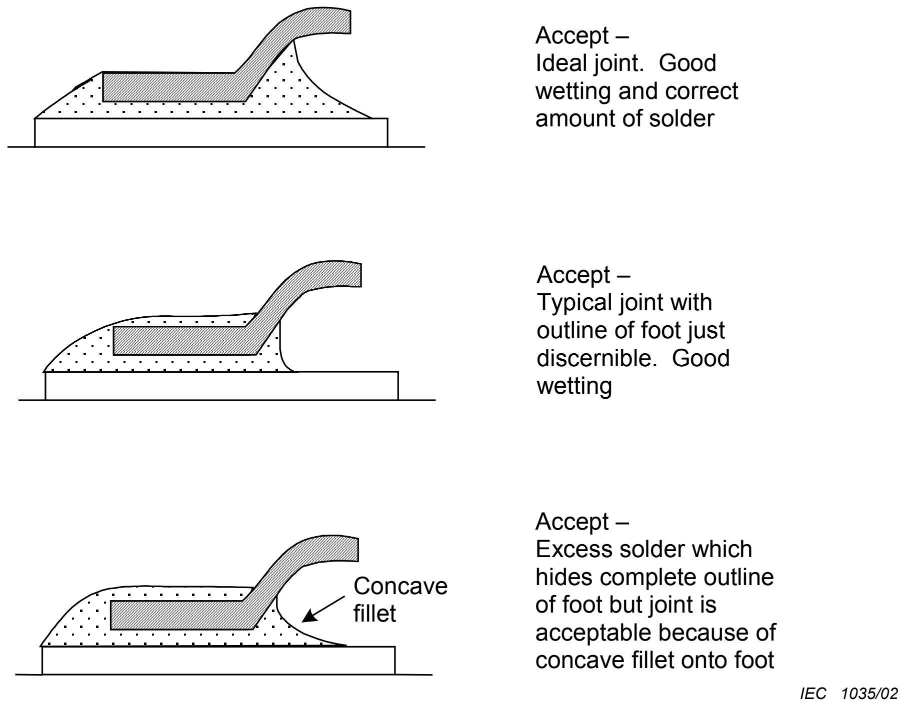


Figure 75 – Combined butt and lap joints solder wetting – Accept

Class H

b) Leads where the total solder fillet does not run along all faces solderable by design for a minimum of 75 % overall and a minimum of 50 % of each of these faces (see figure 76).

Class K

b) Leads where the total solder fillet does not run along the whole of all faces solderable by design (see figure 76).

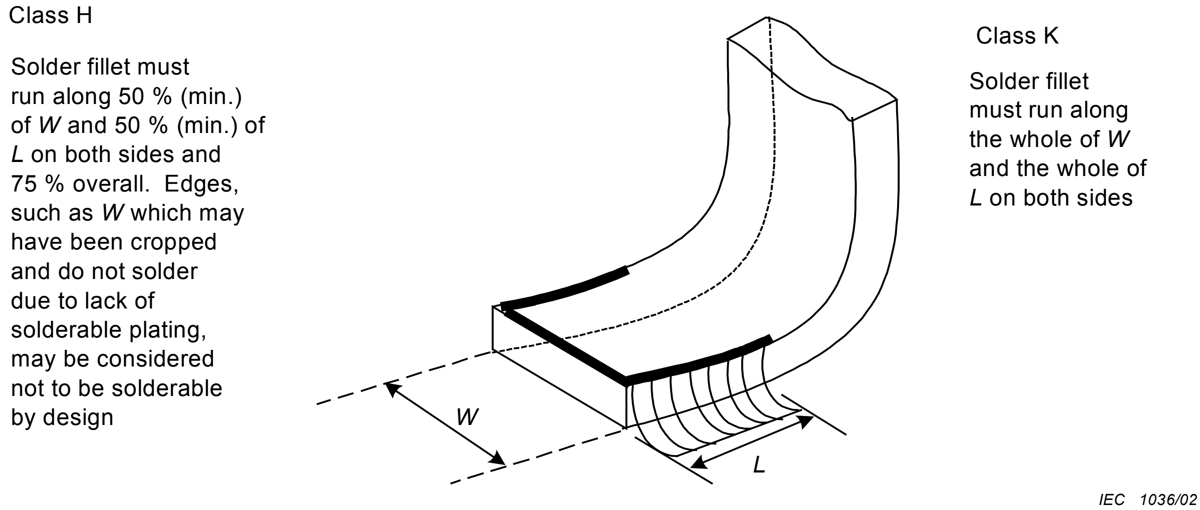


Figure 76 – Solder fillet coverage criteria

9.7 Leadless chip carriers

No device shall be acceptable which exhibits:

Class H

a) Package placement that reduces the isolation between adjacent pads to less than 250 µm or 50 % of the design space whichever is less (overhang of the chip carrier terminal to substrate pad shall not exceed 50 % of the lead out.

b) Inadequate solder wetting (see 9.1) on either the substrate pad or the visible portion of the chip carrier package terminal (although the main solder terminal of the chip carrier is on the underside when attached to the substrate there shall still be a visible solder fillet between the substrate solder pad and the visible perpendicular chip carrier terminal).

Class K

a) Same as Class H.

b) Inadequate solder wetting (see 9.1) on either the substrate pad or the visible portion of the chip carrier package terminal (although the main solder terminal of the chip carrier is on the underside when attached to the substrate there shall still be a visible solder fillet extending to at least 50 % of the available metallization path of each terminal).

10 Element orientation

Elements not located or oriented in accordance with the applicable assembly drawing of the device are not acceptable. Elements whose bond and electrical configuration is symmetrical may be rotated unless otherwise stated in the assembly drawings (see figure 77).

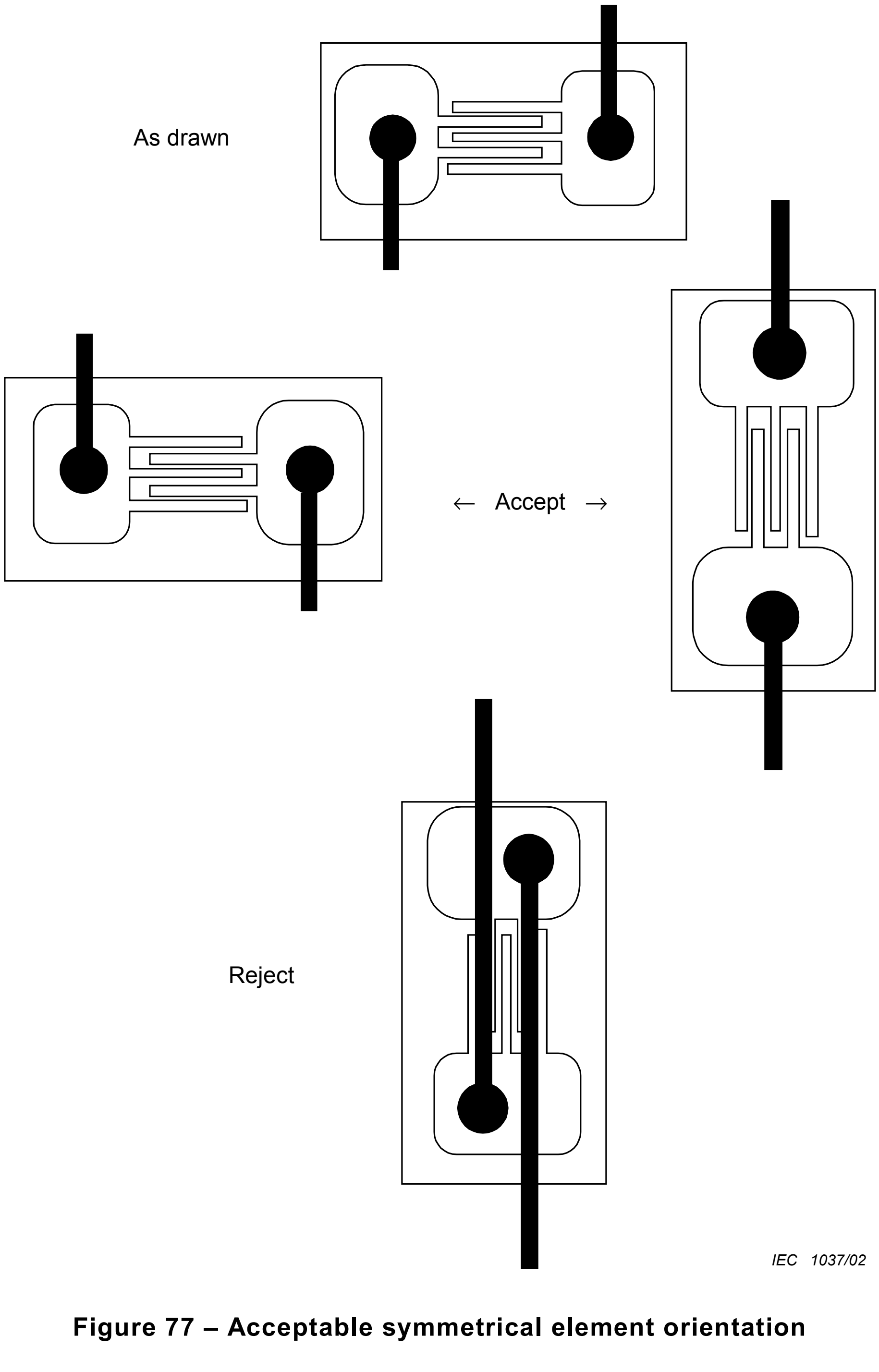


Figure 77 – Acceptable symmetrical element orientation

11 Separation

Elements shall not overhang the edge of the substrate. A minimum clearance of 25 µm shall be maintained between any uninsulated portion of the element and any non-common conductive surface.

12 Bond inspection, magnification 30× to 60×

The following shall be the required inspection for the bond type(s) and location(s) to which they are applicable when viewed from above.

NOTE Wire tail is not considered part of the bond when determining physical bond dimensions.

12.1 Ball bonds

No device shall be acceptable that exhibits:

a) ball bond diameter less than 2,0 times or greater than 5,0 times the wire diameter;
b) ball bonds where the wire exit is not completely within the periphery of the ball;
c) ball bonds where the wire centre exit is not within the boundaries of the bonding site.

12.2 Wire wedge bonds

No device shall be acceptable that exhibits (see figure 78):

a) ultrasonic and thermosonic wedge bonds that are less than 1,0 times or greater than 3,0 times the wire diameter in width or less than 0,5 times the wire diameter in length or no evidence of tool impression;
b) devices with thermocompression wedge bonds that are less than 1,2 times or greater than 3,0 times the wire diameter in width or less than 0,5 times the wire diameter in length or no evidence of tool impression.

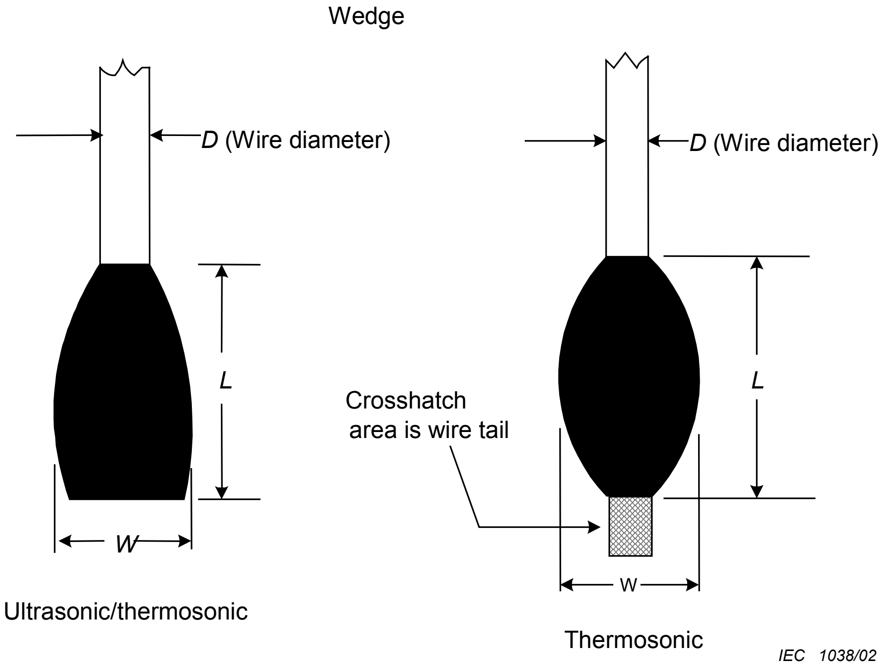


Figure 78 – Bond dimensions

NOTE 1 These criteria are not mandatory for wire bonds of diameters 100 µm and above which are used for applications such as power hybrids.

For wedge bonds of 100 µm diameter and above, the full impression of the bonding tool shall be evident on the surface of the bond.

NOTE 2 The heavy gauge wire used in power applications may use a wedge with an unconventional shape, which may affect the deformation characteristic of the wire during wire-bond operations.

12.3 Tailless bonds (crescent)

No device shall be acceptable that exhibits:

a) tailless bonds that are less than 1,2 times or greater than 5,0 times the wire diameter in width (see figure 79);

b) a tailless bond of a gold wire bonded on the aluminium pads of a die.

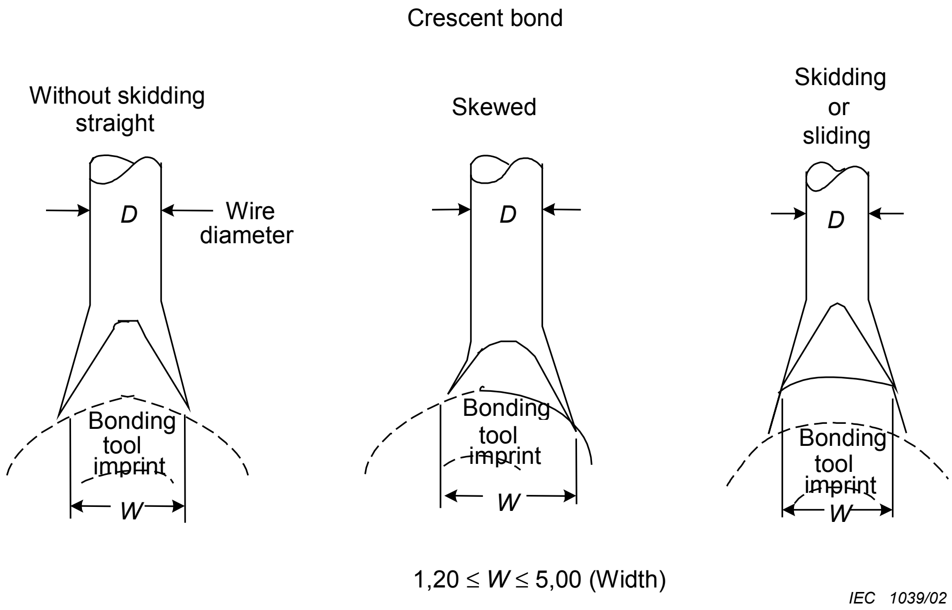


Figure 79 – Bond dimensions

12.4 Compound bond

No device shall be acceptable that exhibits the following:

a) one bond used to secure two common wires (see figure 80);

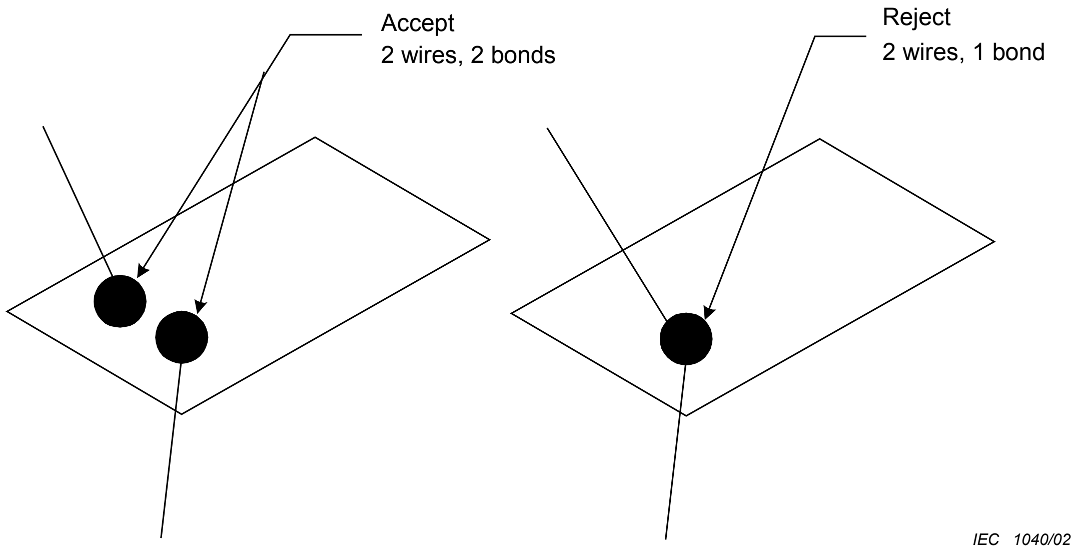


Figure 80 – One bond used to secure two common wires

b) more than one bond on top of original bond;

NOTE When required by design and based on a justifiable technical need, and with the approval of the qualifying or acquiring activity, additional compound bonds may be allowed in addition to the limitations of a) and b) above. Demonstration of acceptable N+1 bond stacks (N = maximum number of compound bonds allowable by the manufacturer's process) and establishment of necessary process controls will be required for approval.

c) compound bond where the contact area of the second bond with the original bond is less than 75 % of the bottom bond;

d) non-monometallic compound bond (i.e. between dissimilar metals, excluding the bond pad metallization).

12.5 Beam lead

This inspection and criteria shall apply to the completed bond area made using direct tool contact. No device shall be acceptable that exhibits:

a) bonds which do not exhibit 100 % bond/weld impression(s) across the width of the beam lead;

NOTE Gaps between bonds/welds on the beam lead caused by the natural footprint of a bond/weld tip (e.g. split tip, etc.), are acceptable provided the total of all gaps does not exceed 25 % of the beam lead width.

b) complete or partial beam separation from the die;

c) bonds on the substrate where the tool impression is not visible on the beam;

d) beam lead width increased by greater than 60 % of the original beam width;

e) bonds where the tool impression length is less than 25 μm (see figures 81a and 81b);

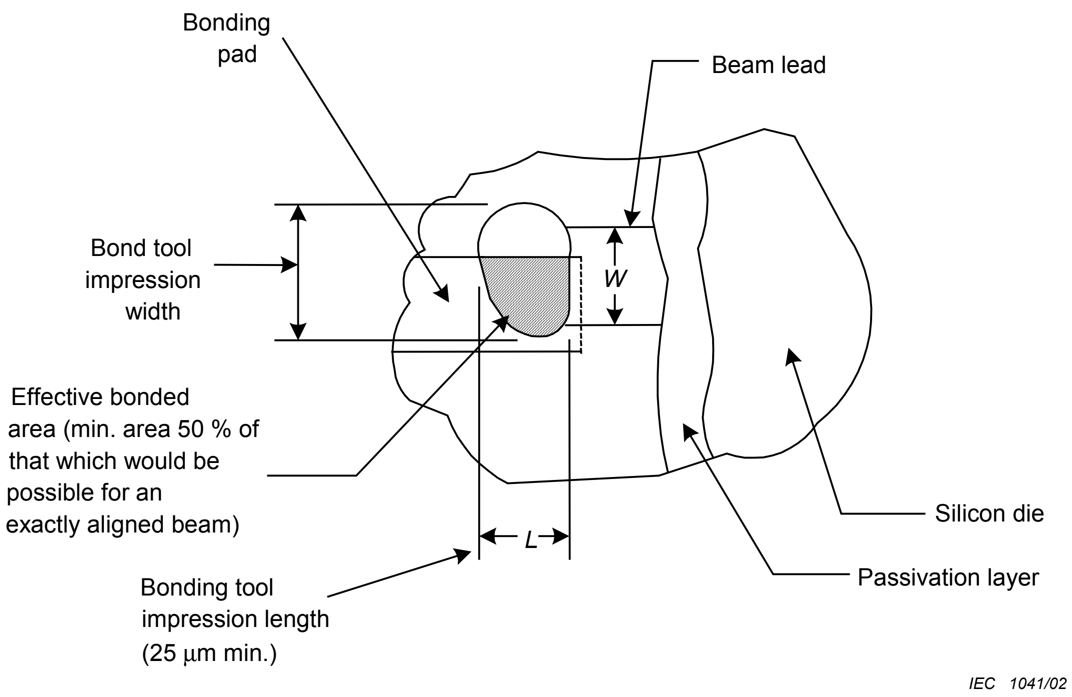


Figure 81a – Beam lead area and location

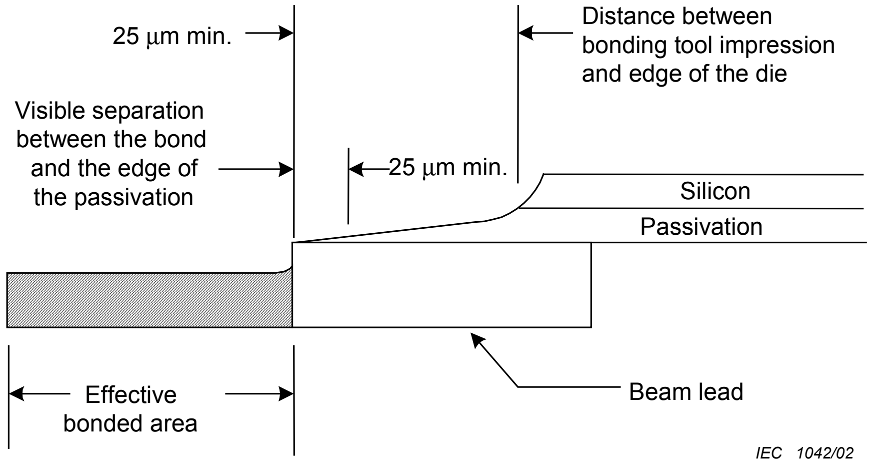


Figure 81b – Beam lead area and location

Figure 81 – Beam lead

f) bonding tool impression less than 25 µm from the die edge (see figures 81a and 81b);

g) effective bonded area less than 50 % of that which would be possible for an exactly aligned beam (see figures 81a and 81b);

h) any tears in the beam lead between the bond junction nearest the die body and the die or in the bonded area of the beam lead within a distance equal to 50 % of the beam lead width (see figure 82);

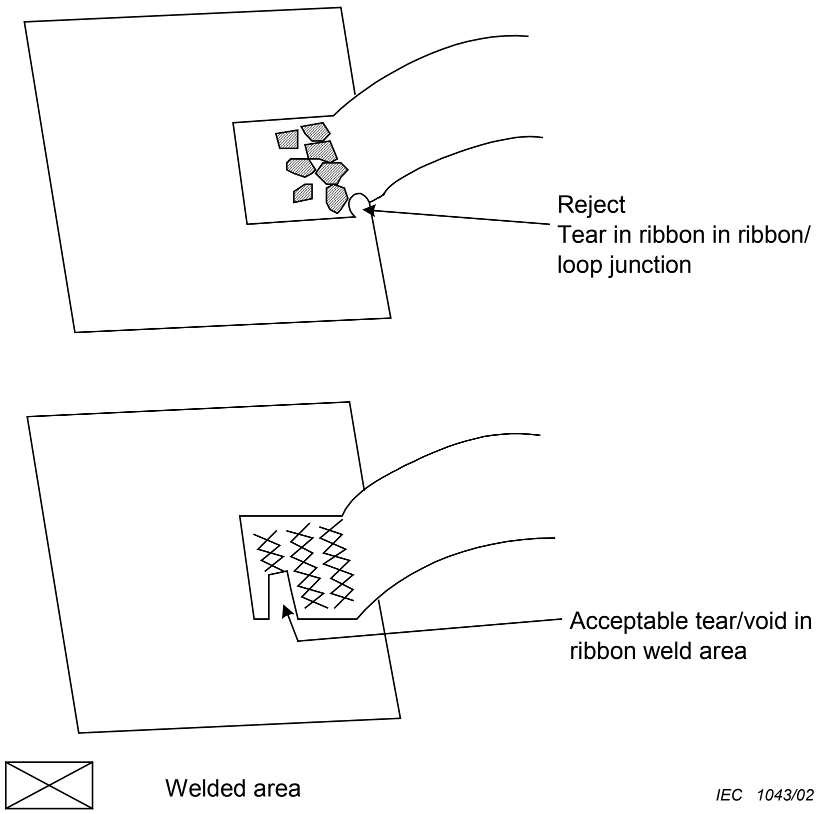


Figure 82 – Acceptable/rejectable tears or voids in ribbon weld area

i) an absence of visible separation between the bond and the edge of the passivation layer (see figure 81b);

j) an absence of visible separation between a beam lead and non-electrically-common metallization. This criterion applies for both glassivated and unglassivated metallization.

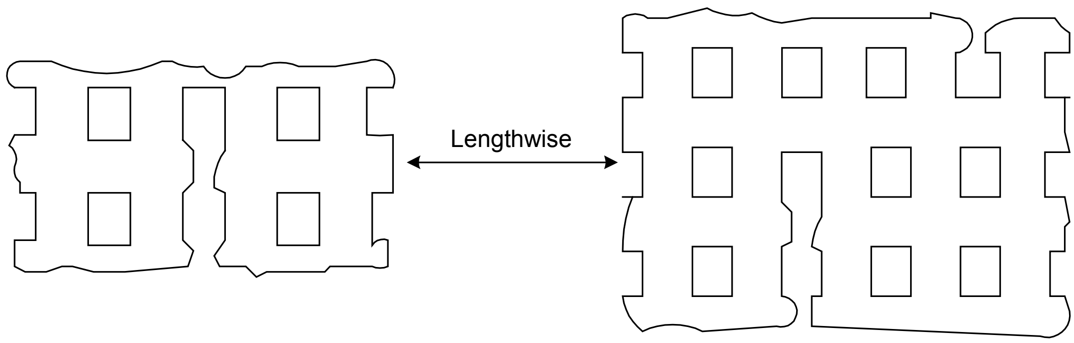
12.6 Mesh bonding

No device shall be acceptable that exhibits the following:

a) less than 50 % of the bond is on substrate metallization;

b) the number of continuous strands along the mesh is less than 50 % of lengthwise strands through each section (see figure 83);

c) less than two continuous conducting paths through a bond (see figure 84).

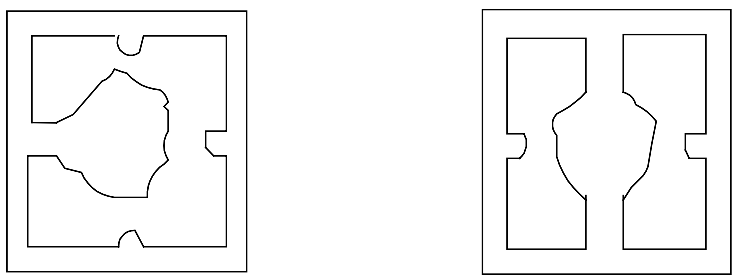


Reject: Less than half of the lengthwise strands are continuous (2 of 3 strands are discontinuous)

Accept: 2 (Half) or more of the lengthwise strands are continuous through each section

IEC 1044/02

Figure 83 – Criterion for strands along the mesh



Reject: No continuous path through the mesh between bonds

Accept: At least one continuous path through the mesh between bonds

IEC 1045/02

Figure 84 – Criterion for continuous conducting paths

12.7 Ribbon bonds

No device shall be acceptable that exhibits the following:

a) any tears in the ribbon at the junction between the ribbon loop and bond/weld;

b) bonds which do not exhibit 100 % bond/weld impression(s) across the width of the ribbon overlapping underlying metallization;

NOTE Gaps between welds on the ribbon caused by the natural footprint of a weld tip (e.g. split tip, etc.) are acceptable provided the total of all gaps does not exceed 25 % of the ribbon width.

c) effective bonded area less than 50 % of that which would be possible for an exactly aligned ribbon;

d) bond tails longer than one ribbon width or 250 µm, whichever is less, or bridging adjacent metallization;

e) the unbonded end of a ribbon bond tuning stub longer than one ribbon width or 250 µm, whichever is less, that is not secured by polymer adhesive.

12.8 General

No device shall be acceptable that exhibits:

Class H	Class K
a) Bonds on the die where less than 50 % of the bond is within the unglassivated bonding site.	Monometallic bonds on the die where less than 50 % of the bond is within the unglassivated bonding site. Bimetallic bonds on the die where less than 75 % of the bond is within the unglassivated bonding site.

b) Bonds on the package post or substrate that are not completely within the bonding site.

NOTE For cases where the substrate bonding site is smaller than 1,5 times the minimum bond size, bonds on the substrate where less than 50 % of the bond is within the bonding site are not acceptable.

c) Bonds placed so that the wire exiting from a bond crosses over another bond, except by design, in which case the clearance shall be 2,0 wire diameters minimum (common bonds are excluded from this criterion).

d) An absence of a visible line of separation between non-electrically-common bonds.

e) An absence of a visible line of separation between a bond and non-electrically-common metallization. This criterion applies to both glassivated and unglassivated metallization.

f) Wire bond tails that extend over or make contact with any non-common, unglassivated active metal.

g) Wire bond tails that exceed two wire diameters in length at the bonding pad or four wire diameters in length at the package post.

h) Bonds on element attach media or on contaminated or foreign material.

i) Any lifted or peeling bond.

j) Intermetallic formation extending completely around the metallic interface of any bond between dissimilar metals.

k) Wedge or crescent bonds at the point where metallization exits from the bonding pad that do not exhibit a line of undisturbed metal visible between the periphery of the bond and at least one side of the entering metallization stripe.

NOTE 1 The criterion of 12.8 k) can be excluded when the entering conductor is >50 μm in width and the bond pad dimension on the entering conductor side is >90 μm.

NOTE 2 For Class H only, the requirements for a visible line of metal can be satisfied when an acceptable wire tail obscures the area of concern, provided the following condition exists:- the bond is located more than 0,25 μm from the intersecting line of the entering metallization stripe and the bonding pad and there is no visual evidence of disturbed pad metallization at the bond and wire tail interface.

NOTE 3 The criterion of 12.8 k) is not applicable to interdigitated (Lange) couplers or when the interface between a thermosonic/ultrasonic (i.e. non-thermocompression) bond and underlying metal is monometallic.

l) Polymeric adhesive which may be material or residue as evidenced by discoloration within 125 μm of the outer periphery of a wire bond.

m) Tearing at the junction of the wire and bond. The junction is the line of deformation of the wire at the bonding site.

13 Internal leads (e.g. wires, ribbons, beams, wire loops, ribbon loops, beams, etc.) – "magnification 10× to 60×"

No device shall be acceptable that exhibits:

a) Within the first 125 μm of wire from the die surface for ball bonds, or 250 μm for wedge bonds, any wire that comes closer than 25 μm to any non-common conductive surface (e.g. unglassivated operating metallization, unpassivated edge of conductive die).

NOTE Insulated wires and electrically common wires are excluded from this criterion.

b) After the first 125 µm of wire from the die surface for ball bond(s), or 250 µm for wedge bonds, any wire that comes closer than two wire diameters to any non-common, uninsulated conductive surface (e.g. unglassivated operating metallization, unpassivated edge of conductive die).

NOTE Insulated wires and electrically common wires are excluded from this criterion.

c) Nicks, cuts, crimps, scoring, sharp bends, or neck-down in any lead that reduces the lead diameter/width by more than 25 %.

d) Missing or extra lead(s) not in conformance with bonding diagram.

NOTE Leads designated for tuning on the bonding diagram are excluded.

e) Any lead making a straight line run from bond to bond that has no arc, unless specifically allowed by the bonding diagram.

NOTE This exception also applies to wires of 100 µm diameter or greater, such as those used for power hybrids, where formation of an arc may not be possible.

f) Wire(s) crossing wire(s) with a separation of less than two lead widths. Common or insulated conductors and insulated wires are excluded.

g) Complete or partial separation of the lead from the body of the element.

h) Excessive loop height such that the wire would contact the lid when it is installed.

14 Screw tabs and through-hole mounting - magnification 3× to 10×

No device shall be acceptable that exhibits:

a) misaligned tabs;

b) missing or broken tabs;

c) cracks emanating from mounting holes;

d) loose substrates;

e) missing or loose screws.

15 Connector and feedthrough centre contact soldering - magnification 10× to 30×

No device shall be acceptable that exhibits:

a) less than 50 % of centre contact overlaps onto metallized pattern (see figure 85);

b) centre contact to substrate protrudes over onto circuit less than 1 diameter of a round pin or the width of a flat pin (see figure 86);

c) voids in solder (see figure 87a);

d) cracked solder joint (see figure 87b);

e) poor adhesion of solder to centre contact or substrate (see figure 87d);

f) insufficient or excess solder (see figures 87c through 87e);

g) less than full coverage of solder along the length of the centre contact and the metallization.

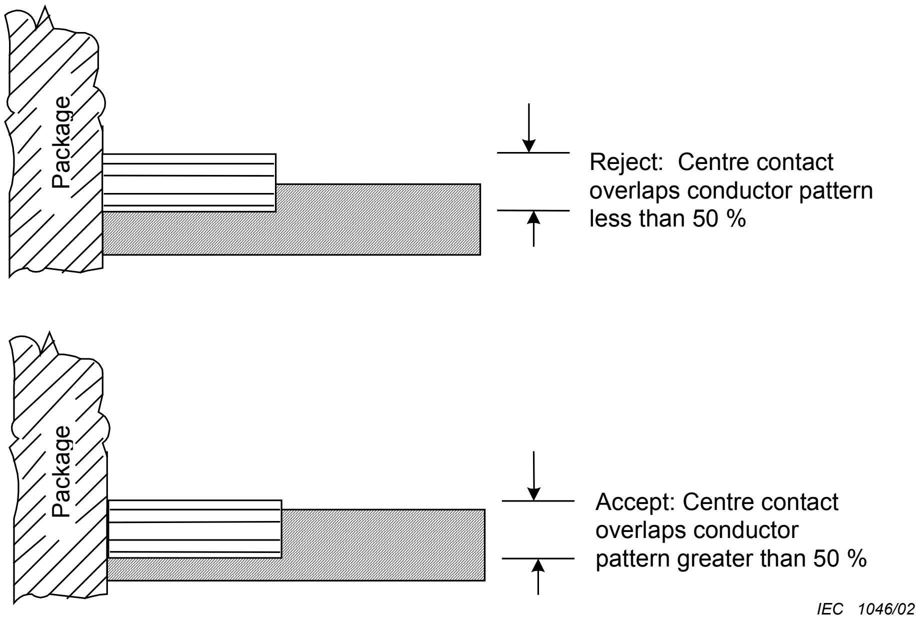


Figure 85 – Centre contact orientations to substrate

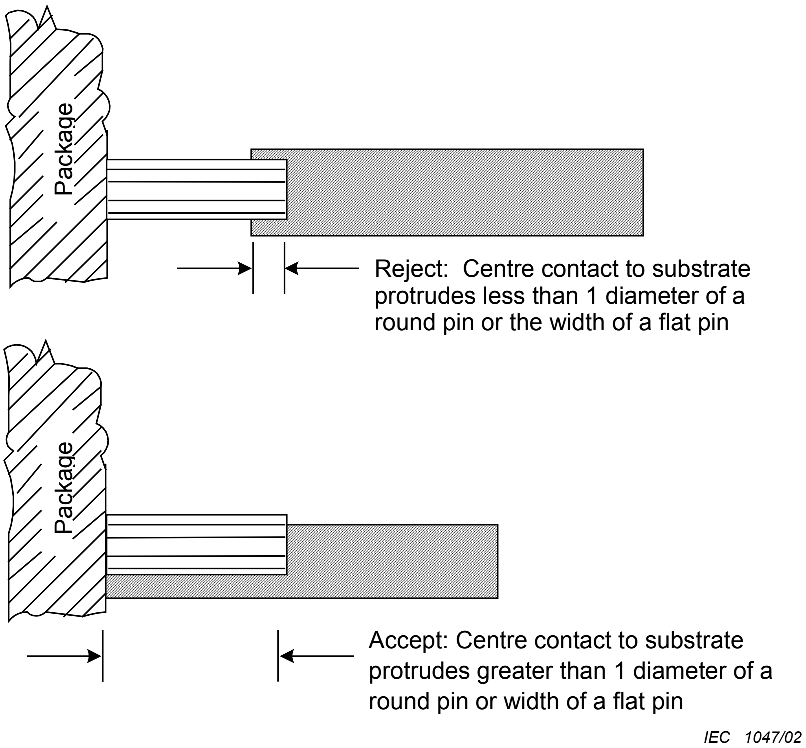


Figure 86 – Centre contact overlap to substrate

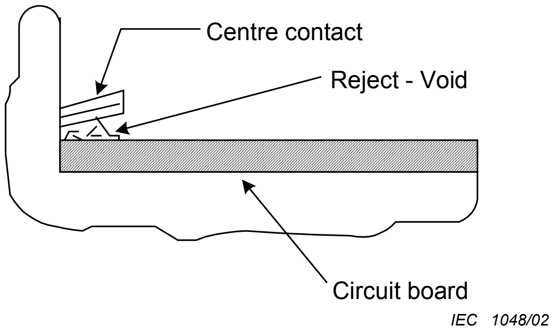


Figure 87a – Void criterion

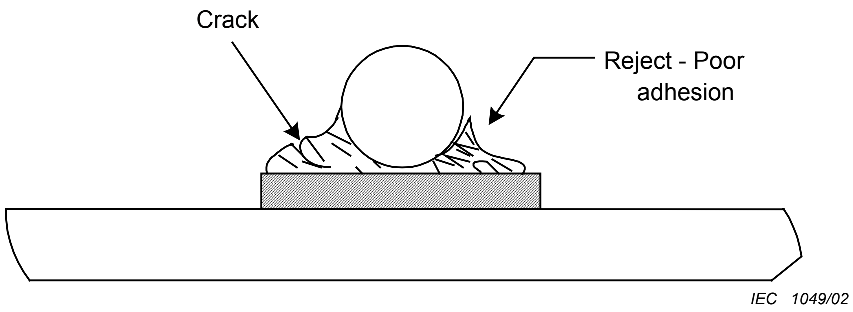


Figure 87b – Crack/adhesion criteria

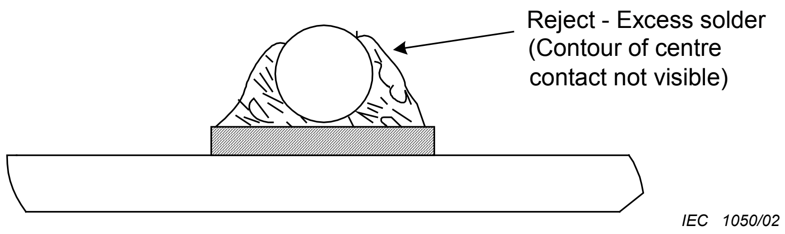


Figure 87c – Excess solder criterion

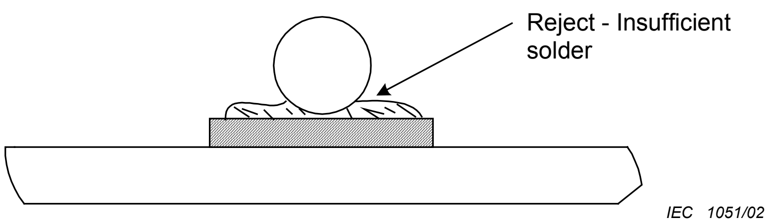


Figure 87d – Insufficient solder criterion

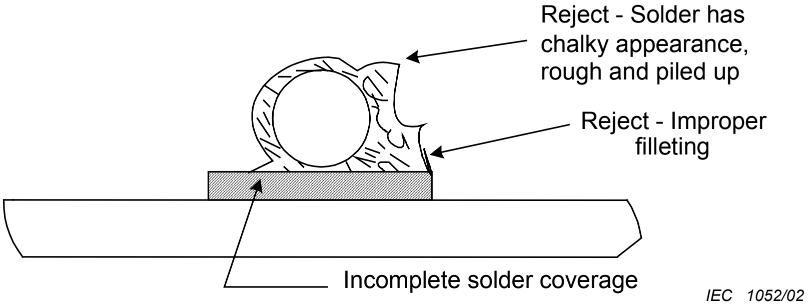


Figure 87e – Multiple solder criteria

Figure 87 – Solder criteria

16 Package conditions, solder assemblies, lead frame attachments, conformal coating - "magnification 10× to 60×"

16.1 Package conditions

No device shall be acceptable that exhibits:

a) Unattached foreign material within the package or on the seal flange.

All foreign material shall be considered to be unattached unless otherwise verified to be attached. Verification of attachments of foreign material whose longest dimensions are greater than 75 % of the closest unglassivated conductive spacing shall be accomplished by a light touch with an appropriate mechanical device (e.g. needle, probe, pick, etc.). Verification of attachments of smaller material can be satisfied by a suitable cleaning process approved by the acquiring activity. All foreign material or particles may be verified as attached with a nominal gas blow (approximately 150 kN/m^2).

Semiconductor chips shall be considered foreign particles.

b) Attached foreign material that bridges metallization paths, package leads, lead to package metallization, functional circuit elements, junctions, or any combination thereof.

c) Liquid droplets or any chemical stain that bridges any combination of unglassivated operating metallization.

d) Physical damage or contamination (eutectic or polymer material) that prevents adequate sealing of the seal surface.

e) Presence of any residual flux (except, by design, ionically neutral flux).

NOTE Use 10× to 15× magnification.

f) Foreign material in melt that does not exhibit a fillet.

16.2 Lead frame attachment

No device shall be acceptable which exhibits:

Class H

a) Misregistration of the lead frame to the pads on the substrate such that the gap between a lead and adjacent pad is reduced to less than 50 % of its design separation (see figure 88).

Class K

a) Misregistration of the lead frame to the pads on the substrate such that the gap between a lead and adjacent pad is reduced to less than its design separation (see figure 88).

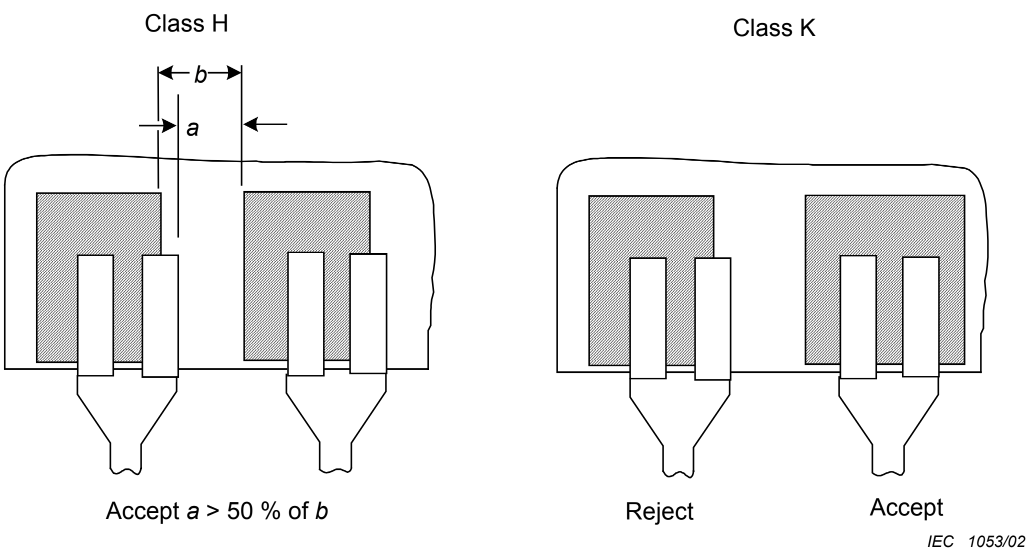


Figure 88 – Lead frame registration

For dual-in-line circuits, misregistrations of the lead frame on one side of circuit relative to the other shall not be greater than 50 % of the substrate pad separation (see figure 89).

For dual-in-line circuits, there shall be no misregistrations of the lead frame on one side of circuit relative to the other.

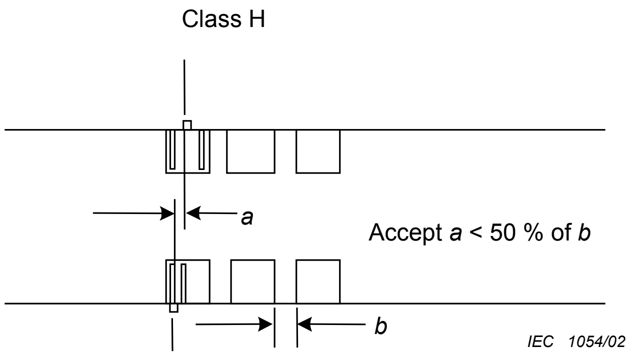


Figure 89 – Dual-in-line lead frame registration

b) Distortion of the lead frame pins after cropping sufficient to prevent the hybrid being readily inserted into the applicable printed circuit board or other substrate.

c) Solder bridging between the pins of adjacent pads, or particulates of solder on the pins which would interfere with insertion into the PCB or other substrate (see figure 90).

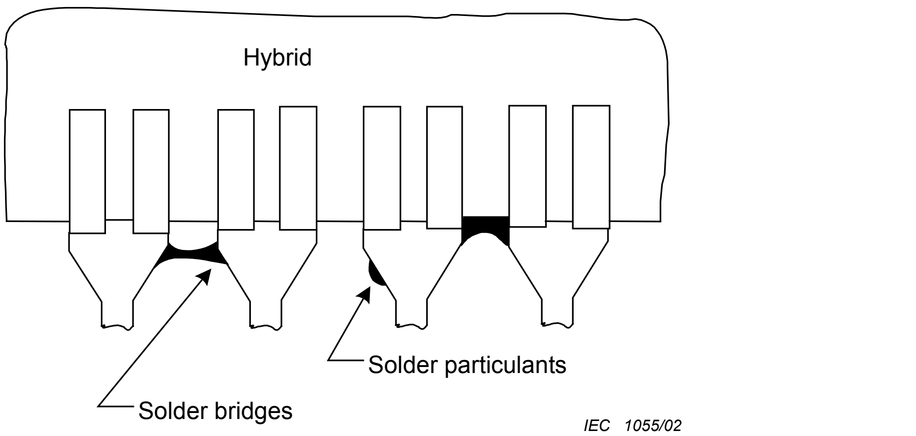


Figure 90 – Solder bridging

d) Tarnished or dirty pins (if the lead frame is subsequently to be soldered by wave or dipping methods).

e) Poor wetting of the solder joint of the lead frame to the thick film pad (see 9.1).

Class H

The profile of the edge connector lead frame tines shall be visible through the surface of the solder. It is not necessary to have a solder bridge between the tines of a double finger lead clip, but each finger shall have solder wetting to at least 50 % of the available edge in contact with the solder pad. There shall be a good solder joint to both the back and the front pads (see figures 91 and 92).

Class K

The profile of the edge connector lead frame tines shall be visible through the surface of the solder. It is not necessary to have a solder bridge between the tines of a double finger lead clip, but each finger shall have solder on the whole of the available edge in contact with the solder pad. There shall be a good solder joint to both the back and the front pads (see figures 91 and 92).

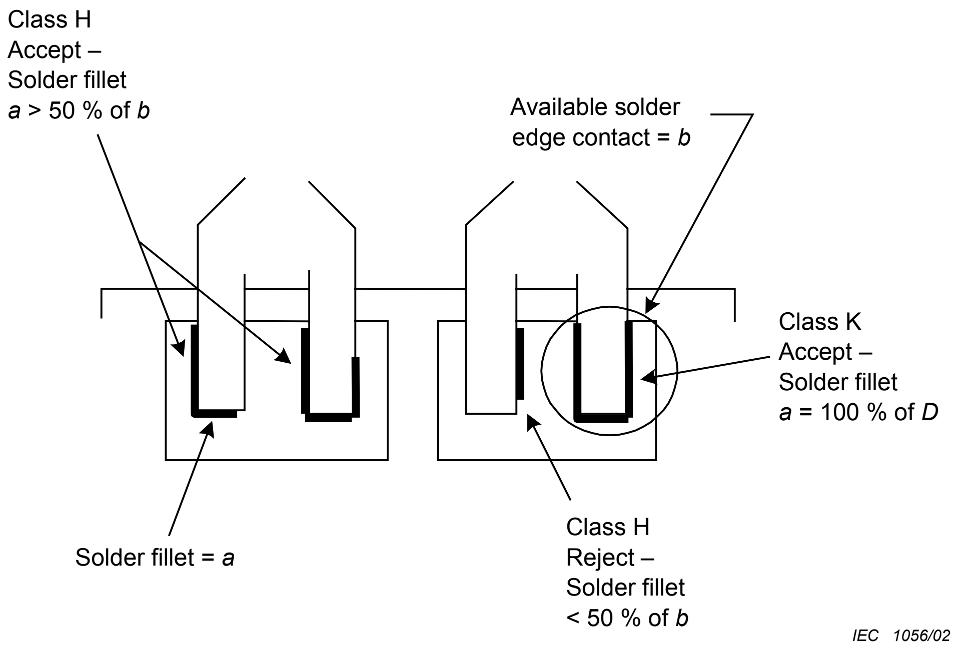


Figure 91 – Lead frame solder fillets

For single finger, the finger must display a total solder fillet along both sides ≥ the width of the finger (see figure 92).

For single finger, the finger must display a total solder fillet for the whole of the perimeter.

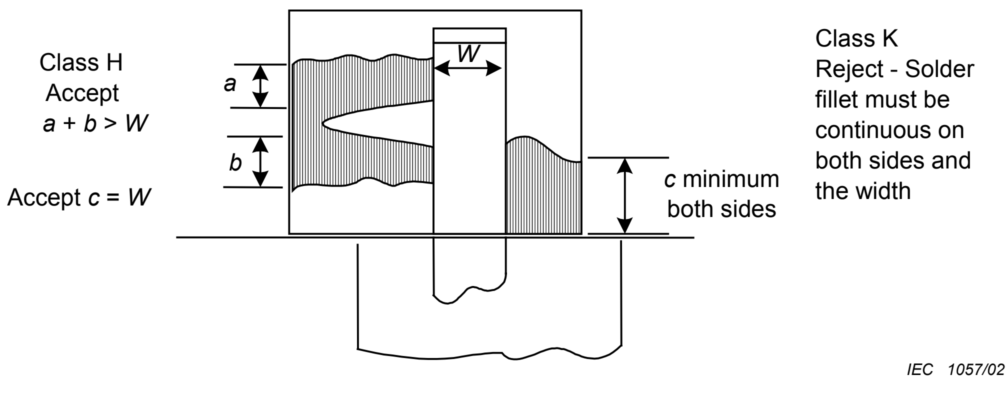


Figure 92 – Single finger solder fillet

f) A gap between the edge of the substrate and the bottom of the lead frame fork greater than 400 µm (provided the overall height of unit is not exceeded) (see figure 93).

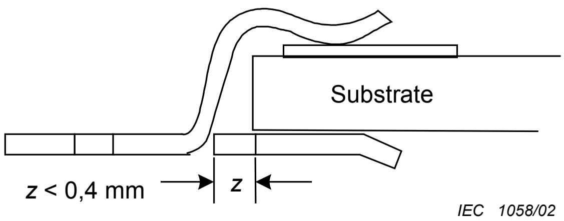


Figure 93 – Substrate to lead frame fork gap

16.3 Conformal coating

No device shall be acceptable that exhibits:

a) a coating which is not smooth and does not comply with the physical dimensions as stated in the drawing or detailed specification;
b) contains open cracks, voids or blisters, or is discoloured due to overheating;
c) coating on the leads extending below the stand-off unless specified in the drawing or detail specification.

17 Non-planar element inspection

Inspection for visual non-conformances described in this clause shall be conducted on each non-planar passive element. The "low magnification" inspection shall be within the range of 10X to 60X.

17.1 General non-planar element non-conformances - "low magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) Peeling or lifting of any metallization.	a) Same as Class H.
b) Protrusion between metallization terminals that leaves less than 125 µm separation (see figure 94).	b) Same as Class H.

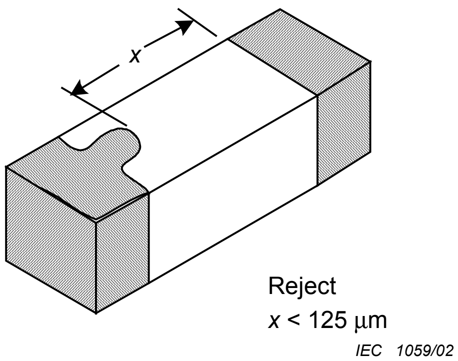


Figure 94 – Class H – Metallization protrusion criterion

Class H	Class K
c) Lifting, blistering, or peeling of insulation.	c) Same as Class H.
d) Voids in metallized terminals that expose underlying material over more than 25 % of any side of the metallized terminal area.	d) Same as Class H.

17.2 Foreign material non-conformances – "low magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) For mounted elements, unattached, conductive foreign material on the surface of the element. For unmounted elements, unattached, conductive foreign material on the surface of the element that is large enough to bridge operating metallization path, active circuitry, or any combination of these.	a) Same as Class H.
NOTE 1 If an element has an insulating layer (such as glassivation) that covers operating metallization paths, active circuitry, or any combination of these, then the presence of unattached conductive foreign material that is large enough to bridge these features is acceptable since the features are protected by the insulating layer.	
All foreign material shall be considered to be unattached unless otherwise verified to be attached. Verification of attachment shall be accomplished by a light touch with an appropriate mechanical device (e.g. needle, probe, pick, etc.) by a suitable cleaning process approved by the acquiring activity, or by a blow-off with a nominal gas blow (approximately 150 kN/m^2).	
NOTE 2 Semiconductor particles are considered to be foreign material.	
NOTE 3 Removal of unattached foreign material may be attempted using the techniques for verification of attachment discussed above.	
b) Attached, conductive foreign material that bridges metallization paths, active circuitry, or any combination of these.	b) Same as Class H.
c) Liquid droplets, ink drops, or any chemical stains that appear to bridge any unglassivated active circuit areas.	c) Same as Class H.
d) Attached foreign material that covers more than 25 % of a bonding pad area.	d) Same as Class H.

17.3 Ceramic chip capacitor non-conformances – "low magnification"

No element shall be acceptable that exhibits:

Class H

a) Crack, chip or void in the body that exposes metal plates (see figure 95).

Class K

a) Same as Class H.

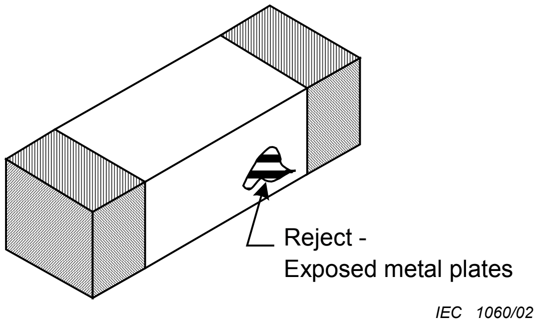


Figure 95 – Class H – Metal plate exposure criteria

b) Crack that is greater than 50 % of the width of the unmetallized sides, top, or bottom, or that extends around a corner (see figure 96).

b) Crack.

NOTE No cracks are allowed.

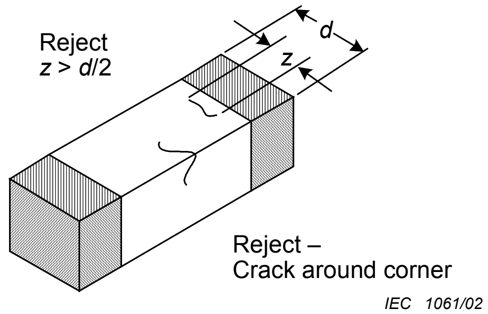


Figure 96 – Class H – Crack criteria

c) Evidence of separation (delamination) of metal plates or cracks along the plane of the metal plates (see figure 97).

NOTE Narrow grooves or channels less than 25 µm wide that exhibit a glass-like appearance and do not expose metal plates are acceptable.

c) Delamination.

NOTE No delamination is allowed.

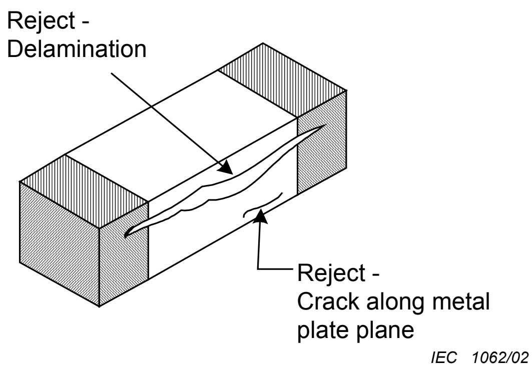


Figure 97 – Class H – Delamination criteria

Class H

d) Crack or void in the metallization that exposes metal plates, or voids that are greater than 25 % of the area of the metallized terminal (see figure 98).

Class K

d) Same as Class H.

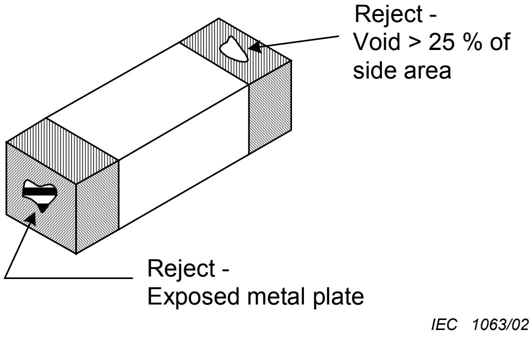


Figure 98 – Class H – Termination non-conformance criteria

Class H

e) Voids in the metallized edges of the element that are greater than 10 % of the metallized edge dimension, or bare corners of metallized terminals (see figure 99).

NOTE These criteria are applicable to solder attached elements only.

Class K

e) Same as Class H.

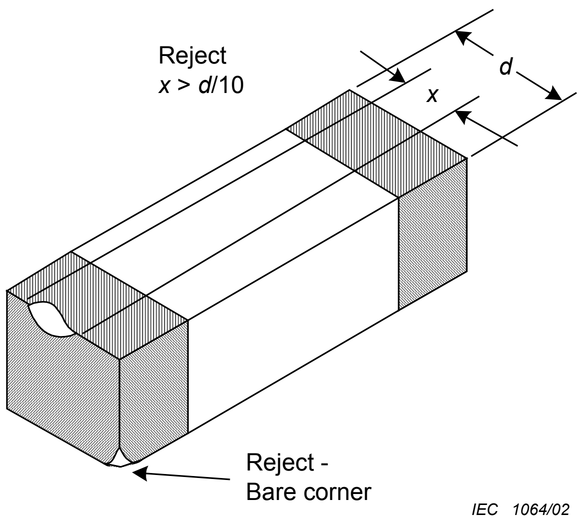


Figure 99 – Class H – Metallized edge non-conformance criteria

Class H

f) Attached foreign material on the body that covers an area greater than 125 µm square on any side.

Class K

f) Same as class H.

17.4 Tantalum chip capacitor non-conformances – "low magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) Flaking or peeling of the encapsulant that exposes any underlying material.	a) Same as Class H.
b) A metallized terminal that is less than 90 % free of encapsulant material.	b) Same as Class H.
c) Less than 50 % continuous metallized terminal weld area without cracks.	c) Same as Class H.
d) Metallized terminal containing residue from the welding operation that is not firmly attached metallurgically to the anode cap.	d) Same as Class H.
e) Metallized terminal not aligned as shown in the applicable drawing.	e) Same as Class H.
f) Encapsulant preventing the metallized terminal from resting on the substrate bonding pads when the capacitor is in the bonding position except where the metallized terminal electrical contact is made by alternative means.	f) Same as Class H.
g) Lifting, blistering or peeling of metallized terminal encapsulant.	g) Same as Class H.

17.5 Parallel plate chip capacitor non-conformances – "low magnification"

No element shall be acceptable that exhibits:

a) Metallization that extends more than 50 % around the edge of the capacitor (see figure 100).	a) Same as Class H.

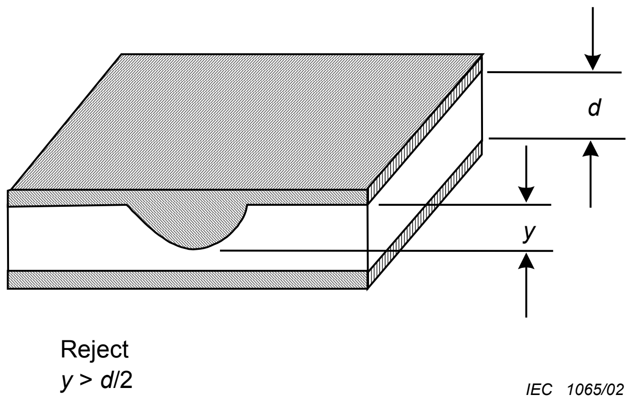


Figure 100 – Class H – Metallization extension criterion

Class H	Class K
b) Evidence of cracks in the dielectric body (see figure 101).	b) Same as Class H.

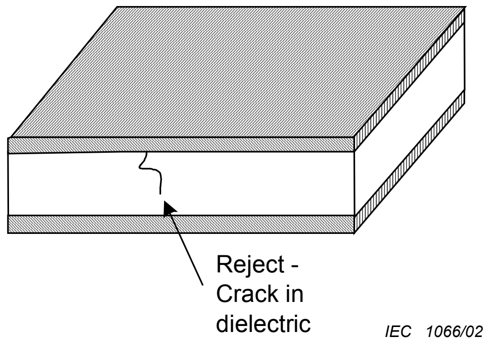


Figure 101 – Class H – Crack in dielectric criterion

17.6 Inductor and transformer non-conformances – "low magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) Peeling, lifting or blistering of winding metallization or insulation.	a) Same as Class H.
b) Evidence of shorts between adjacent turns or windings.	b) Same as Class H.
c) Cracks or exposure of bare magnetic core material.	c) Same as Class H.
d) Pits or voids in the core insulation greater than 125 µm that expose the magnetic core material.	d) Same as Class H.
e) Separation less than 125 µm between wire termination points of the same or adjacent windings.	e) Same as Class H.
f) Missing polarity identification unless by design.	f) Same as Class H.
g) Operating metallization and multilevel thick film non-conformances as described in 7.1 and 7.12.	g) Same as Class H.

17.7 Chip resistor non-conformances – "low magnification"

No element shall be acceptable that exhibits:

Class H

a) Reduction of the resistor width resulting from voids, bubbles, nicks, or scratches, or a combination of these, that leaves less than 50 % ofthe narrowest resistor width (see figure 102).

Class K

a) Same as Class H.

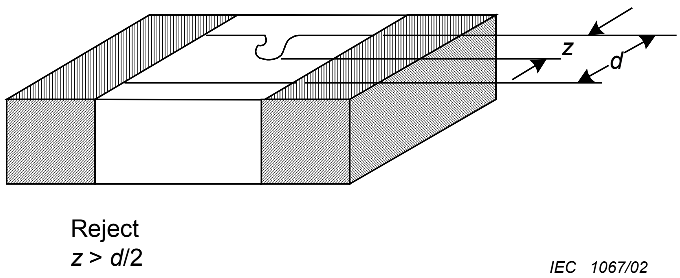


Figure 102 – Class H – Resistor width reduction criterion

Class H

b) A kerf that leaves less than 50 % of the original width of the resistor unless by design.

c) Metallized termination width less than 250 µm unless by design (see figure 103).

Class K

b) Same as Class H.

c) Same as Class H.

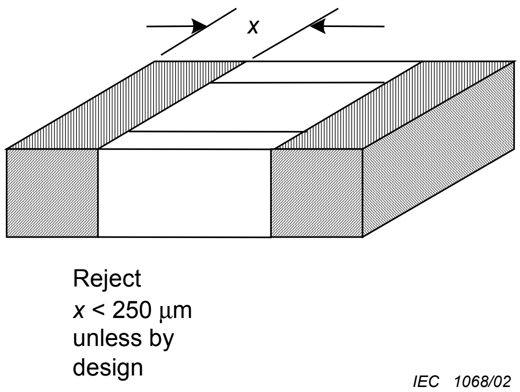


Figure 103 – Class H – Termination width criterion

Class H

d) A crack, chipout or void in the substrate greater than 75 µm in any direction (see figure 104).

Class K

d) Same as Class H.

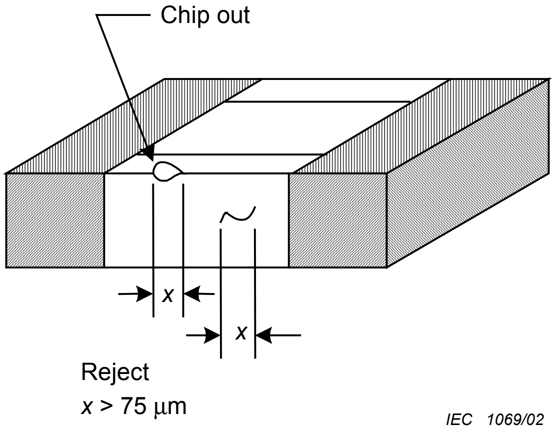


Figure 104 – Class H – Substrate non-conformance criteria

e) Build-up of termination material on metallized termination areas greater than 75 µm high for weldable metallized terminations or 200 µm high for solderable metallized terminations (see figure 105).

e) Same as Class H.

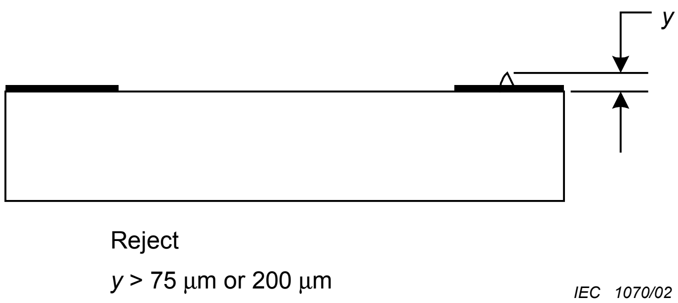


Figure 105 – Class H – Termination material build-up criteria

Class H

f) Termination material splattered throughout the resistor (see figure 106).

Class K

f) Same as class H.

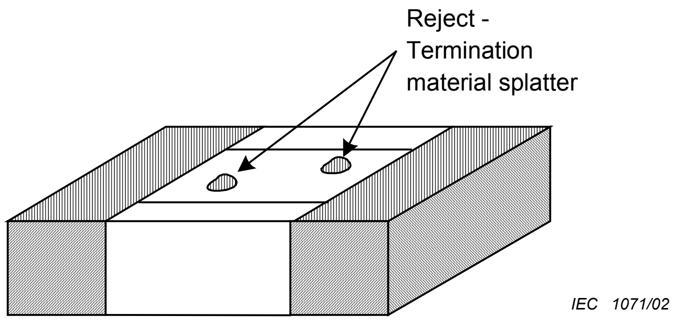


Figure 106 – Class H – Termination material splatter criteria

18 Surface acoustic wave (SAW) element inspection

Inspection for visual non-conformances described in this clause shall be conducted on each SAW element. When inspection is performed prior to mounting, then SAW elements may be inspected using backlighting. All inspection shall be performed at "low magnification" within the range of 10× to 60× for both Class H and Class K.

18.1 Operating metallization non-conformances - "low magnification"

No element shall be acceptable that exhibits:

18.1.1 Metallization corrosion

Class H	Class K
Any metallization corrosion.	Same as Class H.

18.1.2 Metallization adherence

Class H	Class K
Any metallization lifting, peeling or blistering.	Same as Class H.

18.2 Substrate material non-conformances - "low magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) Any crack that exceeds 125 µm in length.	a) Same as Class H.
b) Any crack that is within 2,5 µm of an active circuit area or operating metallization.	b) Same as Class H.
c) Any crack exceeding 25 µm in length extending from the element edge directly toward the active circuit area or operating metallization.	c) Same as Class H.

18.3 Foreign material non-conformances - "low magnification"

No element shall be acceptable that exhibits:

Class H	Class K
a) For mounted and unmounted elements, unattached conductive foreign material on the surface of the element that is large enough to bridge operating metallization paths.	a) Same as Class H.

Class H	Class K
All foreign material shall be considered to be unattached unless otherwise verified to be attached. Verification of attachment shall be accomplished by a light touch with a mechanical device (e.g. needle, probe, pick, etc.) or by a suitable cleaning process approved by the acquiring activity, or by a nominal gas blow (approximately 150 kN/m^2). Removal of unattached foreign material may be attempted using the techniques for verification of attachment discussed above.	
b) Liquid droplets, ink drops, or chemical stains that appear to bridge unglassivated metallization.	b) Same as Class H.
c) Attached foreign material that covers more than 25 % of a bonding pad area.	c) Same as Class H.

19 Summary

The following details shall be specified in the applicable acquisition document:

a) class H or Class K visual requirement;

b) where applicable, gauges, drawings and photographs that are to be used as standards for operator comparison (see clause 4);

c) where applicable, specific magnification if other than that specified (see clause 5);

d) where applicable, any conflicts with element design.

20 Radiographic inspection

This details the inspection requirements for use in determining the minimum acceptance criteria when radiographic inspection is called for in the customer detail specification. Its purpose is the non-destructive evaluation of hybrid devices after lid sealing.

NOTE EN 100012 gives requirements for equipment and the procedures that may be used for radiographic inspection.

20.1 Requirements

20.1.1 Views

20.1.1.1 Flat, dual in-line and single ended cylindrical packages

Unless otherwise specified in the detail specification, one view shall be taken along the *Y* axis as detailed in 7.2.3 of IEC 60748-23-1. The detail specification may call for more views if required.

20.1.1.2 Stud mounted or axial cylindrical packages

Unless otherwise specified in the detail specification, one view shall be taken along the *X* axis as detailed in 7.2.3 of IEC 60748-23-1. The detail specification may call for more views if required.

20.1.2 Reports and records

Normal release procedures shall be used unless otherwise specified in the customer detail specification.

20.1.3 Examination and acceptance criteria

The devices shall be examined in accordance with the following criteria and any other requirements called for in the customer detail specification. Items which fail the examination shall be removed from the lot; if agreed rework procedures can correct the failure, corrected devices may be resubmitted in the usual manner.

20.1.3.1 Construction

The radiograph(s) shall be examined against a controlled layout drawing for conformity of layout including number and position of bonds, components etc.

20.1.3.2 Foreign particles

The radiograph(s) shall be examined and the device rejected on any of the following criteria:

a) Any loose particle >0,020 mm, or of a dimension that could bridge non-common elements.
b) Any non-bonded wire tail exceeding two wire diameters.
c) Any excessive attach material exceeding the height of the device or substrate, or which noticeably deflects the object from being parallel to its mounting plane.
d) All mounting material shall be of a homogeneous nature. Where lumps or bumps are present the attach width shall be greater than the height.
e) Any extraneous bonds.
f) Any evidence of flaking material.

Where it cannot be determined whether a foreign particle is of a loose nature or not, the device shall be removed from the lot and undergo particle impact noise detection in accordance with the summary given in 7.5.17 of IEC 60748-23-1, and the detailed description given below. Devices passing the PIND test shall again be radiographed and rejected if any particle does not align with the original inspection.

20.1.3.3 Processing

The radiograph(s) shall be examined and the device rejected on any of the following criteria:

a) Any void or series of voids in mounting material which exceed 10 % of the design contact area.
b) Any wire/bond wire not called up in the device build standard.
c) Any cracks, chips or voids of electrical elements.
d) Any device where the lid seal is not continuous or <75 % of the design seal width.
e) Bond wires that are either too short or too long, following established design criteria for the device.
f) Any wire overlapping or crossing another wire/non-common element, or within 0,025 mm.
g) Any wire/component or attach material touching or within 0,05 mm of the case or lead out, except where deliberately attached.
h) Any non-common bond within 0,025 mm of another bond.
i) Any internal post noticeably bent or deformed from its design position.
j) Any noticeable package defects such as voids/cracks in glass-metal seals, misalignment of post positions etc.

21 Particle impact noise detection (PIND) test

This test is to detect the presence of loose particles inside a cavity device such as, for example, chips of ceramic, pieces of bonding wire or solder balls (prills).

21.1 General

An acoustic transducer is attached to the test specimen via an acoustic coupling medium, and its output fed via a suitable amplifier to an audio/visual monitoring system. The test specimen is subjected to sinusoidal vibration and a series of controlled mechanical shocks by a suitable mechanical shaker and shock mechanism/impact tool. As a result of this mechanical stimulation loose particles within the cavity of the test specimen will impact the internal walls of the cavity, producing noise which will be detected by the acoustic transducer and indicated by the monitoring system.

The test is classified as non-destructive.

21.2 Equipment

The following equipment and/or materials (or their equivalents) is required:

a) Vibration shaker (sinusoidal).

   Output: 20 g_n peak at 40 Hz to 250 Hz.

b) Mechanical shock mechanism/tool.

   Shock pulse: 1 000 g_n ± 200 g_n peak.

   Main shock duration: 100 µs maximum.

   NOTE If an integral vibration/shock system is used (co-test system), the interruption to the vibration source during the mechanical shock should not exceed 250 ms from initiation of the last shock pulse in the sequence; the duration of this shock test should be measured at the 50% ± 5 % points.

c) Impact sensor (acoustic transducer – acoustically coupled to the device under test).

   Peak sensitivity: -77,5 dB ± 3 dB with respect to 1 V/microbar at a point in the range 150 kHz to 160 kHz.

d) Impact sensor amplifier (connected to the output of the impact sensor).

   Gain: 60 dB ± 2 dB (centred at peak sensitivity frequency of the acoustic transducer, in c) above).

   Output noise: 10 mV peak maximum.

e) Threshold detector (connected to the output of the impact sensor amplifier).

   Threshold voltage: 20 mV ± 1 mV peak absolute, reference to system ground and including audio output/oscilloscope output (optional).

   NOTE Total system noise generated by c), d) and e): 20 mV pk-pk maximum as observed over a period of 30 s to 60 s.

f) Attachment medium (to provide good acoustic coupling) between item c) above and the device under test).

   Examples of suitable attachment media are

   – water solvent soluble acoustic couplant,

   – water soluble ultrasonic couplant,

   – double-sided adhesive tape.

g) Sensitivity test unit, comprising a d.c. source capable of producing an output of 250 µV ±20 % connected to the input of an acoustic transducer (of the same type as in c) above).

21.3 Test procedure

NOTE ESD precautions in accordance with IEC 61340-5-1 should be adopted to protect devices under test.

a) Adjust vibration shaker frequency/amplitude to the specified conditions (see table 1).

b) Adjust shock pulse generator for 1 000 g_n ± 200 g_n peak.

c) Verify noise detection equipment operation with the sensitivity test unit attached to the impact sensor, using the same attachment medium that will be used with the actual devices to be tested.

d) Verify system noise is within the specification limits given in 21.2e).

e) Attach the test specimen directly to the shaker with the largest flat surface centred against the surface of the transducer with the attachment medium.

   Where more than one large surface exists, attach the thinnest and most uniform thickness surface against the surface of the transducer.

   Where unusual specimen shapes are encountered special holding fixtures may be required and should be constructed with the following considerations:

   – low mass;
   – high acoustic transmission;
   – full transducer surface contact;
   – no moving parts;
   – suitable for attachment medium mounting.

f) Start test sequence, of which one cycle comprises the following:

   – three pre-test shocks;
   – vibration only 3 s ± 1 s;
   – three co-test shocks;
   – vibration only 3 s ± 1 s;
   – three co-test shocks;
   – vibration only 3 s ± 1 s;
   – three co-test shocks;
   – vibration only 3 s ± 1 s;
   – accept or reject.

g) Measurements – each test cycle shall be continuously monitored: the period during the co-test shocks and up to 250 ms after the shocks shall not be included in the failure criteria analysis.

NOTE Co-test refers to equipment that combines vibration and mechanical shock stimulus in a single mechanism.

21.4 Failure criteria

Any noise detected by the monitoring system during the measurement period that exceeds the total system noise defined in 21.2e) will be noise resulting from particle impact noise and shall therefore constitute a failure.

21.5 Lot acceptance

Unless otherwise specified, the inspection lot (or sub-lot) shall be submitted to 100 % PIND testing a maximum of five times. PIND prescreening shall not be performed. The lot may be accepted on any of the five runs if the percentage of defective devices is less than 1 %. All defective devices shall be removed after each run. Lots that do not meet the 1 % PDA on the fifth run, or exceed 25 % defectives cumulative, shall be rejected and re-submission is not allowed.

21.6 The detail specification

The detail specification shall prescribe test conditions in accordance with table 1.

Table 1 – Shaker frequencies

Internal cavity height (average) (see note) mm	**Frequency** Hz
≤1,02	130
1,03 – 1,27	120
1,28 – 1,52	110
1,53 – 1,78	100
1,79 – 2,03	90
2,04 – 2,29	80
2,30 – 2,54	70
>2,54	60
NOTE Average internal package height is measured from the floor of the package.	

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