METHOD 2076.3

RADIOGRAPHY

1. Purpose. The purpose of this examination is to nondestructively detect defects within the sealed case, especially those resulting from sealing of the lid to the case, and internal defects such as foreign objects, improper interconnecting wires, and voids in the die attach material or in the glass when glass seals are used. This test establishes methods, criteria, and standards for radiographic examination of discrete devices.

NOTE: For certain case types, the electron shielding effects of device construction materials (packages or internal) may effectively prevent radiographic identification of certain types of defects from some or all possible viewing angles. This factor should be considered in relation to the design of each when application of this test method is specified.

2. Apparatus. The apparatus and materials for this test shall include:

a. Radiographic equipment with a sufficient voltage range to penetrate the device. The focal distance shall be adequate to maintain a sharply defined image of a object with a major dimension of .001 inch (0.025 mm).

b. Radiographic film: (Eastman type R or equivalent).

c. Radiographic viewer capable of .001 inch (0.025 mm) resolution in any major dimension.

d. Holding fixtures capable of holding devices in the required positions without interfering with the accuracy or ease of image interpretation.

e. Radiographic quality standards capable of verifying the ability to detect all specified defects for particular package types being x-rayed.

f. A .062 inch (1.57 mm) minimum lead topped table shall be used to prevent back scatter of radiation.

3. Procedure. The x-ray exposure factors, voltage, milliampere setting and time settings shall be selected or adjusted as necessary to obtain satisfactory exposures and achieve maximum image details within the sensitivity requirements for the device or defect features the radiographic test is directed toward. Unless otherwise specified, the x-ray voltage shall be the lowest consistent with these requirements and shall not exceed 150 kV. Although higher voltages may be necessary to penetrate certain packages, these levels may be damaging to some device technologies.

3.1 Mounting and views. The devices shall be mounted in the holding fixture so that the devices are not damaged or contaminated and are in the proper plane as specified. The devices may be mounted in any type of fixture and masking with lead diaphragms or barium clay may be employed to isolate multiple specimens provided the fixtures or masking materials do not block the path of the x-rays to the film or any portion of the device.

3.1.1 Views.

a. Unless otherwise specified, flat packages and single ended cylindrical devices shall have one view taken with the x-rays penetrating in the Y direction as defined in figures 1 and 2 of the general requirements herein. When more than one view is required, the second and third views, as applicable, shall be taken with the x-rays penetrating in the X and Z directions respectively.

b. Unless otherwise specified, stud-mounted and cylindrical axial lead devices shall have one view taken with the x-rays penetrating in the X direction as defined in figures 1 and 2 of the general requirements herein. When more than one view is required, the second and third views, as applicable, shall be taken with the x-rays penetrating in the Z direction and at 45E between the X and Z directions.

c. All JANS devices shall have two views taken with x-rays penetrating in the X and Y directions, stud-mounted and axial lead device views shall be taken with x-rays penetrating in the X and Z directions.

3.2 Radiographic quality standard. The radiographic quality standard shall consist of a suitable standard penetrameter such as radiographic quality standard ASTM type B - Image quality indicator for semiconductor radiography or equivalent device. Each radiograph shall have two image quality standards exposed with each view located (and properly identified) in opposite corners of the film. The radiographic density of penetrameters chosen shall bracket the density of the devices beings inspected.

3.3 Film and marking. The radiograph film shall be in a film holder backed with a minimum of .062 inch (1.57 mm) lead or the holder shall be placed on the lead topped table (see 2.f). The film shall be identified using techniques that legibly print the following information, photographically on the radiograph:

a. Device manufacturer's name or code identification number.

b. Device type or Part or Identifying Number (PIN).

c. Production lot number, date code, or inspection lot number.

d. Radiographic film view number and date.

e. Device serial or cross reference numbers, when applicable (see 3.3.2).

f. X-ray laboratory identification, if other than device manufacturer.

g. X-ray axis view (X, Y, or Z).

3.3.1 Nonfilm techniques, when specified. The use of nonfilm techniques is permitted under the following conditions:

a. Permanent records are not required.

b. The equipment is capable of producing results of equal quality when compared with film techniques.

c. All requirements of this method are complied with except those pertaining to the actual film.

3.3.2 Serialized devices. When device serialization is required, each device shall be readily identified by a serial number. The devices shall be radiographed in consecutive, increasing serial order. When a device is missing, the blank space shall contain either the serial number or other x-ray opaque objects to readily identify and correlate the x-ray data. When more than one consecutive device is missing within serialized devices, the serial number of the last device before the skip and the first device after the skip may, at the manufacturers option, be used in place of the multiple opaque objects.

3.3.3 Special device marking. When specified (see 4.c), the devices that have been x-rayed and found acceptable shall be identified with a blue dot on the external case. The blue dot shall be approximately .062 inch (1.57 mm) in diameter. The color selected from FED-STD-595 shall be any shade between 15102-15123 or 25102-25109. The dot shall be placed so that it is readily visible but shall not obliterate other device marking.

3.4 Tests. The x-ray exposure factor shall be selected to achieve resolution of .001 inch (0.025 mm) major dimension, less than 10 percent distortion and an "H" and "D" film density between 1 and 2.5 in the area of interest of the device image. Radiographs shall be made for each view required (see 4.).

3.5 Processing. The radiographic film manufacturer's recommended procedure shall be used to develop the exposed film, and film shall be processed so that it is free of processing defects such as fingerprints, scratches, fogging, chemical spots, blemishes.

3.6 Operating personnel. Personnel who will perform radiographic inspection shall have training in radiographic procedures and techniques so that defects revealed by this method can be validly interpreted and compared with applicable standards. The following minimum vision requirements shall apply for visual acuity of personnel inspecting film as well as personnel authorized to conduct radiographic tests:

a. Distant vision shall equal at least 20/30 in both eyes, corrected or uncorrected.

b. Near vision shall be such that the operator can read Jaegger type No. 2 at a distance of 16 inches (406.4 mm), corrected or uncorrected.

c. Vision tests shall be performed by an oculist, optometrist, or other professionally recognized personnel at least once a year.

3.7 Interpretation of radiographs. Utilizing the equipment specified herein, radiographs shall be inspected to determine if each device conforms to this standard or if it is defective and shall be rejected. Interpretation of the radiograph shall be made under low light level conditions without glare on the radiographic viewing surface. The radiographs shall be examined on a suitable illuminator with variable intensity or on a viewer suitable for radiographic inspection on projection type viewing equipment. The radiograph shall be viewed at a magnification between 6X and 20X. Viewing masks may be used when necessary. Any radiograph not clearly illustrating the features in the radiographic quality standards is not acceptable and another radiograph of the devices shall be taken.

3.8 Reports and records.

3.8.1 Reports of inspection. For JANS devices, or when specified for other device classes, the manufacturer shall furnish inspection reports with each shipment of devices. The report shall describe the results of the radiographic inspection, and list the purchase order number or equivalent identification, the PIN, the date code, the quantity inspected, the quantity rejected, and the date of test. For each rejected device, the PIN, the serial number, when applicable, and the cause for rejection shall be listed.

3.8.2 Radiograph submission. When specified, one set of the applicable radiographs shall accompany each shipment of devices.

3.8.3 Radiograph and report retention. When specified, the manufacturer shall retain a set of the radiographs and a copy of the inspection report. These shall be retained for the period specified.

3.9 Examination and acceptance criteria.

3.9.1 Device construction. Acceptable devices shall be of the specified design and construction with regard to the characteristics discernible through radiographic examination. Devices that deviate significantly from the specified construction shall be rejected.

3.9.2 Individual device defects. The individual device examination shall include, but not be limited to, inspection for foreign particles, solder or weld "splash" build up of bonding material, proper shape and placement of lead wires or whiskers, and bond of lead or whisker to semiconductor element. Devices for which the radiograph reveals any of the following defects shall not be accepted.

3.9.2.1 Unacceptable construction. In the examination of devices, the following aspects shall be considered unacceptable construction and devices that exhibit any of the following defects shall be rejected:

a. Total contact area voids in excess of one-half of the total contact area.

b. A single void which traverses either the length or width of the semiconductor die and exceeds 10 percent of the total intended contact area.

(1) Voids: When radiographing devices, certain types of mounting do not give true representations of voids. When such devices are inspected, the mounting shall be noted on the inspection report (see figure 2076-1).

(2) Wires present, other than those connecting specific areas of the semiconductor die to the external leads.

(3) Angle between semiconductor die surface and edge less than 45°.

(4) Defective seal: Any device wherein the integral lid seal is not continuous or is reduced from its designed sealing width by more than 75 percent.

NOTE: Expulsion resulting from the final sealing operation is not considered extraneous material as long as it can be established that it is continuous, uniform, and attached to the parent material and does not exhibit a ball, splash, or tear-drop configuration.

(5) Inadequate clearance: Acceptable devices shall have adequate internal clearance to assure that the elements cannot contact one another or the case. No crossover of wires connected to different electrical elements shall be allowed. Depending upon the case type, devices shall be rejected for the following conditions:

(a) Flat pack and dual-in-line (see figure 2076-2).

1. Any lead wire that appears to touch or cross another lead wire or bond (Y plane only).

2. Any lead wire that deviates from a straight line from bond to external lead and appears to be within .002 inch (0.0504 mm) of another bond (Y plane only).

3. Lead wires that do not deviate from a straight line from bond to external lead and appear to touch another wire or bond (Y plane only).

4. Any lead wire that touches or is less than .002 inch (0.0504 mm) from the case or external lead to which it is not attached (X and Y plane).

5. Any bond that is less than .001 inch (0.0254 mm) (excluding bonds connected by a common conductor) from another bond (Y plane only).

6. Any wire making a straight line run (with no arc) from die bonding pad to package post.

(b) Round or "box" transistor type (see figure 2076-3).

1. Any lead wire that touches or is less than .002 inch (0.0504 mm) from the case or external lead to which it is not attached (X and Y plane).

2. Lead wires that sag below an imaginary plane across the top of the bond (X plane only).

3. Any lead wire that appears to touch or cross another lead wire or bond (Y plane only) if bonded to different electrical elements.

4. Any lead wire that deviates from a straight line from bond to external lead appears to touch or to be within .002 inch (0.0504 mm) of another wire or bond (Y plane only).

5. Any bond that is less than .001 inch (0.0254 mm) (excluding bonds connected by a common conductor) from another bond (Y plane only).

6. Any wire making a straight line run (with no arc) from die bonding pad to package post, unless specifically designed in this manner (e.g., clips, rigid connecting leads, or heavy power leads).

7. Any internal post that is bent more than 10° from the vertical (or intended design position) or is not uniform in length and construction or comes closer than one post diameter to another post.

8. Any post in a low profile case (such as a TO-46) which comes closer to the top of the case than 20 percent of the total inside dimension between the header and the top of the case. Any device in which the semiconductor element is vertical to the header, and comes closer than .002 inch (0.0504 mm) to the header or to any part of the case.

(c) Axial lead type (see figure 2076-4).

1. Whisker embedded within glass body wall.

2. Whisker tilted more than 5° in any direction from the device lead axis or deformed to the extent that it touches itself.

3. Either half of an S or C bend whisker that is compressed so that any dimension is reduced to less than 50 percent of its design value. On diodes with whiskers metallurgically bonded to the post and to the die, the whisker may be deformed to the extent that it touches itself if the minimum whisker clearance zone specified in figure 2076-4a is maintained for metal packages.

4. Whiskerless construction device with plug displacement distance more than one-fourth of the diameter of the plug with respect to the central axis of the device.

5. Semiconductor element mounting tilted more than 15E from normal to the main axis of the device.

6. Die hanging over edge of header or pedestal more than 20 percent of the die contact area by design.

7. Less than 75 percent of the semiconductor element base area is bonded to the mounting surface.

8. Voids in the welds which reduce the lead to plug connection by more than 25 percent of the total weld area.

9. Devices with package deformities such as body glass cracks, incomplete seals (e.g., voids, position of glass), die chip outs, and severe misalignment of S- and C-shaped whisker connections to die or post that exceed the limits of the applicable visual inspection requirements.

3.9.3 Encapsulated non-cavity assemblies of discrete devices. External to the individual devices, the encapsulating material shall be examined and rejected for the following defects.

3.9.3.1 Extraneous material. Extraneous matter of any shape with any dimension exceeding .020 inches (0.51 mm). Also, any two adjacent particles of such matter with total dimensions exceeding .030 inches (0.76 mm).

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

a. Number of views, if other than indicated in 3.1.1 and 3.1.1.1.

b. Radiograph submission, if applicable (see 3.8.2).

c. Marking, if other than indicated in 3.3 and marking of samples to indicate they have been radiographed, if required (see 3.3.3).

d. Sample defects and criteria for acceptance or rejection, if other than indicated in 3.9.

e. Radiograph and report retention, if applicable (see 3.8.3).

f. Test reports when required.

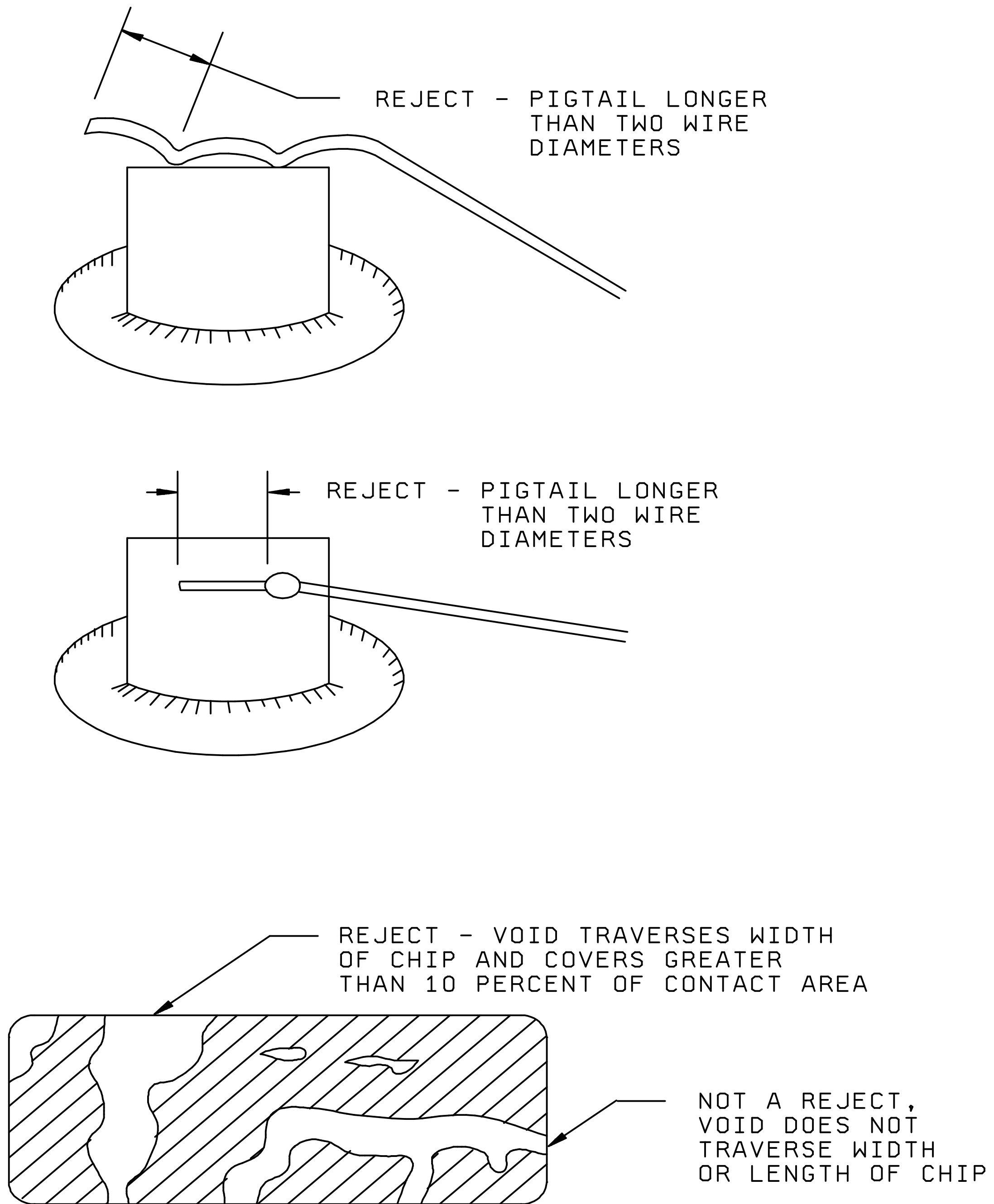


FIGURE 2076-1. Acceptable and unacceptable voids and excessive pigtails.

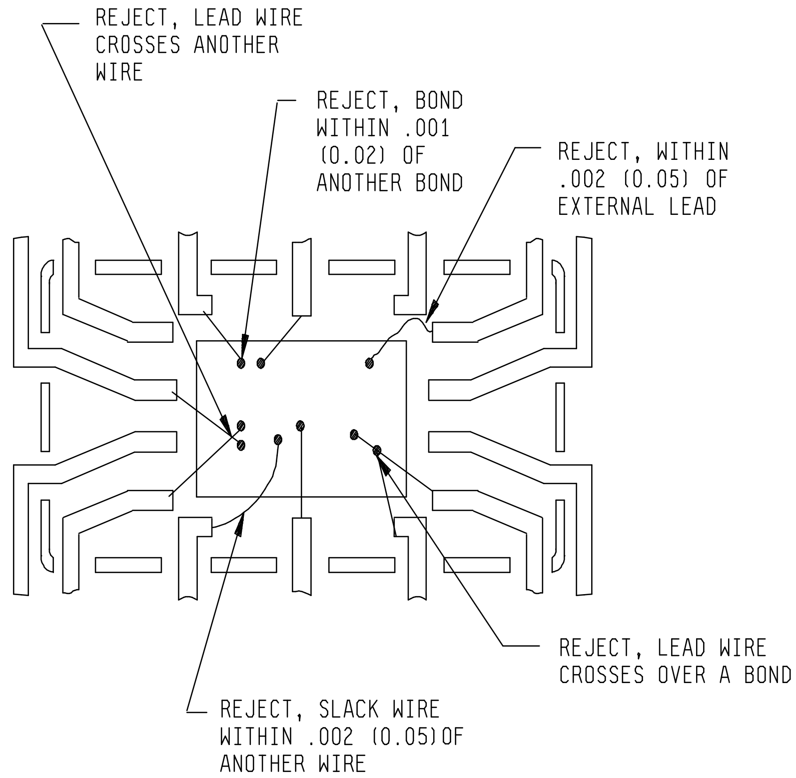


FIGURE 2076-2. Clearance in dual-in-line or flat pack type device.

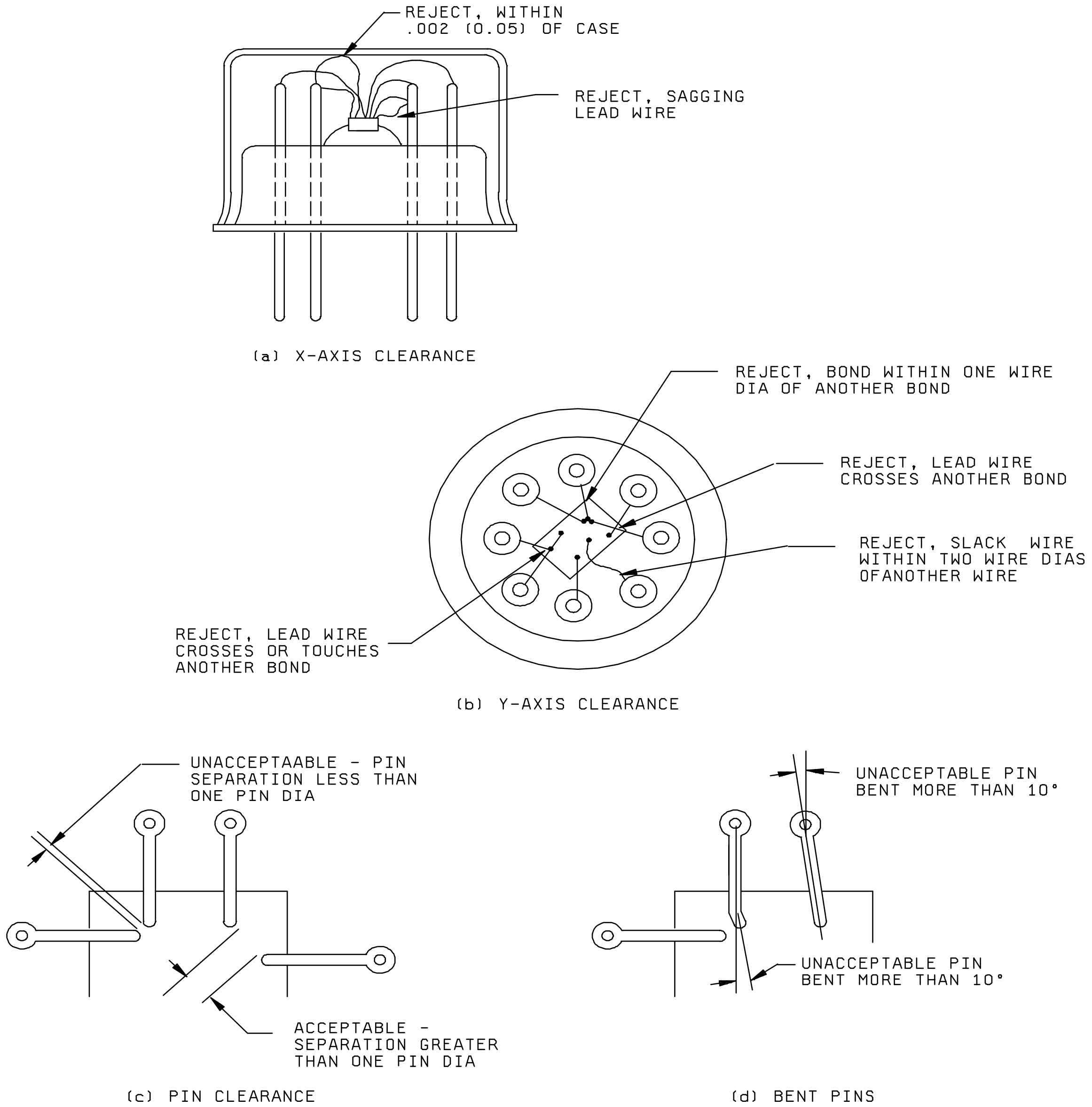
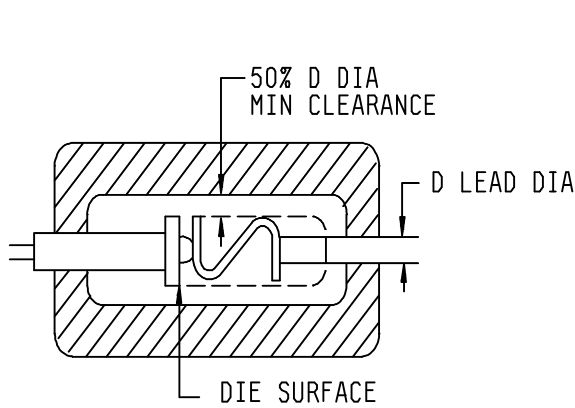
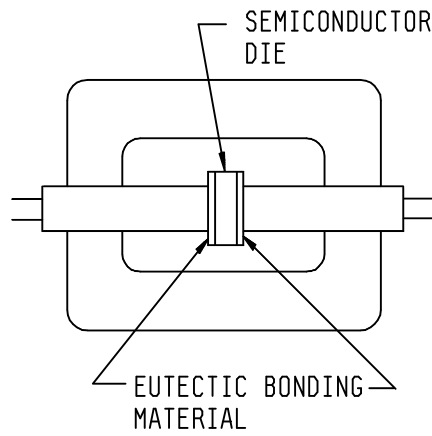
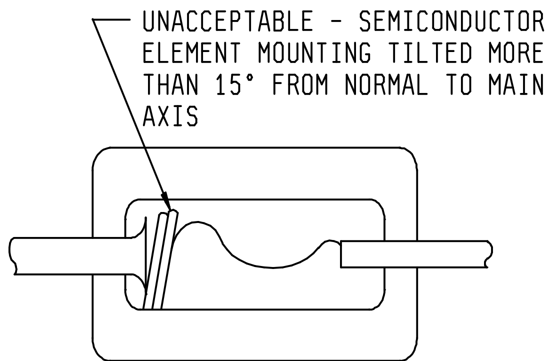


FIGURE 2076-3. Clearance in round or box transistor type device.







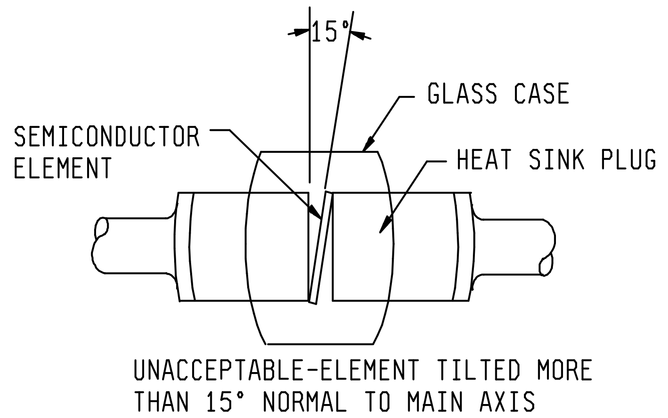


FIGURE 2076-4. Clearance in cylindrical axial lead type device.