METHOD 2072.6

INTERNAL VISUAL TRANSISTOR (PRE-CAP) INSPECTION

1. Purpose. The purpose of this inspection is to verify the construction and workmanship of bipolar transistors, field effect transistors (FET), discrete monolithic, multichip, and multijunction devices excluding microwave and selected RF devices. This test will be performed prior to capping or encapsulation to detect those devices with internal defects that could lead to failures in normal application and verify compliance with the requirements of the applicable detail specification.

2. Apparatus. The apparatus for this inspection shall consist of the following:

a. Optical equipment capable of the specified magnifications.

b. Light sources of sufficient intensity to adequately illuminate the devices being inspected.

c. Adequate fixturing for handling the devices being inspected without causing damage.

d. Adequate covered storage and transportation containers to protect devices from mechanical damage and environmental contamination.

e. Any visual standards (drawings and photographs) necessary to enable the inspector to make objective decisions as to the acceptability of the devices being examined.

3. Definitions.

3.1 Glassivation. The top layer of transparent insulating material that covers the active circuit area metallization, but excluding bonding pads.

3.2 Passivation. Silicon oxide, nitride, or other insulating material that is grown or deposited directly on the die prior to the deposition of any metal.

4. Procedure.

4.1 General. The device shall be examined in a suitable sequence of observations within the specified magnification range to determine compliance with the requirements of the applicable detail specification and the criteria of the specified test condition. If a specified visual inspection requirement is in conflict with the topology or construction of a specific device design, alternate inspection criteria may be included in the detail specification. Any alternate inspection criteria contained in the detail specification shall take precedence over the criteria of this test method. Any criteria of this test method intended for a specific device process or technology has been indicated. Where applicable, unused cells shall not be subjected to internal visual criteria.

a. 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. Visual criteria specified in 4.1.1, 4.1.2, 4.1.3, and 4.1.7, may be examined prior to die attachment with reexamination at low or high magnification after die attachment for these criteria. Visual criteria specified in 4.1.6.2 and 4.1.6.3 may be examined prior to lead wire bonding without reexamination after bonding.

b. Inspection control. Within the time interval between visual inspection and preparation for sealing, devices shall be stored in a controlled environment (one which controls airborne particle count and relative humidity). The use of an inert gas environment, such as dry nitrogen shall satisfy the requirements for storing in a controlled environment. Devices examined in accordance with this test method shall be inspected and stored in a class 100,000 environment, in accordance with FED-STD-209, except that the maximum allowable relative humidity shall not exceed 65 percent.

   If devices are subjected to a high temperature bake (>+100°C) immediately prior to sealing, the humidity control is not required. Unless a cleaning operation is performed prior to sealing, devices shall be in covered containers when transferred from one controlled environment to another.

c. Magnification. High magnification inspection shall be performed perpendicular to the die surface with normal incident illumination. Low magnification inspection shall be performed with either a monocular, binocular, or stereo microscope, and the inspection performed within any appropriate angle, with the device under suitable illumination. The inspection criteria of 4.1.4 and 4.1.6.1 may be examined at "high magnification" at the manufacturer's option. High power magnification may be used to verify a discrepancy noted at a low power.

TABLE 2072.1. Die magnification requirements.

Chip size 1/	High magnification	Low magnification
30 mils or less	100X to 200X	30X to 50X
31 to 60 mils	75X to 150X	30X to 50X
61 to 150 mils	35X to 120X	10X to 30X
Greater than 150 mils	25X to 75X	10X to 30X

1/ Length of shortest dimension.

d. Reinspection. Unless a specific magnification is required by the detail specification, 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 herein. If sampling is used rather than 100 percent reinspection, reevaluation of lot quality in accordance with the "Reevaluation of lot quality" of MIL-S-19500 shall be used.

e. Exclusions. If 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.

4.1.1 Die metallization defects (high magnification). A die which exhibits any of the following defects shall be rejected.

4.1.1.1 Metallization, scratches, and voids exposing underlying material (see figure 2072-1).

a. A scratch or void that severs the innermost metallized guard ring.

b. Any die containing a void in the metallization at the bonding pad covering more than 25 percent of the pad area.

c. For devices with nonexpanded contacts and all power devices. Any scratch or void which isolates more than 25 percent of the total metallization of an active region from the bonding pad.

d. For all devices with expanded contacts. A scratch or void, whether or not underlying material is exposed, which leaves less than 50 percent undisturbed metal width in the metal connecting the pad and contact regions.

e. For expanded contacts with more than 10 contact regions. A scratch or void extending across more than 50 percent of the first half of any contact region (beginning at the bonding area) in more than 10 percent of the contact regions.

f. For expanded contacts with less than 10 contact regions. A scratch or void in the contact area which isolates more than 10 percent of the metallized area from the bonding pad.

4.1.1.2 Metallization corrosion. Any metallization which shows evidence of corrosion.

4.1.1.3 Metallization adherence. Any metallization which has lifted, peeled, or blistered.

4.1.1.4 Metallization probing. Criteria contained in 4.1.1.1 shall apply as limitations on probing damage.

4.1.1.5 Metallization bridging. Metallization bridging between two normally unconnected metallization paths which reduces the separation, such that a line of oxide is not visible (no less than 0.1 mil) when viewed at the prescribed high magnification.

4.1.1.6 Metallization alignment.

a. Except by design, contact window that has less than 50 percent of its area covered by continuous metallization.

b. A metallization path not intended to cover a contact window which is separated from the window by less than 0.1 mil.

c. Except by design, any misalignment to the extent that continuous passivation color cannot be seen (i.e., metallization crossing passivation).

4.1.2 Passivation and diffusion faults (high magnification). A device which exhibits any of the following defects (see figure 2072-2) shall be rejected:

a. Any diffusion fault that allows bridging between any two diffused areas, any two metallization strips, or any such combination not intended by design.

b. Any passivation fault including pinholes not covered by glassivation that exposes semiconductor material and allows bridging between any two diffused areas, any two metallization strips, or any such combination not intended by design.

c. Unless intended by design, a diffusion area which is discontinuous.

d. Except by design, an absence of passivation visible at the edge and continuing under the metallization causing an apparent short between the metal and the underlying material (closely spaced double or triple lines on the edges of the defect indicate that it may have sufficient depth to penetrate down to the silicon).

e. Except by design, any active junction not covered by passivation or glassivation.

f. Unless by design, a contact window in a diffused area which extends across a junction.

4.1.3 Scribing and die defects (high magnification). A device which exhibits any of the following defects (see figure 2072-3) shall be rejected:

a. Unless by design, less than 0.1 mil passivation visible between active metallization or bond pad periphery and the edge of the die.

b. Any chip-out or crack in the active area.

c. Except by design, die having attached portions of the active area of another die and which exceeds 10 percent of the area of the second die.

d. Any crack which exceeds 2.0 mils in length inside the scribe grid or scribe line that points toward active metallization or active area and extends into the oxide area.

e. Any chip-out that extends to within 1 mil of a junction.

f. Any crack or chip-out that extends under any active metallization area.

g. Any chip-out which extends completely through the guard ring.

4.1.4 Bond inspection (low magnification). This inspection and criteria shall be the required inspection for the bond type(s) and location(s) to which they are applicable when viewed from above (see figures 2072-4 and 2072-5). Wire tail is not considered part of the bond when determining physical bond dimensions. A device which exhibits any of the following defects shall be rejected.

4.1.4.1 Gold ball bonds.

a. Gold ball bonds on the die or package post where the ball bond diameter is less than 2.0 times or greater than 5.0 times the wire diameter.

b. Gold ball bonds where the wire exit is not completely within the periphery of the ball.

c. Gold ball bonds where the existing wire is not within the boundaries of the bonding pad.

d. Any visible intermetallic formation at the periphery of any gold ball bond.

4.1.4.2 Wedge bonds.

a. Ultrasonic wedge bonds on the die or package post that are less than 1.2 times or greater than 3.0 times the wire diameter in width, or are less than 1.5 times or greater than 5.0 times the wire diameter in length.

b. Thermocompression wedge bonds on the die or package post that are less than 1.2 times or greater than 3.0 times the wire diameter in width or are less than 1.5 or greater than 5.0 times the wire diameter in length.

4.1.4.3 Tailless bonds (crescent).

a. Tailless bonds on the die or package post that are less than 1.2 times or greater than 5.0 times the wire diameter in width, or are less than 0.5 times or greater than 3.0 times the wire diameter in length.

b. Tailless bonds where the bond impression does not cover the entire width of the wire.

4.1.4.4 General (gold ball, wedge, and tailless). As viewed from above, a device which exhibits any of the following defects shall be rejected:

a. Bonds on the die where less than 75 percent of the bond is within the unglassivated bonding pad area (except where due to geometry, the bonding pad is smaller than the bond, the criteria shall be 50 percent).

b. Wire bond tails that extend over and make contact with any metallization not covered by glassivation and not connected to the wire.

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

d. Bonds on the package post that are not bonded entirely on the flat surface of the post top.

e. A bond on top of another bond.

f. Bonds placed so that the separation between bonds and adjacent unglassivated die metallization is less than 1.0 mil.

g. Bonds placed so that the separation between bonds and adjacent glassivated die metallization is less than 0.25 mil.

h. Bonds placed so that the separation between adjacent bonds is less than 0.25 mil. This criteria does not apply to designs which employ multiple bond wires in place of a single wire.

i. Bonds located where any of the bond is placed on an area containing die preform mounting material.

j. Repair on conductors by bridging or addition of bonding wire or ribbon.

k. For aluminum wires over 2.0 mils diameter, the bond width shall not be less than 1.0 times the wire diameter.

4.1.5 Internal lead wires (low magnification). This inspection and criteria shall be required inspection for the location(s) to which they are applicable when viewed from above. A device which exhibits any of the following defects shall be rejected:

a. Any wire that comes closer than two wire diameters or 5 mils, whichever is less, to unglassivated operating metallization, another wire (common wires and pigtails excluded) package post, unpassivated die area, or any portion of the package, including the plane of the lid to be attached. (Within a 5.0 mil spherical radial distance from the perimeter of the bond on the die surface, the separation can be 1.0 mil.)

b. Nicks, tears, bonds, cuts, crimps, scoring, or neckdown in any wire that reduces the wire diameter by more than 25 percent.

c. Missing or extra lead wires.

d. Bond lifting or tearing at interface of pad and wire (see figure 2072-5).

e. Any wire which runs from die bonding pad to package post and has no arc or stress relief.

f. Except in common connectors, wires which cross other wires.

g. Wire(s) not in accordance with bonding diagram.

h. Wire is kinked (unintended sharp bend) with an interior angle of less than 90° or twisted to an extent that stress marks appear.

i. Wire (ball bonded devices) not within 10° of the perpendicular to the surface of the chip for a distance of greater than 0.5 mil before bending toward the package post or other termination point.

j. Excessive lead burn at lead post weld.

k. Pigtail longer than 50 percent of post diameter.

l. A bow or loop between double bonds at post greater than four times wire diameter.

m. Excessive loops, bows, or sags in any wire such that it could short to another wire, to another pad, to another package post, to the die or touch any portion of the package.

n. When clips are used, solder fillets shall encompass at least 50 percent of the clip-to-die and post-to-clip periphery. There shall be no deformation or plating defects on the clip.

4.1.6 Package conditions (magnification as indicated). A device which exhibits any of the following defects shall be rejected.

4.1.6.1 Conductive foreign material on die surface. All foreign material or particles may be blown off with a nominal gas blow (approximately 20 psi (138 kPa)) or removed with a soft camel hair brush. The device shall then be inspected for the following criteria (low magnification):

a. Loosely attached foreign particles (conductive particles which are attached by less than one-half of their largest dimension) which are present on the surface of the die that are large enough to bridge the narrowest unglassivated active metal spacing (silicon chips shall be included as conductive particles).

b. Embedded foreign particles on the die that bridge two or more metallization paths or semiconductor junctions, or any combination of metallization or junction.

c. Liquid droplets, chemical stains, or photoresist on the die surface that bridge any combinations of unglassivated metal or bare silicon areas.

d. Except for unused cells, ink on the surface of the die that covers more than 25 percent of a bonding pad area or that bridges any combination of unglassivated metallization or bare silicon areas.

4.1.6.2 Die mounting (low magnification).

a. Die mounting material buildup that extends onto the top surface of the die or extends vertically above the top surface of the die and interferes with bonding.

b. Die to header mounting material which is not visible around at least three complete sides or 75 percent of the die perimeter. Wetting criteria is not required if the devices pass an approved electrical die attach evaluation test.

c. Any flaking of the die mounting material.

d. Any balling of the die mounting material which does not exhibit a fillet when viewed from above.

4.1.6.3 Die orientation.

a. Die is not located or orientated in accordance with the applicable assembly drawing of the device.

b. Die is visibly tipped or tilted (more than 10°) with respect to the die attach surface.

4.1.6.4 Internal package defects (low magnification inspection) (applicable to headers, bases, caps, and lids). As an alternative to 100 percent visual inspection of lids and caps in accordance with the criteria of 4.1.6.1a, the lids or caps may be subjected to a suitable cleaning process and quality verification procedure approved by the qualifying activity, provided the lids or caps are subsequently held in a controlled environment until capping or preparation for seal.

a. Any header or post plating which is blistered, flaked, cracked, or any combination thereof.

b. Any conductive particle which is attached by less than one-half of the longest dimension.

c. A bubble or a series of interconnecting bubbles in the glass surrounding the pins which are more than one-half the distance between the pin and body or pin-to-pin.

d. Header posts which are severely bent.

e. Any glass, die, or other material greater than 1.0 mil in its major dimension which adheres to the flange or side of the header and would impair sealing.

f. Any stain, varnish, or header discoloration which appears to extend under a die bond or wire bond.

g. For isolated stud packages:

(1) Any defect or abnormality causing the designed isolating paths between the metal island to be reduced to less than 50 percent of the design separation.

(2) A crack or chip-out in the substrate.

4.1.6.5 Presence of extraneous matter. Extraneous matter (foreign particles) shall include, but not be limited to:

a. Any foreign particle, loose or attached, greater than .003 inch (0.08 mm) or of any lesser size which is sufficient to bridge nonconnected conducting elements of the device.

b. Any wire tail extending beyond its normal end by more than two diameters at the semiconductor die pad or by more than four wire diameters at the package post (see figure 2072-6).

c. Any burr on a post (header lead) greater than .003 inch (0.08 mm) in its major dimension or of such configuration that it may break away.

d. Excessive semiconductor die bonding material buildup. A semiconductor die shall be mounted and bonded so that it is not tilted more than 10° from mounting surface. The bonding agent that accumulates around the perimeter of the semiconductor die and touches the side of the semiconductor die shall not accumulate to a thickness greater than that of the semiconductor die (see figures 2072-7 and 2072-8). Where the bonding agent is built up but is not touching the semiconductor die, the build up shall not be greater than twice the thickness of the semiconductor die. There shall be no excess semiconductor die bonding material in contact with the active surface of the semiconductor die or any lead or post, or separated from the main bonding material area (see figure 2072-9).

e. Flaking on the header or posts or anywhere inside the case.

f. Extraneous ball bonds anywhere inside case, except for attached bond residue when rebonding is allowed.

4.1.7 Glassivation and silicon nitride defects (high magnification). No device shall be acceptable that exhibits any of the following defects:

a. Glass crazing that prohibits the detection of visual criteria contained herein.

b. Any glassivation which has delaminated. (Lifting or peeling of the glassivation may be excluded from the criteria above, when it does not extend more than 1.0 mil distance from the designed periphery of the glassivation, provided that the only exposure of metal is adjacent to bond pads or of metallization leading from those pads.)

c. Except by design, two or more adjacent active metallization paths which are not covered by glassivation.

d. Unglassivated areas at the edge of bonding pad which expose silicon.

e. Glassivation which covers more than 25 percent of the design bonding pad area.

4.2 Post organic protective coating visual inspection. If devices are to be coated with an organic protective coating the devices shall be visually examined in accordance with the criteria specified in 4.1 prior to application of the coating. After the application and cure of the organic protective coating the devices shall be visually examined under a minimum of 10X magnification. Devices which exhibit any of the following defects shall be rejected:

a. Except by design, any unglassivated or unpassivated areas or insulating substrate which has incomplete coverage.

b. Open bubbles, cracks or voids in the organic protective coating.

c. A bubble or a chain of bubbles which covers two adjacent metallized surfaces.

d. Organic protective coating which has flaked or peeled.

e. Organic protective coating which is tacky.

f. Conductive particles which are embedded in the coating and are large enough to bridge the narrowest unglassivated active metal spacing (silicon chips shall be included as conductive particles).

g. A web of varnish (organic protective coating) that connects the wire with the header.

5. Summary. The following conditions shall be specified in the applicable detail specification:

a. Test conditions, exceptions, or additions to the test method.

b. Where applicable, any conflicts with approved circuit design topology or construction.

c. Where applicable, gauges, drawings, and photographs that are to be used as standards for operator comparison.

d. When applicable, specific magnification.

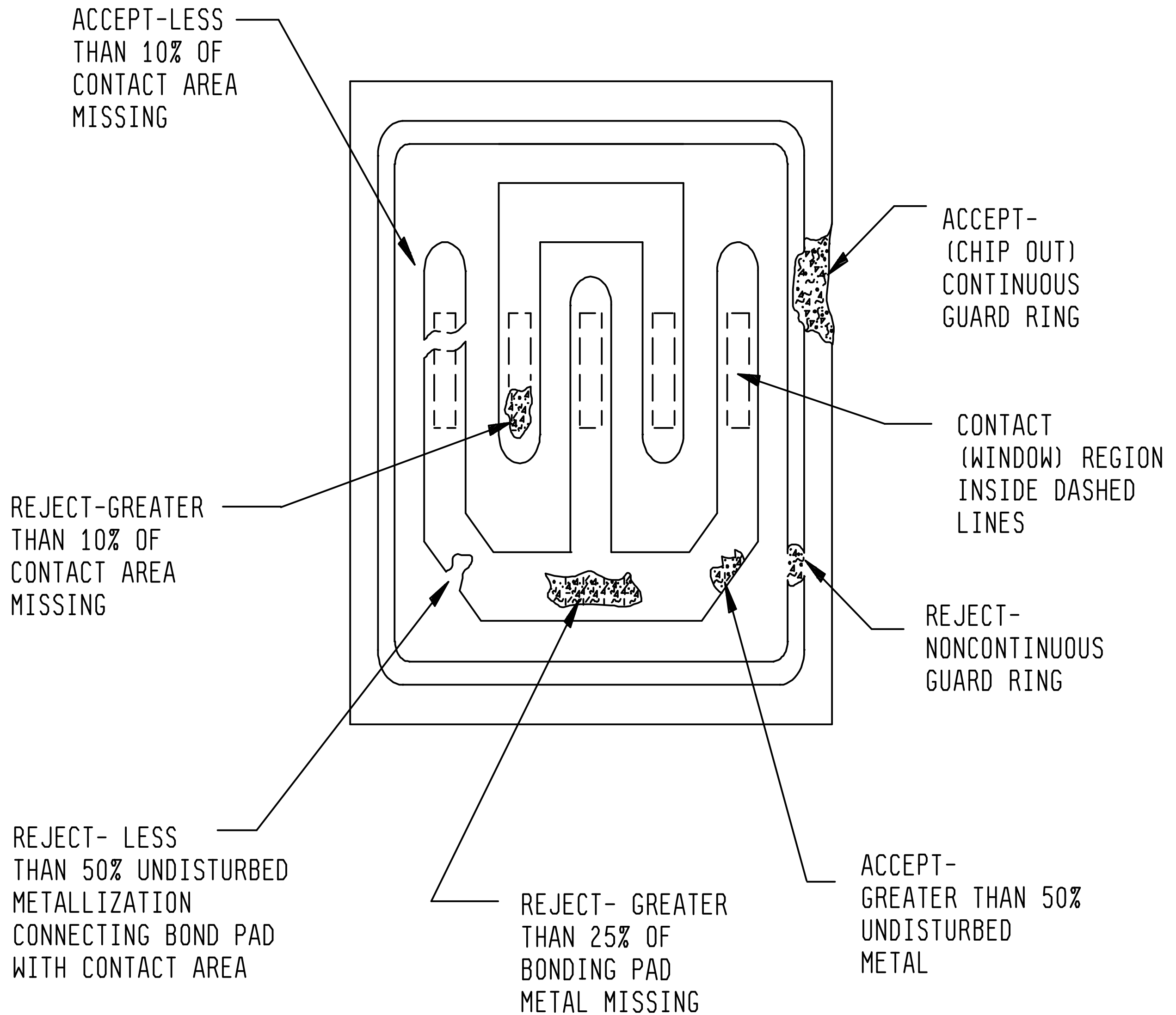
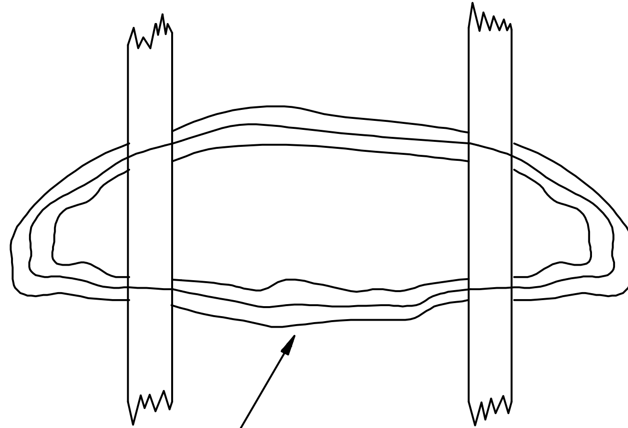


FIGURE 2072-1. Metallization scratches and voids (expanded contact).



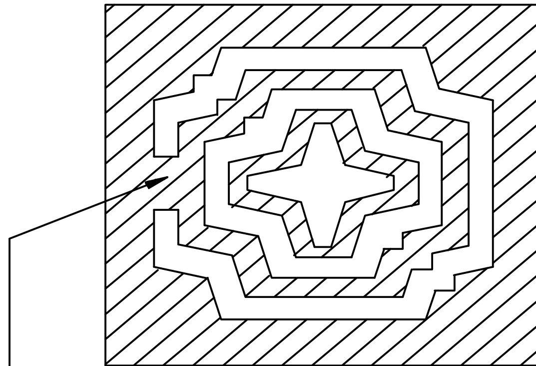
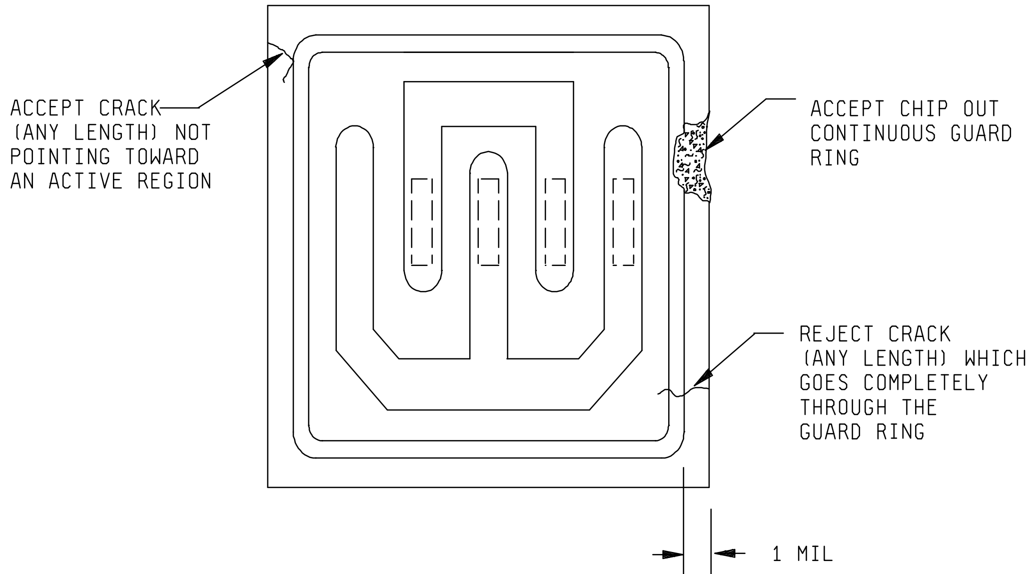
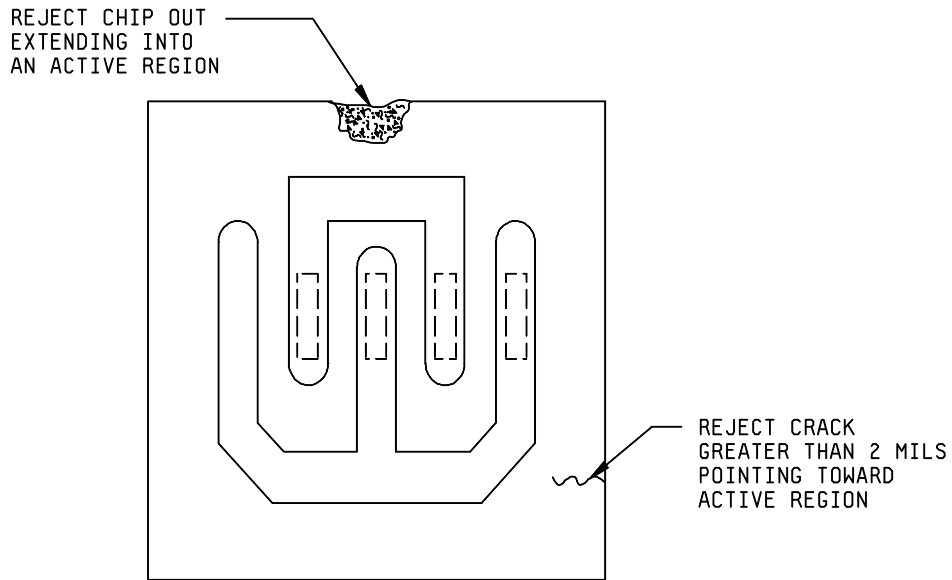


FIGURE 2072-2. Passivation and diffusion faults.

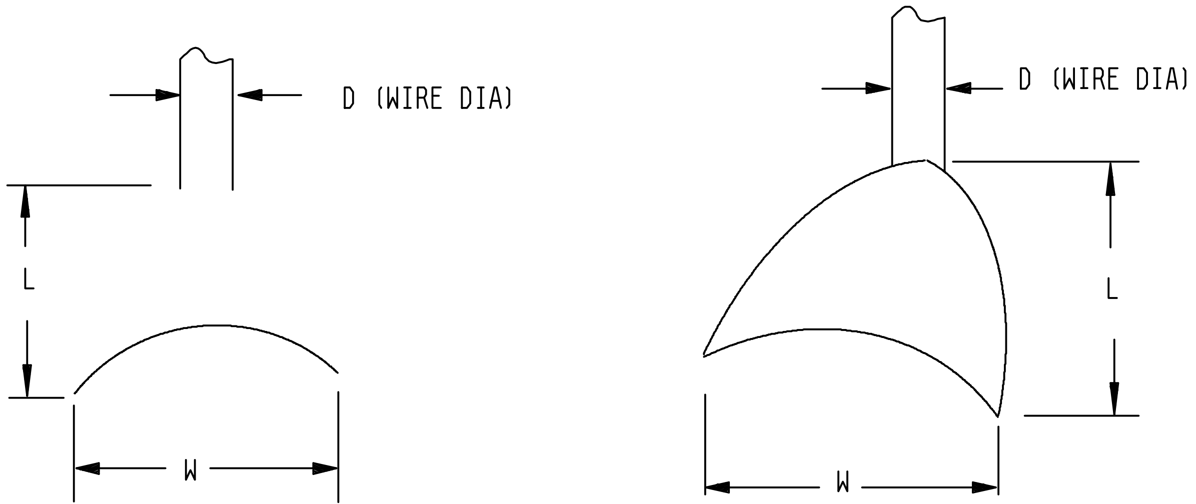


A. Die with guard ring.



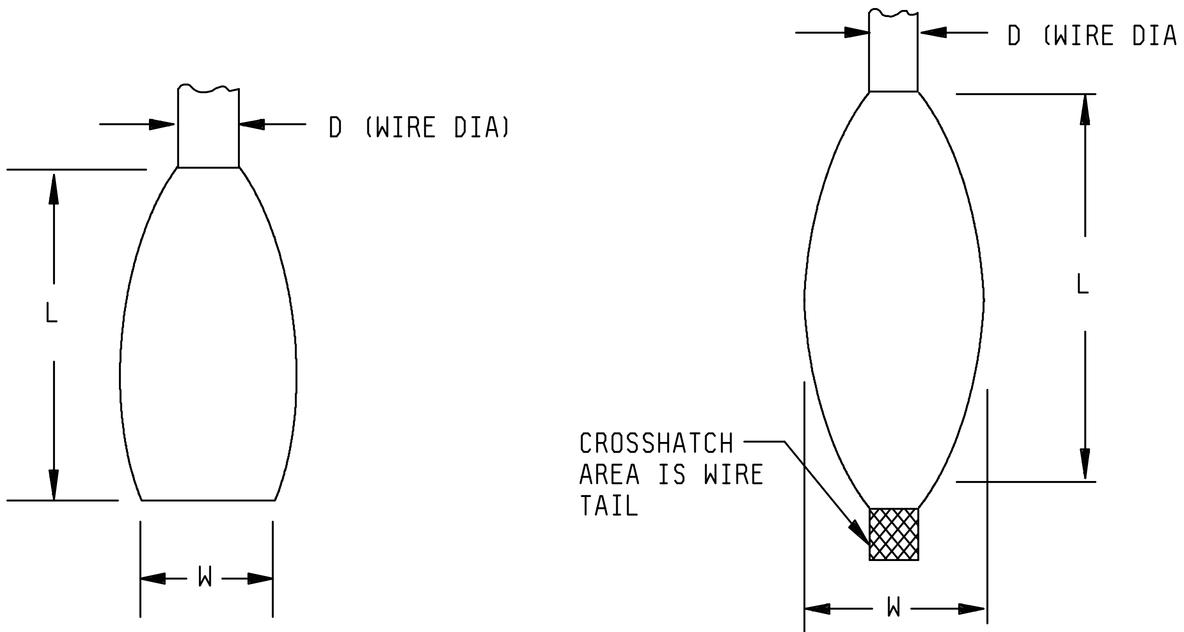
B. Die without guard ring.

FIGURE 2072-3. Cracks and chips.



A. Tailless or crescent.

NOTES:
1. 1.2.D ≤ W ≤ 5.0 D (width).
2. 0.5 D ≤ L ≤ 3.0 D (length).



B. Wedge.

Ultrasonic

NOTES:
1. 1.2 D ≤ W ≤ 3.0 D (width).
2. 1.5 D ≤ L ≤ 5.0 D (length).

Thermocompression

NOTES:
1. 1.2 D ≤ W ≤ 3.0 D (width).
2. 1.5 D ≤ L ≤ 5.0 D (length).

FIGURE 2072-4. Bond dimensions.

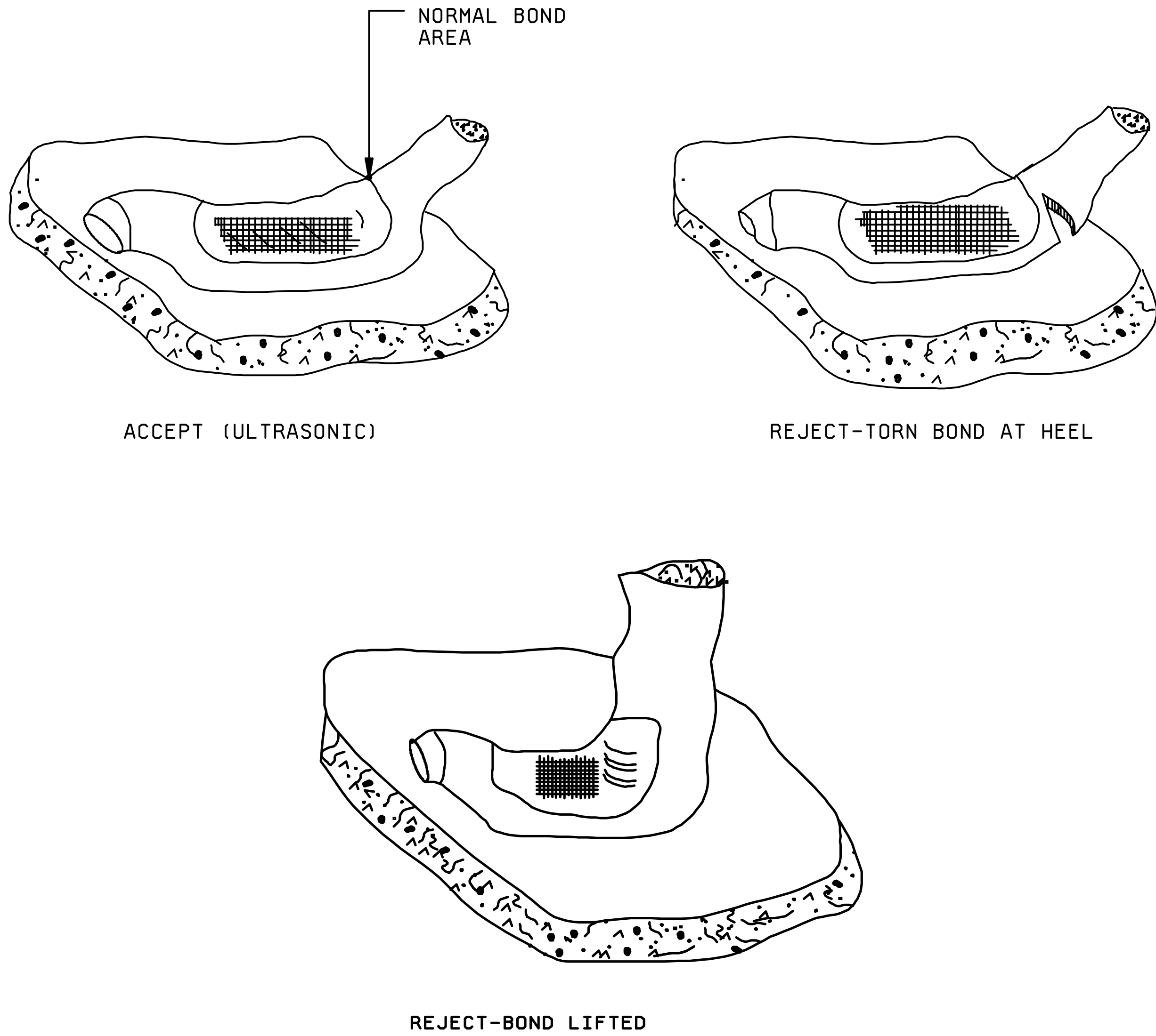


FIGURE 2072-5. Lift/torn bonds.

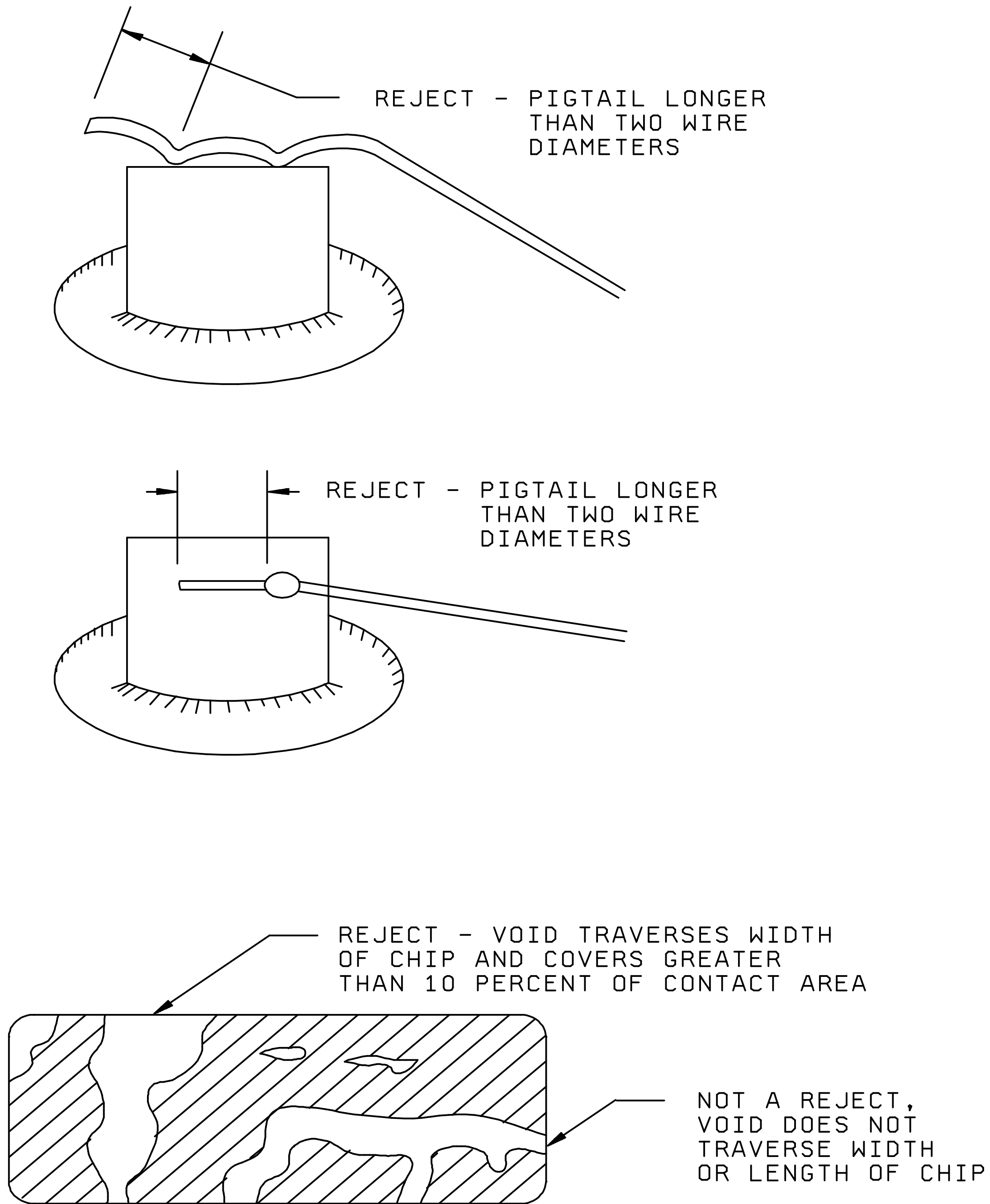


FIGURE 2072-6. Acceptable and unacceptable voids and excessive pigtails.

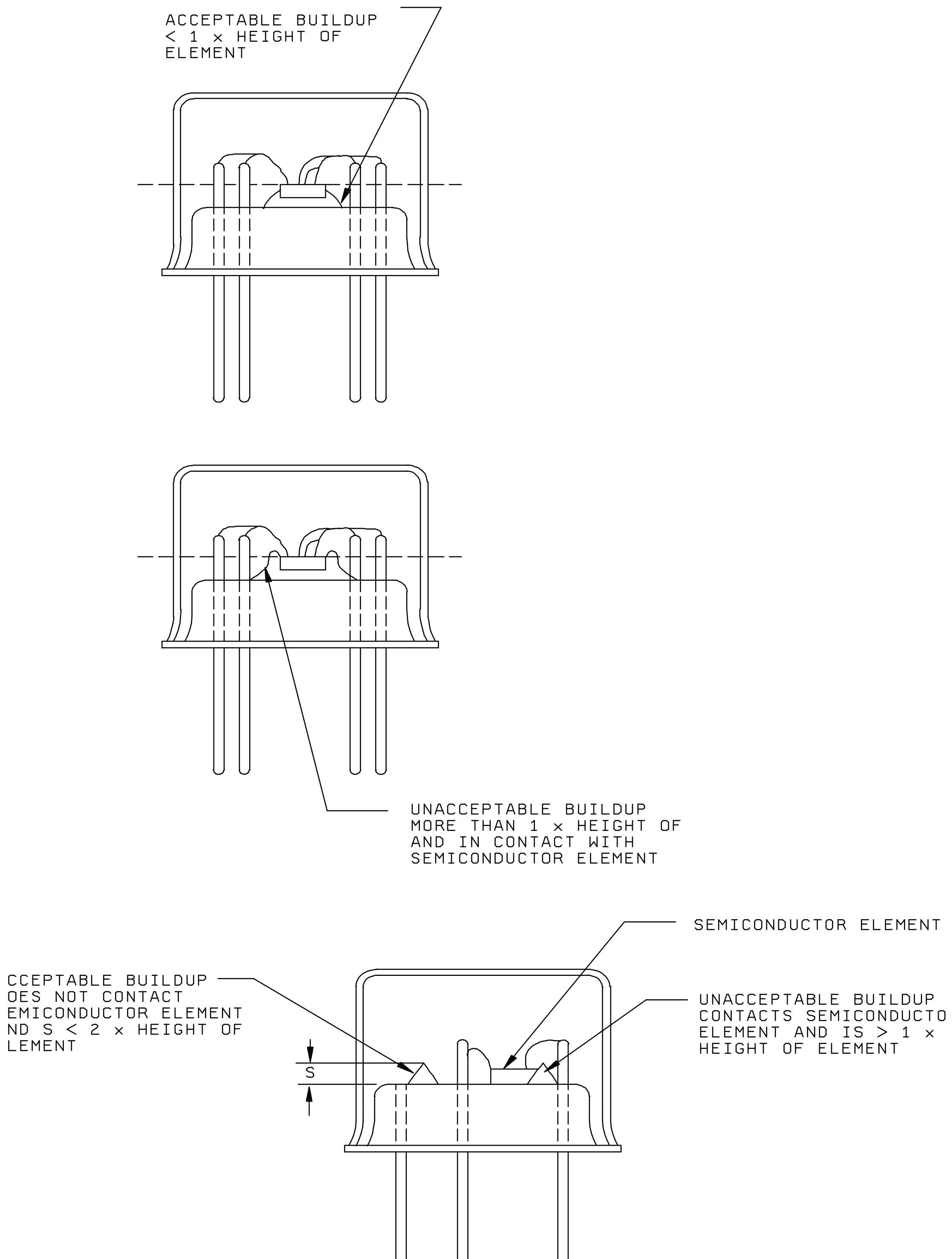
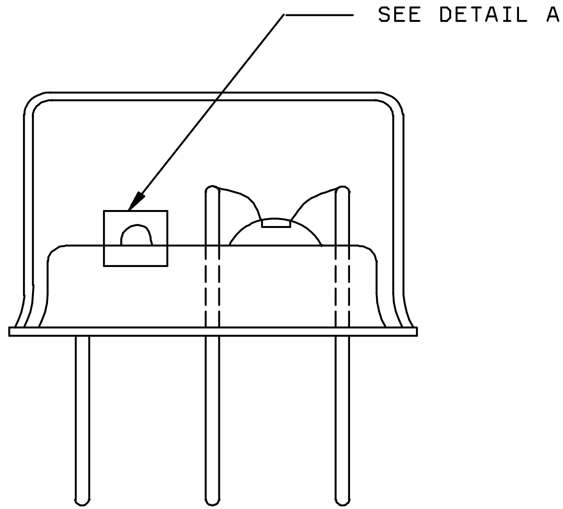
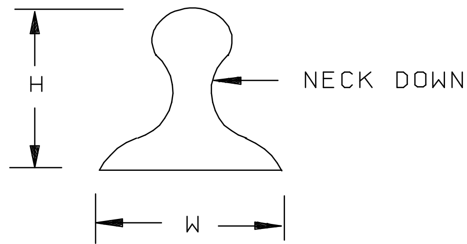


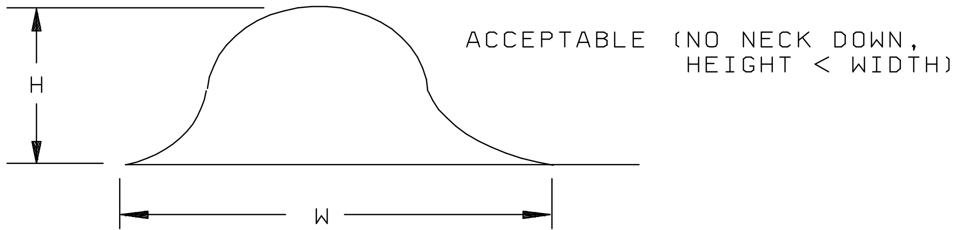
FIGURE 2072-7. Acceptable and unacceptable bonding material build-up.



2 x SEMICONDUCTOR ELEMENT
HEIGHT MAXIMUM

UNACCEPTABLE (NECK DOWN)
PEDESTAL (HEIGHT > WIDTH)





DETAIL A

NOTE: Die and wire are not necessarily visible.

FIGURE 2072-8. Extraneous bonding material build-up.

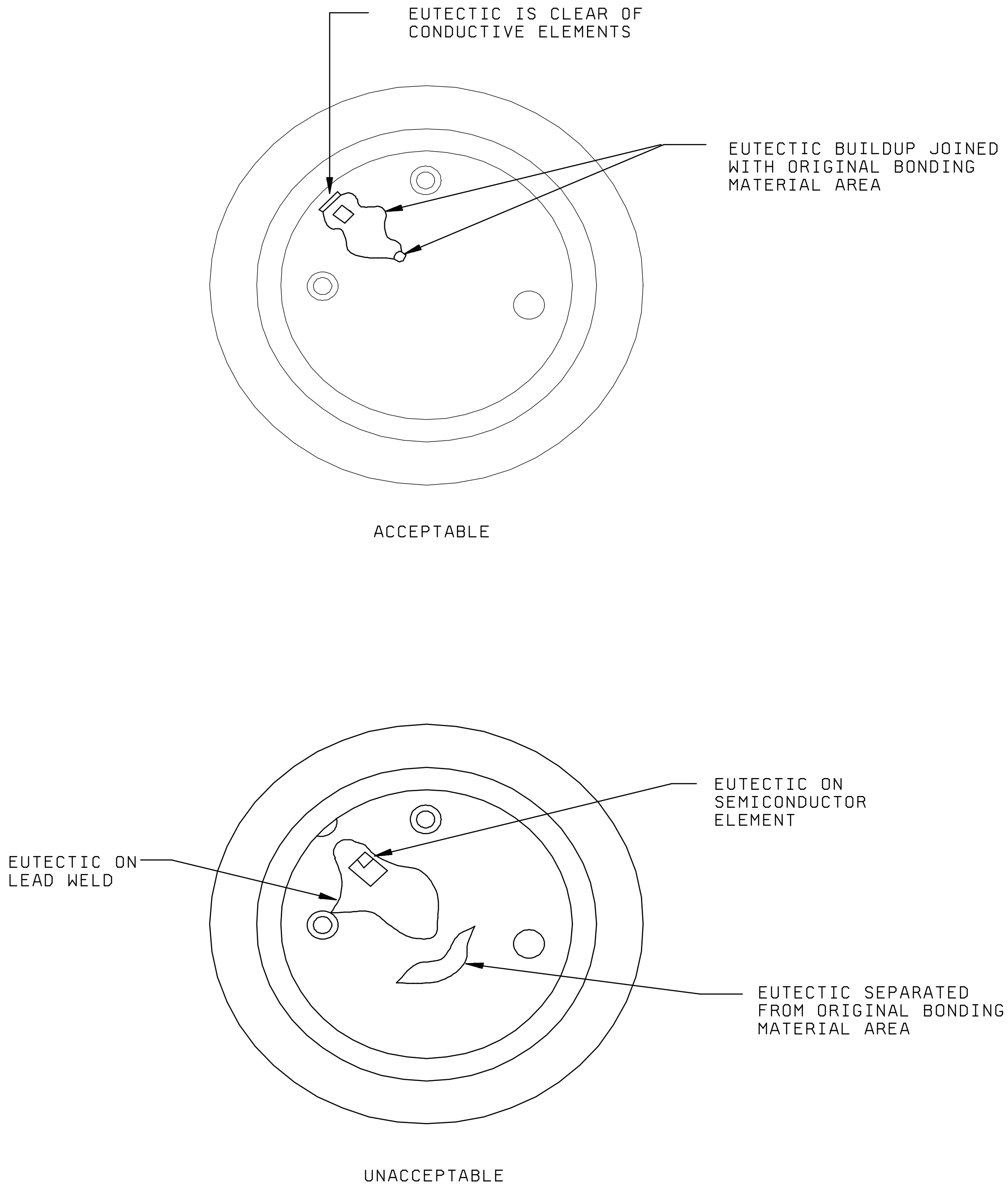


FIGURE 2072-9. Acceptable and unacceptable excess material.