constant acceleration

1. PURPOSE. This test is used to determine the effects of constant acceleration on microelectronic devices. It is an accelerated test designed to indicate types of structural and mechanical weaknesses not necessarily detected in shock and vibration tests. It may be used as a high stress test to determine the mechanical limits of the package, internal metallization and lead system, die or substrate attachment, and other elements of the microelectronic device. By establishing proper stress levels, it may also be employed as an in-line 100 percent screen to detect and eliminate devices with lower than nominal mechanical strengths in any of the structural elements.

2. APPARATUS. Constant acceleration tests shall be made on an apparatus capable of applying the specified acceleration for the required time.

3. PROCEDURE. The device shall be restrained by its case, or by normal mountings, and the leads or cables secured. Unless otherwise specified, a constant acceleration of the value specified shall then be applied to the device for 1 minute minimum in each of the orientations X1, X2, Y1, Y2, Z1, and Z2 (see note 1). For devices with internal elements mounted with the major seating plan perpendicular to the Y axis, the Y1 orientation shall be defined as that one in which the element tends to be removed from its mount. Unless otherwise specified, test condition E shall apply. Note: The “Stress level(s)” are absolute minimums with no lower tolerances. The spin radius shall be from the center of the rotor to the 1st point of element attachment. See Figure 2001-1.

Note 1: Dual cavity devices may require multiple spins with the device orientation reversed to properly stress the device.

<table>
<thead>
<tr>
<th>Test condition</th>
<th>Stress level (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5,000</td>
</tr>
<tr>
<td>B</td>
<td>10,000</td>
</tr>
<tr>
<td>C</td>
<td>15,000</td>
</tr>
<tr>
<td>D</td>
<td>20,000</td>
</tr>
<tr>
<td>E</td>
<td>30,000</td>
</tr>
<tr>
<td>F</td>
<td>50,000</td>
</tr>
<tr>
<td>G</td>
<td>75,000</td>
</tr>
<tr>
<td>H</td>
<td>100,000</td>
</tr>
<tr>
<td>J</td>
<td>125,000</td>
</tr>
</tbody>
</table>

4. SUMMARY. The following details shall be specified in the applicable acquisition document:
   a. Amount of acceleration to be applied, in gravity units (g) if other than test condition E (see 3).
   b. When required, measurements to be made after test.
   c. Any variations in duration or limitations to orientation (e.g., Y1 only) (see 3).
   d. Sequence of orientations, if other than as specified (see 3).
g = acceleration to be applied in gravity units
\omega = revolutions per minute
r = radius in inches (center of rotor to the 1st point of element attachment)

\begin{align*}
g &= 2.8416 \times 10^{-5} \omega^2 \quad \text{or} \\
g \text{ force} &= \text{Radius in inches} \times \text{RPM}^2 \times 2.8416 \times 10^{-5} \\
\omega &= \left(\frac{g}{2.8416 \times 10^{-5}}\right)^{1/2} \quad \text{or} \\
\text{RPM} &= \left(\frac{g \text{ force/Radius in inches} \times 2.8416 \times 10^{-5}}{\omega^2}\right)^{1/2} \\
r &= \frac{g}{(2.8416 \times 10^{-5}) \omega^2} \quad \text{or} \\
\text{Radius} &= \frac{g \text{ force}}{(\text{RPM}^2 \times 2.8416 \times 10^{-5})}
\end{align*}
1. **PURPOSE.** The shock test is intended to determine the suitability of the devices for use in electronic equipment which may be subjected to moderately severe shocks as a result of suddenly applied forces or abrupt changes in motion produced by rough handling, transportation, or field operation. Shocks of this type may disturb operating characteristics or cause damage similar to that resulting from excessive vibration, particularly if the shock pulses are repetitive.

2. **APPARATUS.** The shock-testing apparatus shall be capable of providing shock pulses of 500 to 30,000 g (peak) as specified with a pulse duration between 0.1 and 1.0 millisecond, to the body of the device. The acceleration pulse shall be a half-sine waveform with an allowable distortion not greater than ±20 percent of the specified peak acceleration, and shall be measured by a transducer and optional electronic filter with a cut-off frequency of at least 5 times the fundamental frequency of the shock pulse. The pulse duration shall be measured between the points at 10 percent of the peak acceleration during rise time and at 10 percent of the peak acceleration during decay time. Absolute tolerances of the pulse duration shall be the greater of ±0.1 millisecond or ±30 percent of the specified duration.

3. **PROCEDURE.** The shock-testing apparatus shall be mounted on a sturdy laboratory table or equivalent base and leveled before use. The device shall be rigidly mounted or restrained by its case with suitable protection for the leads. Means may be provided to prevent the shock from being repeated due to "bounce" in the apparatus. Unless otherwise specified, the device shall be subject to 5 shock pulses of the peak (g) level specified in the selected test condition and for the pulse duration specified in each of the orientations X1, X2, Y2, Y1, Z1, and Z2. For devices with internal elements mounted with the major plane perpendicular to the Y axis, the Y1 orientation shall be defined as that one in which the element tends to be removed from its mount. Unless otherwise specified, test condition B shall apply. Note: The "g level (peak) limits are absolute minimums with no lower tolerances.

<table>
<thead>
<tr>
<th>Test condition</th>
<th>g level (peak)</th>
<th>Duration of pulse (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>500</td>
<td>1.0</td>
</tr>
<tr>
<td>B</td>
<td>1,500</td>
<td>0.5</td>
</tr>
<tr>
<td>C</td>
<td>3,000</td>
<td>0.3</td>
</tr>
<tr>
<td>D</td>
<td>5,000</td>
<td>0.3</td>
</tr>
<tr>
<td>E</td>
<td>10,000</td>
<td>0.2</td>
</tr>
<tr>
<td>F</td>
<td>20,000</td>
<td>0.2</td>
</tr>
<tr>
<td>G</td>
<td>30,000</td>
<td>0.12</td>
</tr>
</tbody>
</table>

**CAUTION:** If this test is performed using a potting compound type test fixture (e.g., waterglass/sodium silicate) the facility performing the test shall assure that this procedure/material does not mask fine/gross leakers.

3.1 **Examination.** After completion of the test, an external visual examination of the marking shall be performed without magnification or with a viewer having a magnification no greater than 3X and a visual examination of the case, leads, or seals shall be performed at a magnification between 10X and 20X. This examination and any additional specified measurements and examination shall be made after completion of the final cycle or upon completion of a group, sequence, or subgroup of tests which include this test.

3.2 **Failure criteria.** After subjection to the test, failure of any specified measurements or examination (see 3 and 4), evidence of defects or damage to the case, leads, or seals, or illegible markings shall be considered a failure. Damage to marking caused by fixturing or handling during tests shall not be cause for device rejection.

4. **SUMMARY.** The following details shall be specified in the applicable acquisition document:

   a. Test condition, if other than test condition B (see 3).
   b. Number and direction of shock pulses, if other than specified (see 3).
   c. Electrical-load conditions, if applicable (see 3).
   d. When required, measurement made after test (see 3 and 3.1).
   e. When required, measurement during test.
1. **PURPOSE.** The purpose of this test method is to provide a referee condition for the evaluation of the solderability of terminations (including leads up to 0.125 inch in diameter) that will be assembled using tin lead eutectic solder. This evaluation is made on the basis of the ability of these terminations to be wetted and to produce a suitable fillet when coated by tin lead eutectic solder. These procedures will test whether the packaging materials and processes used during the manufacturing operations produce a device that can be successfully soldered to the next level assembly using tin lead eutectic solder. A preconditioning test is included in this test method, which degrades the termination finish to provide a guard band against marginal finishes.

1.1 **Terms and definitions.** The definition of terms shall be in accordance with the following:

1.1.1 **Solderability.** The property of a metal to be wetted by molten solder.

1.1.2 **Wetting.** The formation of a relatively uniform, smooth and unbroken film of solder, adherent to the surface of the base metal tested.

1.1.3 **Nonwetting.** A condition whereby a surface has contacted molten solder, but the solder has not adhered to all of the surface, leaving the surface base metal partially or totally exposed. See Figure 2003-1.

1.1.4 **Pinholes.** Holes occurring as imperfections that penetrate entirely through the solder layer. See Figure 2003-2.

1.1.5 **Dewetting.** A condition that results when molten solder has coated a surface and then receded leaving irregularly shaped mounds of solder separated by areas covered with a thin solder film, and where the base metal is not exposed. See Figure 2003-3.

1.1.6 **Foreign material.** Particles of material located on, but different from, the lead material or coating.

1.1.7 **DIP.** Dual In-line Package.

1.1.8 **TO.** Transistor Outline.

1.1.9 **PGA.** Pin Grid Array.

1.1.10 **QFP.** Quad Flat Pack.

1.1.11 **LCC.** Leadless Chip Carrier.

1.1.12 **LGA.** Land Grid Array.

1.1.13 **QFN.** Quad Flat No-lead.

2. **APPARATUS.**

2.1 **Solder pot.** A thermostatically controlled static solder vessel of sufficient size to contain at least two pounds of solder. The solder shall be static during the dipping procedure. The apparatus shall be capable of maintaining the solder at the temperature specified in 4.4.1.2

2.2 **Dipping mechanism.** A dipping mechanism capable of controlling the rates of immersion and emersion of the terminations and providing a dwell time (total time at the required depth) in the solder bath as specified in 4.4.1.2. It is also capable of orienting and dipping the device to meet the dipping requirements. The specimen holder shall be designed to minimize the trapping of flux.

2.3 **Ceramic substrate.** A thin unmetallized ceramic substrate with a thickness range of 0.025 inch to 0.035 inch (used for testing of ball grid arrays).

2.4 **Metallized substrate.** A substrate made of glass-reinforced epoxy (e.g., FR-4) with metallized pads (e.g., Electroless Nickel Immersion Gold). The pad diameter shall be at least 0.010 inch larger than the column diameter (used for testing of column grid arrays).

2.5 **Screen print stencil.** A metal (or other acceptable material, such as plastic) stencil with pad geometry openings appropriate for the device being tested. Alternative dispense systems may be used that do not use a stencil or squeegee (e.g., jet printing). Unless otherwise agreed upon between vendor and user, the nominal stencil thickness shall be 0.004 inch (for lead pitch < 0.020 inch), 0.006 inch (for lead pitch ≥ 0.020 inch and up to 0.025 inch), and 0.008 inch (for lead pitch > 0.025 inch).

2.6 **Squeegee.** A rubber, plastic, or metal tool used to print the solder paste. This is not applicable if alternative dispense systems (e.g., jet printing) are used.
2.7 **Base fixture.** A fixture designed to hold the substrate and aid in the alignment of the screen print stencil.

2.8 **Reflow equipment.** A forced-convection reflow oven or equivalent reflow system capable of achieving the recommended reflow profile.

2.9 **Cutting equipment.** A system capable of cutting the columns without excessive burrs and without damaging the columns (e.g., diamond wire saw).

2.10 **Optical equipment.** A stereo optical system capable of providing a minimum magnification of 10x.

2.11 **Lighting equipment.** A lighting system that will provide a uniform, non-glare, non-directional illumination of the device.

2.12 **Steamaging equipment.** A non-corrodible container and cover of sufficient size to allow the placement of devices inside the vessel. The devices shall be placed such that the lowest portion of the device is a minimum of 1.5 inches above the surface of the water. A suitable method of supporting the devices shall be improvised using non-contaminating material. The apparatus shall be capable of having the specified temperature verified.

2.12.1 **Cleaning of the system.** The apparatus shall be drained and cleaned at least once per month or prior to use. A more frequent cleaning cycle may be necessary as indicated by resistivity, visual, or general cleanliness of the water. No contaminating solvents shall be used.

2.13 **High-temperature bake equipment.** A bake oven of sufficient size and capable of continuously maintaining 150°C ± 5°C temperature control shall be used.

3. **MATERIALS.** All chemicals shall be of commercial grade or better. Fresh solvents shall be used as often as is necessary to preclude contamination.

3.1 **Flux.** The flux shall be a standard activated rosin flux having a composition of 25% ± 0.5% by weight of Colophony (rosin) and 0.15% ± 0.01% by weight diethylamine hydrochloride (CAS 660-68-4), in 74.85% ± 0.05% by weight of isopropyl alcohol. When specified by the procuring activity low activity fluxes labeled conforming to ROL0, ROL1, or RMA may be substituted.

3.2 **Solder.** The solder shall conform to type Sn63Pb37, Sn60Pb40, or equivalent.

3.3 **Solder paste.** The solder paste shall be Sn60Pb40, Sn63Pb37, or equivalent, with mesh size of -325/+500, flux type ROL1. The solder paste shall meet the storage and shelf life requirements of the manufacturer’s specification.

3.4 **Cleaning solution.** Solutions used for flux removal shall be compatible with the device and the metallized substrate.

3.5 **Isopropyl alcohol.** Commercial grade isopropyl alcohol or better shall be used.

3.6 **Water.** The water to be used for steamaging purposes shall be either distilled or deionized.

**WARNING:** These materials may involve substances that are flammable, toxic to eyes, skin, or respiratory tract, or present a serious burn potential. Eye and skin protection should be used. Heat resistant gloves should be used when handling hot objects.

4. **PROCEDURE.** The test procedure shall be performed on the number of terminations specified in the acquisition document. If no number is specified then the sample size shall be 22(0). The test may be performed just prior to packaging for storage or shipment, immediately upon removal from the manufacturer’s protective packaging, or as a qualification or quality conformance test. The samples shall have the lead finish that is to be supplied to the customer. (e.g., if gold and solder finish are supplied, both finishes shall be tested.) The sample shall be selected at random using at least 3 different devices. During handling, special care shall be exercised to prevent the surfaces being tested from being abraded or contaminated by grease, perspiration, or abnormal atmospheres. The test procedure shall consist of the following operations:

a. **Preparation of terminations** (see 4.1), if applicable.

b. **Preconditioning of all specimens** (see 4.2).

c. **Solderability test** (see 4.4).

d. **Examination and evaluation of the tested portions of the terminations upon completion of the solder dip process** (see 4.5).

4.1 **Preparation of terminations.** No wiping, cleaning, scraping, or abrasive cleaning of the terminations shall be performed prior to testing. Any special preparation of the terminations, such as bending or reorientation prior to the test, shall be specified in the acquisition document.
4.2 Preconditioning categories. The preconditioning categories shall be as follows:

a. Category A – All device finishes, which have no gold or tin content specified (Steamage for 1 hour ± 5 min)
b. Category B – Column grid arrays (Steamage for 4 hours ± 10 min)
c. Category C – For all other device finishes, including gold (Steamage for 8 hours ± 15 min)
d. Category D – For LGAs (Dry-bake for 4 hours ± 15 min)

4.2.1 Steamaging. (Categories A, B, and C) Prior to the application of the flux and subsequent solder dips, specimens shall be subjected to aging by exposure of the surfaces to be tested to water vapor (see 4.2) in the apparatus specified in 2.12. The water vapor temperature at the device lead level shall be in accordance with table I. Aging may be interrupted once for 10 minutes maximum. The devices shall be removed from the test apparatus upon completion of the specified test period.

4.2.1.1 Drying and storage procedures. Upon removal of test specimens from the steamaging apparatus following preconditioning, the devices shall be dried (if applicable) using one of these two procedures:

a. Bake at 100ºC maximum for no more than 1 hour in a dry atmosphere (dry nitrogen atmosphere is recommended).
b. Air dry at ambient temperature for a minimum of 15 minutes.

TABLE I. Altitude versus steam temperature (see 4.2.1).

<table>
<thead>
<tr>
<th>Altitude (feet)</th>
<th>Steam Temperature (+/-3°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1,000</td>
<td>93</td>
</tr>
<tr>
<td>1,001 - 2,000</td>
<td>92</td>
</tr>
<tr>
<td>2,001 - 3,000</td>
<td>91</td>
</tr>
<tr>
<td>3,001 - 4,000</td>
<td>90</td>
</tr>
<tr>
<td>4,001 - 5,000</td>
<td>89</td>
</tr>
<tr>
<td>5,001 - 6,000</td>
<td>88</td>
</tr>
<tr>
<td>Greater than 6,000</td>
<td>87</td>
</tr>
</tbody>
</table>

4.2.2 Dry-bake. (Category D) Prior to the application of the flux and subsequent solder dips, specimens shall be subjected to aging by exposure of the surfaces to be tested to high temperature (see 4.2) in the apparatus specified in 2.13. Aging may be interrupted once for 10 minutes maximum. The devices shall be removed from the test apparatus upon completion of the specified test period.

4.3 Post preconditioning requirements. If solderability test cannot be performed within 2 hours after preconditioning, then devices shall be stored in a desiccant jar or dry nitrogen cabinet. Test must be performed within 72 hours after removal from the preconditioning equipment.

4.4 Solderability test. The test method shall be as follows.

Test A – For Dip and Look Test
Test B – For Ball Grid Array (BGA) Surface Mount Simulation Test
Test C – For Column Grid Array (CGA) Surface Mount Simulation Test

4.4.1 Dip and look. Dip and look test shall be performed on the following devices:

a. Leaded through hole mount (e.g., DIP, TO can, PGA)
b. Leaded surface mount (e.g., J-lead, QFP)
c. Leadless surface mount (e.g., LCC, LGA, QFN)

4.4.1.1 Application of flux. The terminations to be tested shall be immersed in flux maintained at room ambient temperature. The critical area of the terminations to be tested shall be immersed in the flux for 5 to 10 seconds, and shall be drained for 5 to 20 seconds prior to dipping in the solder pot. The flux shall be covered when not in use and discarded a minimum of once a day. Any obvious droplets of flux clinging to the termination may be removed by blotting.

4.4.1.1.1 Leaded and leadless surface mount devices. Perform the test on the terminations on one side of the device at a time. The fluxing and solder dipping operations shall be performed sequentially on the terminations of the side under test.
4.4.1.1.2 All other devices. The terminations shall be immersed to the seating plane or to within 0.050 inch of the body of the device under test.

4.4.1.2 Solder dip. The dross and burned flux shall be skimmed from the surface of the molten solder prior to testing. A wave solder pot may be used for this purpose, but the solder shall be static during the dipping procedure (skimming may not be required in wave or flow pots). The molten solder shall be at a uniform temperature of 245°C ± 5°C (473°F ± 9°F). The device shall be attached to a dipping mechanism (see 2.2) and the flux covered terminations immersed once (except for the possible duplicate immersion of corner terminations on leadless surface mount devices) in the molten solder.

The test specimen shall not be suspended above the hot solder pot for longer than 7 seconds. The immersion and emersion rates shall be 1.0 inch per second ± 0.250 inch per second. The dwell time in the solder shall be 5 seconds ± 0.5 second. The dwell time for terminations greater than or equal to 0.040 inch in diameter shall be 7 seconds ± 0.5 second. After the dipping process, the device shall be allowed to cool in air. Residual flux shall be removed from the terminations by dipping the devices in isopropyl alcohol or other suitable solvent. If necessary, a clean soft cloth, cotton swab, or equivalent, moistened with clean isopropyl alcohol or other suitable solvent, may be used to remove all remaining flux.

4.4.1.2.1 Solder dipping of gold plated terminations. Gold plated terminations shall be cycled twice in flux and solder using one or two solder pots. The first immersion is to scavenge the gold on the terminations. It is recommended that a separate solder pot be used for gold plated devices. In any case, the user of this test should use two separate pots, a sufficiently large pot, or monitor closely the contamination level of a single small pot to assure that the test is performed as intended.

4.4.1.2.2 Immersion angle. Unless otherwise specified, the terminations shall be immersed to the solder surface as follows:

a. Leaded through hole mount (e.g., DIP, TO can, PGA) 90°
b. Leaded surface mount (e.g., J-lead, QFP) 20° to 45° (or 90°)
c. Leadless surface mount (e.g., LCC, LGA, QFN) 20° to 45°

4.4.1.2.3 Solder bath contaminants. The manufacturer shall have a system to verify that the solder bath does not exceed the contaminant levels specified in table II.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Contaminant percentage limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>0.300</td>
</tr>
<tr>
<td>Gold</td>
<td>0.200</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.005</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.005</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.006</td>
</tr>
<tr>
<td>Antimony</td>
<td>0.500</td>
</tr>
<tr>
<td>Iron</td>
<td>0.020</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.030</td>
</tr>
<tr>
<td>Bismuth</td>
<td>0.250</td>
</tr>
<tr>
<td>Silver</td>
<td>0.100</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.010</td>
</tr>
</tbody>
</table>

NOTE: The total copper, gold, cadmium, zinc, and aluminum contaminants shall not exceed 0.4 percent.

4.4.2 BGA/CGA Surface mount simulation. Surface mount simulation test shall be performed on ball and column grid arrays only.
4.4.2.1 Ball grid arrays.

a. Place the ceramic substrate onto the base fixture. Place the screen print stencil on the substrate.
b. Apply the solder paste uniformly across the screen print stencil to fill the array pattern using the squeegee.
c. Slowly remove the stencil off the substrate to avoid smearing the paste print. Verify a paste print is equivalent in geometry to the terminal of the device to be tested.
d. Gently press the device down to allow the solder balls to make contact with the solder paste.
e. Place the substrate in the oven and reflow. The reflow profiles shall be per table III, based on the reflow method used.
f. After reflow, allow the ceramic substrate to cool before handling.
g. Slowly remove the device from the substrate. The solder balls may adhere slightly to the substrate due to flux residue.
h. After cooling, clean the device and substrate in the cleaning solution.

4.4.2.2 Column grid arrays.

i. Place the metallized substrate and screen print stencil onto the base fixture.
ii. Place a sufficient amount of solder paste on the screen print stencil. Print the terminal pattern onto the substrate by wiping paste over the stencil/screen in one smooth motion using the squeegee.
iii. Carefully remove the screen print stencil and verify complete coverage of the metallized pads.
iv. Carefully place the solder columns into the printed solder paste.
v. Carefully remove the device and substrate together from the base fixture.
vi. Verify proper alignment with a microscope, use 10x-30x magnification.
vii. Reflow the device and substrate. The reflow profile shall be per table III, based on the reflow method used.
viii. After cooling, clean the device and substrate in the cleaning solution.
ix. Using the cutting equipment, cut the device from the substrate using care to preserve the solder joints at the interface with the substrate.

TABLE III. Reflow parameter requirements.

<table>
<thead>
<tr>
<th>Method</th>
<th>Peak Temperature (°C)</th>
<th>Time (above 183°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vapor Phase Reflow</td>
<td>215 - 219</td>
<td>30 - 90 seconds</td>
</tr>
<tr>
<td>IR/Convection Reflow</td>
<td>200 - 230</td>
<td>60 - 120 seconds</td>
</tr>
<tr>
<td>Oven</td>
<td>215 - 230</td>
<td>2 - 5 minutes</td>
</tr>
</tbody>
</table>

Note: TABLE III reflow parameter values are for solderability testing purposes only and are not related to moisture sensitivity level reflow test parameters. These reflow parameters refer to measurements taken on the device body.

4.5 Examination of terminations. All flux is to be removed prior to visual inspection of the terminal surface.

For devices that were dip and look tested, the dipped portion of the terminations shall be examined using a magnification of 10-15x. Dipped portions of fine-pitch devices (pitch ≤ 0.020 inch) shall be examined at 30x. Verification of failures may be accomplished with higher magnifications up to 60x. The customer/equipment manufacturer of the device may establish a critical portion of the termination within the dipped area. The customer/equipment manufacturer has the option to accept solderability defects outside their established critical area. The customer/equipment manufacturer has the option of cleaning devices to remove carbonate/sulfate deposits caused by exposure of the devices to the steamaging or cleaning process. The customer/equipment manufacturer shall assure that the cleaning process does not adversely affect the physical, mechanical, electrical, or reliability performance of the devices. This cleaning process shall be fully documented. For leaded devices only, the cut portions of the lead which expose lead ends shall not be used for examination and evaluation of the solder coverage of the termination.

For column grid arrays, the number of columns specified in the procurement document shall be randomly selected for examination. Columns which are not within the perimeter of the pad shall be excluded from the selection process. The solder fillets (on the metallized substrate) shall be examined at 15x to 30x magnification. Verification of failures may be accomplished with higher magnifications up to 60x.
4.5.1 Critical area for dip and look tested devices. Examples of critical areas for some devices are discussed below.

a. **Dual-in line.** From the termination tip to 0.020 inch above the seating plane, except, devices where the leads exit from the bottom of the device, shall be from the termination tip to the seating plane. Unplated (trim) areas are excluded. See Figure 2003-4.

b. **Gull wing.** All surfaces of the termination at or below the top of the foot, excluding the top of the foot. Unplated (trim) areas are excluded. See Figure 2003-5.

c. **J-lead.** The narrow portion of the termination below the transition from the termination shoulder. Only the three visible surfaces are to be included. The termination tip is excluded. See Figure 2003-6.

d. **L-lead.** The bottom of the termination and one times the lead thickness up the side of the termination. Termination edges are excluded. See Figure 2003-7.

e. **Passive (rectangular).** The bottom of the termination and side of the termination up to the top, excluding the top. See Figure 2003-8.

f. **Leadless chip carrier.** The bottom of the termination and 2/3 of the height of the connecting metallized surface. See Figure 2003-9.

g. **QFN.** The bottom of the termination and exposed pad. See Figure 2003-10.

h. **Other devices.** 0.050 inch from the body and extending away from the body to the end of the lead or for a distance of 1 inch, whichever is shorter.

If the seating plane is not defined, the critical area shall extend from the termination tip to within 0.040 inch of the lead/device interface. For top brazed and bottom brazed flat pack devices, the critical area shall extend from the termination tip to within 0.070 inch of the lead/device interface.
4.5.2 Criteria for acceptance. The criteria for acceptance solderability shall be as follows:

4.5.2.1 For all devices, except ball and column grid arrays:
   a. The dipped portion of the terminations is at least 95% covered by a continuous new solder coating.
   b. Pinholes, nonwetting, or dewetting do not exceed 5% of the total area.
   c. For leadless terminations and elements having solder attachment terminations, there shall be no solder bridging between any termination area and any other metallization not connected to it by design. In the event that the solder dipping causes bridging, the test shall not be considered a failure provided that a local application of heat (e.g., gas, soldering iron, or redipping) results in solder pullback and no wetting of the dielectric area as indicated by microscopic examination.
   d. For devices with exposed pad (e.g., QFN), the exposed pad surfaces shall exhibit a continuous solder coating free from defects for a minimum of 80% of the critical area of those surfaces.
   e. Wetting angle shall be less than or equal to 90 degrees.

4.5.2.2 For ball grid arrays:
   a. Each solder ball shall “take in” the solder paste deposit producing a uniform and smooth surface with no more than 5% dewetting or non-wetting.
   b. The solder balls shall be wetted in a consistent and unified manner.

4.5.2.3 For column grid arrays:
   a. Each column fillet shall exhibit evidence of good wetting for at least 50% of the column circumference.
   b. Wetting angles ($\theta$) shall be less than or equal to 90°, as shown in Figure 2003-11.

FIGURE 2003-1. Non-wetting.

Exposed base metal


FIGURE 2003-5. Critical area for gull wing devices. Critical area = "A" (up to 1x Lead Thickness) and edges "B".

FIGURE 2003-6. Critical area for J-lead devices. Critical area = "A" (equal to 2x Lead Thickness) and edges "B" within the 2xT zone. Surface "C" is excluded.
FIGURE 2003-7. Critical area for L-lead devices. Critical area = "A" (equal to 1x Lead Thickness). Surfaces "B" and "C" are excluded.


FIGURE 2003-10. Critical area for QFNs. Critical area = “A” and “B”. Surface “C” is excluded.

Acceptable <90 degrees
Reject ≥ 90 degrees


5. SUMMARY. The following details shall be specified in the applicable procurement document:
   a. The number of terminations of each device to be tested, if other than 22(0).
   b. The number of devices used for the test, if other than 3.
   c. Special preparation of the terminations, if applicable.
   d. Depth of immersion if other than specified.
   e. Angle of immersion, if other than specified.
   f. Solder composition, flux, and temperature, if other than those specified in this document.
   g. Measurements after test, where applicable.
   h. For ball and column grid arrays:
      1. Screen print stencil thickness, if other than specified.
      2. Solder paste, if other than specified.
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MIL-STD-883K
w/CHANGE 3

METHOD 2004.7

LEAD INTEGRITY

1. PURPOSE. This method provides various tests for determining the integrity of microelectronic device leads (terminals), welds, and seals. Test condition A provides for straight tensile loading. Test condition A1 provides testing the solder or braze material lead attach on packages with brazed leads. Test condition B1 provides for application of bending stresses to determine integrity of leads and seals. Test condition B2 employs multiple application of bending stresses primarily to determine the resistance of the leads to metal fatigue under repeated bending. Test conditions C1 and C2 provide for application of torque or twisting stresses to device leads or studs, respectively, to determine integrity of leads and seals. Test condition D provides for application of peel and tensile stresses to determine integrity of terminal adhesion and plating of leadless packages. Test condition E provides for application of a bend test to determine integrity of plating for flexible and semi-flexible leads. It is recommended that test condition A, B1, B2 and C1 be followed by a seal test in accordance with method 1014 to determine any effect of the stresses applied on the seal as well as on the leads (terminals).

Note: This test method does not apply to ball grid array (BGA) or column grid array (CGA) devices.

2. APPARATUS. See applicable test condition.

3. DEFINITIONS.
   a. Arc. An arc is defined as the movement of the case, without torsion, to a position perpendicular to the pull axis and return to normal. All arcs on a single lead shall be made in the same direction and in the same plane without lead restriction.
   b. Bending Cycle. A bending cycle is one bend of a lead from a reference position (e.g. 0 Deg), to a defined arc and then back to the original reference to original position (e.g. 0 Deg).
   c. Flexible Lead. A rectangular lead is considered flexible if it’s section modules is less than or equal to that of an equivalent rectangular lead with a cross section of 0.15 x 0.51 mm (.006 x .020 inch). Round leads less than or equal to 0.51 mm (.020 inch) in diameter shall be considered flexible even if the lead is not intended to be bent as these leads may be subject to routine handling disturbances.
   d. Rigid Lead or terminal. A rectangular lead or terminal shall be considered rigid if it’s section modules is greater than that of an equivalent rectangular lead with a cross section of 0.15 x 0.51 mm (.006 x .020 inch) and is not intended to be bent or formed in it’s end use application. Round leads greater than 0.51 mm (.020 inch) diameter that are not intended to be bent or formed in their end use application shall be considered rigid.
   e. Section modules. Section modulus is defined as bh²/6 (width x thickness ²/6) for rectangular leads, and 0.098 (qb1)³ or .098D³ for round leads (see MIL-STD-1835). A rectangular lead with a cross section of .006 x .020 has a section modules of 1.2x10⁻⁷. A round lead with a .020 inch diameter has a section modules of 7.8x10⁻⁷.
   f. Semi-flexible Lead. A rectangular lead is considered semi-flexible if it’s section modules is greater than that of an equivalent rectangular lead with a cross section of 0.15 x 0.51 mm (.006 x .020 inch) and is intended to be bent or formed in it’s end use application. Round leads greater than 0.51 mm (.020 inch) diameter that are intended to be bent or formed in their end use application shall be considered semi-flexible.

4. GENERAL PROCEDURE APPLICABLE TO ALL TEST CONDITIONS. The device shall be subjected to the stresses described in the specified test condition and the specified end-point measurements and inspections shall be made except for initial conditioning or unless otherwise specified. Unless otherwise specified, the sample size series sampling shall apply to the leads, terminals, studs or pads chosen from a minimum of 3 devices.

5. SUMMARY. The following details and those required by the specific test condition shall be specified in the applicable acquisition document:
   a. Test condition letter.
   b. Number and selection of leads (terminals), if different from above.
TEST CONDITION A - TENSION

1. **PURPOSE.** This test is designed to check the capabilities of the device leads, welds, and seals to withstand a straight pull.

2. **APPARATUS.** The tension test requires suitable clamps and fixtures for securing the device and attaching the specified weight without lead restriction. Equivalent linear pull test equipment may be used.

3. **PROCEDURE.** A tension of 0.227 kg (8 ounces), unless otherwise specified, shall be applied, without shock, to each lead or terminal to be tested in a direction parallel to the axis of the lead or terminal and maintained for 30 seconds minimum. The tension shall be applied as close to the end of the lead (terminal) as practicable.

3.1 **Failure criteria.** When examined using magnification between 10X and 20X after removal of stress, any complete breakage (e.g. separation of the lead from the body) or loosening of the lead at the glass/ceramic seal that has caused a method 1014 seal failure shall be considered a failure. When a seal test in accordance with method 1014 is conducted as a post test measurement following the lead integrity test(s), meniscus cracks shall not be cause for rejection of devices which pass the seal test.

4. **SUMMARY.** The following details shall be specified in the applicable acquisition document:
   a. Weight to be attached to lead, if other than .227 kg (8 ounces) (see 3).
   b. Length of time weight is to be attached, if other than 30 seconds (see 3).

TEST CONDITION A1 – LEAD BRAZE INTEGRITY

1. **PURPOSE.** This test is for packages with brazed leads and is intended to test the lead to package attach integrity. This test applies to both flat package and dual in-line package construction.

2. **APPARATUS.** The lead braze integrity test requires suitable clamps and fixtures for securing the device and attaching the specified weight without lead restriction. Equivalent linear pull test equipment may be used.

3. **PROCEDURE.** A tension of 0.227 kg (8 ounces), unless otherwise specified, shall be applied, without shock, to each lead or terminal to be tested in a direction perpendicular to the lead attach surface (i.e. force wants to peel lead out or off the attach medium). The force shall be maintained for 30 seconds minimum. The weight shall be applied as close to the end of the lead (terminal) as practicable.

3.1 **Failure criteria.** When examined using magnification between 10X and 20X after removal of stress, any evidence of lead fracture of the solder/braze connection or disconnection of the lead from the package shall be considered a failure.

4. **SUMMARY.** The following details shall be specified in the applicable acquisition document:
   a. Weight to be attached to lead, if other than .227 kg (8 ounces) (see 3).
   b. Length of time weight is to be attached, if other than 30 seconds (see 3).

TEST CONDITION B1 - BENDING STRESS

1. **PURPOSE.** This test is designed to check the capability of the leads, lead welds, and seals of the devices to withstand stresses to the leads and seals which might reasonably be expected to occur from actual handling and assembly of the devices in application, or to precondition the leads with a moderate bending stress prior to environmental testing.

2. **APPARATUS.** Attaching devices, clamps, supports, or other suitable hardware necessary to apply the bending stress through the specified bend angle.
3. **PROCEDURE**. Each lead or terminal to be tested shall be subjected to a force as specified in 3.1 through 3.5, as applicable. Any number or all of the leads of the device may be tested simultaneously. Rows of leads may be tested one row at a time. Each lead shall be tested in one direction and returned to the approximate original position. All arcs shall be made in the same plane without lead restriction.

3.1 **Direction of bends.** Test leads shall be bent in the least rigid direction. If there is no least rigid direction, they may be bent in any direction. No lead shall be bent so as to interfere with another lead. If interference is unavoidable, the test lead shall be bent in the opposite direction to the angle specified and returned to its approximate original position.

3.2 **Procedure for pre-formed leads.** When normally straight leads are supplied in a pre-formed condition (including the staggered lead dual-in-line configuration), the lead forming operation shall be considered an acceptable bending stress in place of that specified, provided the lead forming has been done after lead plating and the forming is at least as severe in permanent lead deformation as the specified bending.

3.3 **Procedure for flexible and semi-flexible leads (e.g., flat packs and axial-lead metal-can devices).**

3.3.1 **Flexible leads.** Flexible leads shall be bent through an arc of at least 45° measured at the lead extremities, unless otherwise specified.

3.3.2 **Semi-flexible leads.** Semi-flexible leads shall be bent through an arc of at least 30° measured at the lead extremities unless otherwise specified.

3.4 **Procedure for dual-in-line and pin grid array package leads.**

3.4.1 **Dual-in-line (platform, side brazed, bathtub) package leads.** Leads normally aligned in parallel at a 90° angle from the bottom of the package during insertion. Dual-in-line package leads shall be bent inward through an angle sufficient to cause the lead to retain a permanent bend (i.e., after stress removal) of at least 15°. For configuration 1 and 2, the angle of bend shall be measured from the lead extremities to the first bend (see figure 2004-1), for configuration 3, the angle of bend shall be measured from the lead extremities to the seating plane (see figure 2004-1).

3.4.2 **Pin grid array package leads.** Leads required for testing from the outside row of leads on opposite sides bent through an angle sufficient to cause the lead to retain a permanent bend (i.e., after stress removal) of at least 15°. The angle of bend shall be 15° from normal and the bend shall be made at the approximate seating plane.

3.5 **Procedure for rigid leads or terminals.** Unless otherwise specified in the package acquisition document, devices with rigid leads or terminals shall be bent through an angle of at least 10° to cause a permanent bend (i.e., after stress removal).

**Note:** Rigid leads or terminals shall be reviewed by the acquiring device manufacturer to determine if a lead integrity test adds value based on the purpose of this test condition.

3.6 **Failure criteria.** When examined using magnification between 10X and 20X after removal of the stress, any complete breakage (e.g., separation of the lead from the body) or loosening of the lead at the glass/ceramic seal that has caused a method 1014 seal failure shall be considered a failure. When a seal test in accordance with method 1014 is conducted as a post test measurement following the lead integrity test(s), glass meniscus cracks shall not be cause for rejection of devices which pass the seal test.

4. **SUMMARY.** The following details shall be specified in the applicable acquisition document:

a. Bending arc, if other than that specified.

b. Procedure, if other than that specified.

c. Number and selection of leads and procedure for identification, if other than that specified.

d. Post test measurements, if applicable (see 3.6)
1. **PURPOSE.** This test is designed to check the resistance of the leads to metal fatigue.

2. **APPARATUS.** Attaching devices, clamps, supports, or other suitable hardware necessary to apply a repeated bending stress through the specified bend angle.

3. **PROCEDURE.** Each lead or terminal to be tested shall be subjected to a force as specified in 3.1 through 3.7, as applicable. Each lead shall be tested in the same direction through the specified arc in one direction and returned to the approximate original position. All arcs shall be made in the same plane without lead restriction. A test cycle shall be completed in 2 to 5 seconds. For devices with rectangular or ribbon leads, the plane of the arcs shall be perpendicular to the flat plane of the lead. The test shall not be applied to end leads of packages where its application will apply primarily torsion forces at the lead seal.

3.1 **Direction of bends.** Test leads shall be bent in the least rigid direction. If there is no least rigid direction, they may be bent in any direction. No lead shall be bent so as to interfere with another lead. If interference is unavoidable, the test lead shall be bent in the opposite direction to the angle specified and returned to its normal position.

3.2 **Procedure for pre-formed leads.** When normally straight leads are supplied in a pre-formed condition (including the staggered lead dual-in-line configuration), the lead forming operation shall be considered an acceptable lead fatigue test in place of that specified, provided the lead forming has been done after lead plating and the forming is at least as severe in permanent lead deformation as the specified bending.

3.3 **Procedure for packages with Flexible leads.** For flexible rectangular leads or round leads, the test force shall be 0.085kg ±0.009 kg (3oz ±0.3 ounces). Each lead shall be tested for three 90° ±5° arcs, unless otherwise specified.

3.4 **Procedure for packages with Semi-flexible leads.** For semi-flexible rectangle leads or round leads, the test force shall be 0.229kg ±0.014 kg (8oz ±0.5 ounces). Each lead shall be tested for three 90° ±5° arcs, unless otherwise specified.

3.5 **Procedure for dual-in-line and pin grid array package leads.**

3.5.1 Dual-in-line (platform, side brazed, bathtub) package leads are leads normally aligned in parallel at a 90° angle from the bottom of the package during insertion. Dual-in-line package leads shall be bent three times inward through an angle sufficient to cause the lead to retain a permanent bend (i.e., after stress removal) of at least 15°. For configuration 1 and 2, the angle of bend shall be measured from the lead extremities to the first bend (see figure 2004-1), for configuration 3, the angle of bend shall be measured from the lead extremities to the seating plane (see figure 2004-1).

3.5.2 Pin grid array packages shall have the leads required for testing from the outside row of leads on opposite sides bent three times through an angle sufficient to cause the lead to retain a permanent bend (i.e., after stress removal) of at least 15°. The angle of bend shall be 15° from normal and the bend shall be made at the approximate seating plane. At the completion of the initial bend, the leads shall be returned to their approximate original position.

3.6 **Optional procedure for Semi-Flexible and Flexible leads.** As an option for all lead sizes, a force as determined by the following formula, unless otherwise specified, shall be applied to each lead to be tested for 90 degrees ±5 degree arcs of the device. All other conditions of section 3.3, and 3.4 shall apply. The test weight shall be calculated as follows: Weight = (area in square inches) x 2.1 % x (UTS in psi) x 453.6 grams/lb. Where UTS in psi is the ultimate tensile strength (UTS) for a particular material. Typical value for Kovar, Alloy 42 and copper materials are listed below. The UTS for other materials can be found in vendor data sheets. The result shall be rounded to the nearest whole number.

<table>
<thead>
<tr>
<th>Material</th>
<th>UTS in psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kovar</td>
<td>75000</td>
</tr>
<tr>
<td>Alloy 42</td>
<td>71000</td>
</tr>
<tr>
<td>Copper 101</td>
<td>43,500</td>
</tr>
<tr>
<td>Copper 110</td>
<td>31,900</td>
</tr>
</tbody>
</table>

METHOD 2004.7
7 June 2013
3.7 **Procedure for rigid leads or terminals.** Testing of rigid leads or terminals is not required.

3.8 **Failure criteria.** When examined using magnification between 10X and 20X after removal of stress, any complete breakage (e.g. separation of the lead from the body) shall be considered a failure.

4. **SUMMARY.** The following details shall be specified in the applicable acquisition document:

   a. Force to be applied to the lead, if other than above (see 3).

   b. Number of cycles, if other than above (see 3).

   c. Maximum bend angle, if other than above (see 3).

   d. Number and selection of leads (terminals), if different from above.

   e. Post test measurements, if applicable (see 3.8)
TEST CONDITION C1 - LEAD TORQUE

1. **PURPOSE.** This test is designed to check device leads (or terminals) and seals for their resistance to twisting motions.

2. **APPARATUS.** The torque test requires suitable clamps and fixtures, and a torsion wrench or other suitable method of applying the specified torque without lead restriction.

3. **PROCEDURE.** The appropriate procedure of 3.1 or 3.2 for the device under test shall be used.

   3.1 **Procedure for devices with circular cross-section terminals or leads.** The device body shall be rigidly held and the specified torque shall be applied for 15 seconds minimum to the lead (terminal) to be tested, without shock, about the axis of the lead (terminal).

   3.2 **Procedure for devices with rectangular cross-section terminals or leads.** The device body shall be rigidly held and a torque of 1.45 ± .145 kg-mm (2.0 ± 0.2 ounce-inch) unless otherwise specified, shall be applied to the lead (terminal) at a distance of 3.05 ± 0.76 mm (0.12 ± 0.03 inch) from the device body or at the end of the lead if it is shorter than 3.05 mm (0.12 inch). The torque shall be applied about the axis of the lead once in each direction (clockwise and counterclockwise). When devices have leads which are formed close to the body, the torque may be applied 3.05 ± 0.76 mm (0.12 ± 0.03 inch) from the form. For device leads which twist noticeably when less than the specified torque is applied, the twist shall be continued until the twist angle reaches 30° ± 10° or the specified torque is achieved, whichever condition occurs first. The lead shall then be restored to its original position.

   3.3 **Failure criteria.** When examined using magnification between 10X and 20X after removal of the stress, any complete breakage (e.g. separation of the lead from the body) or loosening of the lead at the glass/ceramic seal that has caused a method 1014 seal failure shall be considered a device failure. When a seal test in accordance with method 1014 is conducted as a post test measurement following the lead integrity test(s), meniscus cracks shall not be cause for rejection of devices which pass the seal test.

4. **SUMMARY.** The following details shall be specified in the applicable acquisition document:

   a. Torque to be applied for circular cross-section leads (see 3.1).

   b. Duration of torque application for circular cross-section leads, if other than 15 seconds minimum (see 3.1).

   c. Torque to be applied for rectangular cross-section leads, if other than 1.45 ± .145 kg-mm (2.0 ± 0.2 ounce-inch) (see 3.2).

   d. See general summary above.

   e. Post test measurements, if applicable (see 3.3)
TEST CONDITION C2 - STUD TORQUE

1. PURPOSE. This test is designed to check the resistance of the device with threaded mounting stud to the stress caused by tightening the device when mounting.

2. APPARATUS. The torque test requires suitable clamps and fixtures, and a torsion wrench or suitable method of applying the specified torque.

3. PROCEDURE. The device shall be clamped by its body or flange. A flat steel washer of a thickness equal to six thread pitches of the stud being tested and a new class 2 fit steel nut shall be assembled in that order on the stud, with all parts clean and dry. The specified torque shall be applied without shock to the nut for the specified period of time. The nut and washer shall then be disassembled from the device, and the device then examined for compliance with the requirements.

3.1 Failure criteria. The device shall be considered a failure if any of the following occurs:
   a. The stud breaks or is elongated greater than one-half of the thread pitch.
   b. It fails the specified post-test end point measurements.
   c. There is evidence of thread stripping or deformation of the mounting seat.

4. SUMMARY. The following details shall be specified in the applicable acquisition document:
   a. The amount of torque to be applied (see 3).
   b. Length of time torque is to be applied (see 3).
   c. Measurements to be made after test (see 3).

TEST CONDITION D - SOLDER PAD ADHESION FOR LEADLESS CHIP CARRIER AND SIMILAR DEVICES

1. PURPOSE. This test is designed to check the capabilities of the device solder pads to withstand a delamination (peel) stress of specified tension and time.

2. APPARATUS. Equipment for 10X magnification, suitable clamps and fixtures for securing the device and applying the specified tension/time conditions to wires soldered to the device solder pads. Equivalent linear pull test equipment may be used.

3. PROCEDURE. Unless otherwise specified, a delamination (peel) stress test shall be applied to randomly selected solder pads from each device selected for test. Further, unless otherwise specified, the sampling shall be Sample Size Number = 15, c = 0 based on the number of solder pads tested, chosen from a minimum of three devices. Preparation and testing of devices shall be in accordance with figure 2004-2 of this method and as follows.

   a. Pretinned soft annealed solid copper wire of a gauge (diameter) nearest, but not exceeding that of the nominal solder pad width, shall be soldered using Sn60A or Pb40A or Sn63A or Pb37A of IPC J-STD-006 (previously known as Sn60 or Sn63 solder in accordance with QQ-S-571) to each solder pad to be tested in a manner such that the wire is bonded over the entire solder pad length and terminates at the package edge (see figure 2004-2). The unsoldered portion of the wire shall be bent perpendicular to the bond plane prior to attachment. Caution should be taken to assure that the solder pad metallization is not damaged during the soldering or the wire bending operation.

   b. Unless otherwise specified, a minimum tension of 8 ounces (2.22 N) shall be applied, without shock, to each solder pad to be tested in a direction perpendicular to the solder pad surface and maintained for 30 seconds minimum.

3.1 Failure criteria. When examined, using 10X magnification, after removal of the tension stress, the appearance of any delamination involving constituent solder pad interfaces shall be considered an adhesion failure of the solder pad. Separation of the solder pad from the device is an obvious (without visual magnification) adhesion failure. Separation of the wire from the solder fillet (leaving the solder pad intact) or wire breakage is considered a test procedure failure.
4. SUMMARY. The following details shall be specified in the applicable acquisition document:
   a. Sampling criteria, if other than specified (see 3.0).
   b. Failure criteria, if other than specified (see 3.1).
   c. Tension to be applied in this test if other than 8 ounces (2.22 N).
   d. Length of time tension is to be applied if other than 30 seconds.

TEST CONDITION E – LEAD PLATING INTEGRITY

1. PURPOSE. This test is designed to check the lead plating of flexible and semi-flexible leads which might reasonably be expected to occur from a lead form operation.

   Note: Additional plating adhesion accept/reject criteria may be flowed down by the specified plating specifications.

2. APPARATUS. Attaching devices, clamps, supports, or other suitable hardware necessary to apply the bending stress through the specified bend angle.

3. PROCEDURE. Each flexible or semi-flexible lead to be tested shall be subjected to a 90° bend. Any number or all of the leads of the test device may be bent 90° simultaneously. Each lead shall be bent 90° in one direction in the same plane without lead restriction. Leads may be bent 90° by performing a lead form operation.

   3.1 Direction of bend. Test leads shall be bent in the normal lead form configuration.

   3.2 Procedure for pre-formed leads. When normally straight leads are supplied in a pre-formed condition, then this test condition shall not apply.

   3.3 Procedure for flexible and semi-flexible leads (e.g., flat packs and axial-lead metal-can devices).

   3.3.1 Flexible leads. Flexible leads shall be bent in the middle of the lead through an arc of at least 90°, unless otherwise specified.

   3.3.2 Semi-flexible leads. Semi-flexible leads shall be bent in the middle of the lead through an arc of at least 90°, unless otherwise specified.

   3.4 Failure criteria. When examined using magnification between 10X and 20X after removal of the stress, any cracking of the lead plating which results in flaking, peeling or blistering or the crack can be peeled back with a sharp instrument (i.e. knife) shall be rejected.

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

   a. Bending arc, if other than that specified.
   b. Procedure, if other than that specified.
   c. Number and selection of leads and procedure for identification, if other than that specified.
FIGURE 2004-1  Angle of bend for dual-in-line package configurations.

A = APEX OF ANGLE
a = ANGLE OF DEFLECTION
MATERIALS
Flux: Flux type symbol "A" or "B" (flux type "L0" or "L1") in accordance with IPC J-STD-004 (previously designated as Type R or RMA only, in accordance with MIL-F-14256).
Solder: Sn60A or Pb40A or Sn63A or Pb37A in accordance with IPC J-STD-006 (previously designated as Sn 60 or Sn 63 in accordance with QQ-S-571).
Wire: Soft annealed solid copper.

FIGURE 2004-2 Solder pad adhesion.
1. PURPOSE. The purpose of this test is to determine the effect on the device of vibration in the frequency range specified.

2. APPARATUS. Apparatus for this test shall include equipment capable of providing the sustained vibration within the specified levels and the necessary optical and electrical equipment to conduct post-test measurements.

3. PROCEDURE. The device shall be rigidly fastened on the vibration platform and the leads or cables adequately secured. The device shall be vibrated with a constant amplitude simple harmonic motion having a peak acceleration corresponding to the specified test condition. For test condition A, constant amplitude harmonic motion in the range of 60 ±20 Hz having an amplitude of 0.06 inch double amplitude (total excursion) shall be acceptable as an alternative to the specified peak acceleration. The vibration shall be applied for 32 ±8 hours minimum, in each of the orientations X, Y, and Z for a total of 96 hours, minimum. When specified, devices with an internal cavity containing parts or elements subject to possible movement or breakage during vibration shall be further examined by radiographic examination in accordance with method 2012 or by delidding or opening and internal visual examination at 30X magnification to reveal damage or dislocation. Where this test is performed as part of a group or subgroup of tests, the post-test measurements or inspections need not be performed specifically at the conclusion of this test, but may be performed once at the conclusion of the group or subgroup.

<table>
<thead>
<tr>
<th>Test condition</th>
<th>Peak acceleration, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>70</td>
</tr>
</tbody>
</table>

3.1 Examination. After completion of the test, an external visual examination of the marking shall be performed without magnification or with a viewer having a magnification no greater than 3X and a visual examination of the case, leads, or seals shall be performed at a magnification between 10X and 20X. This examination and any additional specified measurements and examination shall be made after completion of the final cycle or upon completion of a group, sequence, or subgroup of tests which include this test.

3.2 Failure criteria. After subjection to the test, failure of any specified measurement or examination (see 3 and 4), evidence of defects or damage to the case, leads, or seals, or illegible markings shall be considered a failure. Damage to marking caused by fixturing or handling during tests shall not be cause for device rejection.

3.3 Test frequency and amplitude. For test condition A, B, or C, the double amplitude and frequency used shall result in the application of the peak accelerations of 20, 50, or 70 g's. Peak acceleration may be computed using the following equation:

$$g = A \left( \frac{F}{2 \cdot 386} \right)^2$$

Where:
A = double amplitude in inches.
F = frequency in radians/second.

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

a. Test condition (see 3).

b. Test frequency and test double amplitude (see 3 and 3.3), if other than specified.

c. Test time and specimen orientation, if other than specified (see 3).

d. Measurements after test (see 3 and 3.1).
VIBRATION NOISE

1. PURPOSE. The purpose of this test is to measure the amount of electrical noise produced by the device under vibration.

2. APPARATUS. Apparatus for this test shall include equipment capable of providing the required variable frequency vibration at the specified levels, a calibrated high impedance voltmeter for noise measurement during test and the necessary optical and electronic equipment for post-test measurements.

3. PROCEDURE. The device and its leads shall be rigidly fastened on the vibration platform and the leads or cables adequately secured. The device shall be vibrated with simple harmonic motion having either an amplitude of 0.06 inch double amplitude (maximum total excursion) or a constant peak acceleration of 20 g minimum. The vibration frequency shall be varied approximately logarithmically between 20 and 2,000 Hz. The entire frequency range shall be traversed in not less than 4 minutes for each cycle. This cycle shall be performed once in each of the orientations X, Y, and Z (total of 3 times), so that the motion shall be applied for a total period of approximately 12 minutes. The specified voltages and currents shall be applied in the test circuit. The maximum noise-output voltage across the specified load resistance during traverse, shall be measured with an average-responding root-mean-square (rms) calibrated high impedance voltmeter. The meter shall measure, with an error of not more than 3 percent, the rms value of a sine-wave voltage at 2,000 Hz. The characteristic of the meter over a bandwidth of 20 to 2,000 Hz shall be ±1 decibel (dB) of the value at 2,000 Hz, with an attenuation rate below 20 and above 20,000 Hz of 6 ±2 dB per octave. The maximum inherent noise in the circuit shall be at least 10 dB below the specified noise-output voltage. When specified, devices with an internal cavity containing parts or elements subject to possible movement or breakage during vibration shall be further examined by radiographic examination in accordance with method 2012 or by delidding or opening and internal visual examination at 30X magnification to reveal damage or dislocation. Where this test is performed as part of a group or subgroup of tests, the post-test measurements or inspections need not be performed specifically at the conclusion of this test, but may be performed once at the conclusion of the group or subgroup.

3.1 Examination. After completion of the test, an external visual examination of the marking shall be performed without magnification or with a viewer having a magnification no greater than 3X and a visual examination of the case, leads, or seals shall be performed at a magnification between 10X and 20X. This examination and any additional specified measurements and examination shall be made after completion of the final cycle or upon completion of a group, sequence, or subgroup of tests which include this test.

3.2 Failure criteria. After subjectation to the test, failure of any specified measurement or examination (see 3 and 4), evidence of defects or damage to the case, leads, or seals, or illegible markings shall be considered a failure. Damage to marking caused by fixturing or handling during tests shall not be cause for device rejection.

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

a. Test condition (see 3).

b. Test voltages and currents (see 3). Unless otherwise specified, these shall be the nominal operating voltages and currents for the device.

c. Load resistance (see 3). Unless otherwise specified, this shall be the maximum rated operating load of the device.

d. Measurements after test (see 3 and 3.1).

e. Noise-output voltage limit (see 3).
METHOD 2007.3

VIBRATION, VARIABLE FREQUENCY

1. PURPOSE. The variable frequency vibration test is performed for the purpose of determining the effect on component parts of vibration in the specified frequency range. This is a destructive test.

2. APPARATUS. Apparatus for this test shall include equipment capable of providing the required variable frequency vibration at the specified levels and the necessary optical and electrical equipment for post-test measurements.

3. PROCEDURE. The device shall be rigidly fastened on the vibration platform and the leads or cables adequately secured. The device shall be vibrated with simple harmonic motion having either a peak to peak amplitude of 0.06 inch (±10 percent) or a peak acceleration of the specified test condition A, B, or C (+20 percent, -0 percent g). Test conditions shall be amplitude controlled below the crossover frequency and g level controlled above. The vibration frequency shall be varied approximately logarithmically between 20 and 2,000 Hz. The entire frequency range of 20 to 2,000 Hz and return to 20 Hz shall be traversed in not less than 4 minutes. This cycle shall be performed 4 times in each of the orientations X, Y, and Z (total of 12 times), so that the motion shall be applied for a total period of not less than 48 minutes. When specified, devices with an internal cavity containing parts or elements subject to possible movement or breakage during vibration shall be further examined by radiographic examination in accordance with method 2012 or by delidding or opening and internal visual examination at 30X magnification to reveal damage or dislocation. Where this test is performed as part of a group or subgroup of tests, the post-test measurements or inspections need not be performed specifically at the conclusion of this test, but may be performed once at the conclusion of the group or subgroup.

<table>
<thead>
<tr>
<th>Test condition</th>
<th>Peak acceleration, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>70</td>
</tr>
</tbody>
</table>

CAUTION: If this test is performed using a potting compound type test fixture (e.g., waterglass/sodium silicate) the facility performing the test shall assure that this procedure/material does not mask fine/gross leakers.

3.1 Examination. After completion of the test, an external visual examination of the marking shall be performed without magnification or with a viewer having a magnification no greater than 3X and a visual examination of the case, leads, or seals shall be performed at a magnification between 10X and 20X. This examination and any additional specified measurements and examination shall be made after completion of the final cycle or upon completion of a group, sequence, or subgroup of tests which include this test.

3.2 Failure criteria. After subjecting to the test, failure of any specified measurement or examination (see 3 and 4), evidence of defects or damage to the case, leads, or seals, or illegible markings shall be considered a failure. Damage to marking caused by fixturing or handling during tests shall not be cause for device rejection.

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

a. Test condition (see 3).

b. Measurements after test (see 3 and 3.1).
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METHOD 2009.14

EXTERNAL VISUAL

1. PURPOSE. The purpose of this test method is to verify the workmanship of packaged devices. This test method shall also be utilized to inspect for damage due to handling, assembly, and/or test of the packaged device. This examination is normally employed at outgoing inspection within the device manufacturer's facility, or as an incoming inspection of the assembled device.

2. APPARATUS. Equipment used in this test shall be capable of demonstrating device conformance to the applicable requirements. Equipment shall include optical devices capable of magnification of at least 1.5X to 10X, with a relatively large and accessible field of view.

3. PROCEDURE

3.1 Magnification. Devices shall be examined at 1.5X to 10X magnification. Devices may be examined anywhere in the range of 1.5X to 10X; however, acceptable product must be capable of passing all criteria when examined at 10X magnification. Individual glass seals (see 3.3.9) shall be examined at 7X to 10X magnification.

3.2 Foreign material. When foreign material is present, and its adherence is in question, the device may be subjected to a clean filtered gas stream (vacuum or expulsion) of approximately 20 psig.

3.3 Failure criteria. Devices shall fail if they exhibit any of the following:

3.3.1 General
   a. Illegible marking, or marking content or placement not in accordance with the applicable specification.
   b. Presence of any secondary coating material that visually obscures a seal area(s) (i.e., any hermetic interface).
   c. Evidence of any nonconformance with the detail drawing or applicable procurement document, or absence of any required feature.

3.3.2 Foreign/displaced material
   a. Braze material flow, or other foreign material (i.e., contamination or corrosion) that reduces the isolation between leads or between braze pads to less than 50% of the lead separation (pad separation for brazed leads) but in no case less than the case outline minimum.
   b. Leads or terminals with foreign material such as paint or other adherent deposits affecting 5% or greater of the lead surface area.

3.3.3 Construction defects
   a. Protrusions on the bottom (mounting) surface of the package that extend beyond the seating plane.
   b. Protrusions (excluding glass run-out) on any other package surface that exceed the lead thickness in height (leaded packages).
   c. Protrusions on the lid or cover, or extending beyond the surface plane of solder pads, that exceed 25% of the terminal width in height (leadless packages).
   d. Metallization not intended by design between solder pads, between elements of thermal patterns and/or between seal ring or lid to metallized castellations that reduce the isolation to less than 50% of pad separation (leadless packages).
3.3.4 Package Body/Lid Finish

a. Defective finish (peeling, flaking, pitting, blistering, or corrosion). Discoloration that does not exhibit these conditions is acceptable.

b. Scratches, mars, or indentations, either due to damage or processing, that expose base metal. Exposed underplate is acceptable.

3.3.5 Leads

a. Broken leads.

b. Leads or terminals that are not intact or aligned in their normal location, free of sharp or unspecified lead bends, or twisted more than 20° from the normal lead plane.

c. Leads with pits and/or depressions that exceed 25% of the width (diameter for round leads) and are greater than 50% of the lead thickness in depth.

d. Leads with burrs exceeding a height greater than 50% of the lead thickness.

e. Lead misalignment to the braze pad to the extent that less than 75% of the lead braze section is brazed to the pad.

f. Metallization (including solder lead finish) in which the isolation between leads or between lead and other package metallization is reduced to less than 50% of lead separation (pad separation for brazed leads) but in no case less than the case outline minimum.

g. Braze material that increases the lead dimensions to greater than 1.5 times the lead thickness above the design maximum between the seating plane and the ceramic body or that increases the lead dimensions to greater than the design maximum below the seating plane.

h. Scratches that expose base metal over more than 5% of the lead surface area. Exposed base metal on the cut lead ends is acceptable and does not count in the 5%.
3.3.6 Ball/column grid array leads.

a. Nonconformance with any design criteria (see 3.3.1.c herein).

b. Solder columns / solder balls alignment.
   i. Solder column base is misaligned such that the column is not within the perimeter of the pad.
   ii. Solder column tip misalignment that does not meet drawing requirements (typically < 100 μm).
   iii. Solder ball misalignment that does not meet drawing requirements.

c. Broken, twisted or damaged solder columns/spheres. Damaged columns/spheres (scored, gouged) that fail to meet final dimensional requirements.

d. Solder column bends or misalignments that do not meet the drawing design criteria.

e. Solder columns/spheres containing any void, hole, pit, gouge or depression greater than 15% of the column/sphere diameter or volume. For voids, holes, pits less than 15% of the diameter or volume, the cumulative total shall be less than half of the column/sphere diameter.

f. Solder columns/spheres containing cracks.

g. Columns/spheres with burrs or bumps exceeding 20% of the column/sphere diameter.

h. Columns/spheres that exhibit peeling, flaking, or blistering.

i. Solder fillet height which is less than half the column diameter for more than 25% of the column circumference.

j. For copper reinforced columns that exhibit any of the following:
   i. Copper ribbon delamination exceeding 25% around the column circumference.
   ii. Columns with copper wire having copper exposed more than five percent of the column surface area. Exposed (cut) copper on the free end of the column is acceptable.

k. Discoloration of columns/spheres due to corrosion, crusting, or residual flux (there should be a consistent shiny solder appearance). Evidence of flux residue, stains, rust, or signs of corrosion that can be seen at 3 to 10X magnification.

l. Foreign material, discoloration, or adherent deposits within 0.5 mm of the free end of the column.

m. Solder columns/spheres that do not meet requirements for device co-planarity/uniformity of the drawing design criteria (typically < 150 μm).

o. Pad dewetting/non-wetting greater than 5% of the pad surface area.

3.3.7 Package body/lid - leaded devices (See Figure 2009-1).

a. Broken packages or cracks in the packages. Surface scratches shall not be cause for failure except where they violate other criteria stated herein for marking, finish, etc.

b. Any chipping (chip in place/chipout) dimension that exceeds 0.060 inch in any direction on the surface and has a depth that exceeds 25% of the thickness of the affected package element (e.g., cover, base, or wall).

c. External lead metallization stripe forming a conductor to a brazed lead that exhibits voids greater than 25% of the conductor width.

d. Evidence of cracks, delamination, separation, or voiding on any multilayer ceramic package.
Note: Chipping vs Cracks.

i. Cracks are lines of material separation that have one or both terminations in a direction which could be conceived as possibly extending further without limit or in the direction of package structures as it extends.

ii. Chipping is a line of material separation that has both terminations directed towards an edge of the package with no conceivable path for extension beyond the edge.

iii. Chipout is chipping that is so extensive as to have caused the removal of package material.

iv. Chip in Place is chipping that has not cause the removal of material, but forms the semicircular pattern defining a section of material.

FIGURE 2009-1 Cracks Vs Chipping.
3.3.8 Package body/lid - leadless devices (See Figure 2009-1).

a. Ceramic chipping (chip in place /chipout) that dimensionally exceed 50% of the distance between terminals in any direction on the affected surface (edge or corner), and exceed a depth of 25% of the thickness of the affected package element (e.g., cover, lid, base, or wall).

b. Evidence of cracks, delamination, separation, or voiding on any package element.

c. Castellation to solder pad misalignment. The metal in the castellation, exclusive of the angular ring, shall be within the visually extended boundaries of the solder pad (see Figure 2009-2).

FIGURE 2009-2 Castellation to solder pad misalignment.
d. Castellation configuration not in accordance with the following (see Figure 2009-3). The castellation shall be roughly concave, confined by a 3-dimensional space traversing all castellated ceramic layers at the package edge. The surface of the castellation may be irregular. The “3-dimensional space” has these dimensions:

1. Minimum width > 1/3 package terminal pad width.
2. Minimum depth > 1/2 castellation minimum width.
3. Length = as designed (see Figure 2009-3).
5. Maximum depth < 1/2 castellation maximum width.

These dimensions are an attempt to ensure with some reasonableness that the castellations are not viewed, in the extreme sense, as virtual flat surfaces on the package edge and are not virtual closed vias (holes).

NOTE: Ceramic layers shift, edges are rough after punching, plating buildup is not smooth etc., all of these combine during package manufacture to make the castellation measurement difficult. Therefore, in the event of conflicts in determining castellation acceptance, direct contact measurement shall be made using the limits specified in MIL-STD-1835.

FIGURE 2009-3  Castellation requirements.
3.3.9 Glass seals.

a. Crazing of the glass seal surface (see Figure 2009-4).

b. Any single circumferential crack (or overlapping crack) that does not lie completely within a single quadrant (i.e., extends beyond 90° arc or rotation about the lead), and extends beyond or is located in the region beyond the midpoint of distance from the lead to the case (see Figure 2009-5).

c. Radial cracks that exhibit the following:

1. Cracks that do not originate at the lead (see Figures 2009-6a and 2009-6b).
2. Three or more cracks that extend beyond the midpoints of distance from the lead to the case (see Figure 2009-6c).
3. Two cracks that extend beyond the midpoint of the distance from the lead to the case and that lie within the same quadrant (see Figure 2009-6d).
d. Any chip-out that penetrates the sealing glass deeper than the glass meniscus plane. The glass meniscus is defined as that area of glass that wicks up the lead or terminal. Exposed base metal as a result of meniscus chip outs is acceptable, provided that the exposed area is no deeper than 0.010 inch (see Figure 2009-7).

![Figure 2009-7 Chip-outs.](image)

![Figure 2009-8a Surface bubbles.](image)

![Figure 2009-8b Subsurface bubbles.](image)

e. Surface bubbles that exceed the following:

1. Open bubbles in the glass seal that exceed 5 mils in diameter (see Figure 2009-8a). For packages with a glass-filled header (i.e., TO-5), open bubbles that exceed 10 mils diameter, or an open bubble that exceeds 5 mils diameter situated closer than 10 mils to a lead.

2. Open bubbles in strings or clusters that exceed 2/3 of the distance between the lead and the package wall.
f. Subsurface bubbles that exceed the following:

1. Large bubbles or voids that exceed 1/3 of the glass sealing area (see Figure 2009-8a).
2. Single bubble or void that is larger than 2/3 of the distance between the lead and the package wall at the site of inclusion (see Figures 2009-8b and 2009-8c).
3. Two bubbles in a line totaling more than 2/3 distance from pin to case (see Figure 2009-8c).
4. Interconnecting bubbles greater than 2/3 the distance between pin and case (see Figure 2009-8d).

![Figure 2009-9](image)

**FIGURE 2009-9 Subsurface bubbles.**

g. Reentrant seals that exhibit non-uniform wicking (i.e., negative meniscus) at the lead and/or body interface (see Figure 2009-10).

![Figure 2009-10](image)

**FIGURE 2009-10 Reentrant seals.**

4. **SUMMARY.** The following details shall be specified in the applicable acquisition document:

a. Requirements for markings and the lead (terminal), or pin identification.

b. Any additional detailed requirements for materials, design, construction, and workmanship.
INTERNAL VISUAL (MONOLITHIC)

1. PURPOSE. The purpose of this test is to check the internal materials, construction, and workmanship of microcircuits for compliance with the requirements of the applicable acquisition document. This test will normally be used prior to capping or encapsulation on a 100 percent inspection basis to detect and eliminate devices with internal defects that could lead to device failure in normal applications. It may also be employed on a sampling basis prior to capping to determine the effectiveness of the manufacturer's quality control and handling procedures for microelectronic devices. Furthermore, the criteria of this test method will be used during destructive physical analysis (DPA) following the procedures outlined in test method 5009, "Destructive Physical Analysis". Test condition A and B provide a rigorous and detailed procedure for internal visual inspection of high reliability microcircuits as specified in the screening requirements of test method 5004. For condition B product the alternate screening procedure (alternate 1) documented in test method 5004 may be used by the manufacturer as an option to internal visual inspection as specified. For condition A or B product, the alternate screening procedure (alternate 2) documented in test method 5004 may be used by the manufacturer as an option to internal visual inspection as specified.

2. APPARATUS. The apparatus for this test shall include optical equipment capable of the specified magnification and any visual standards (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 fixturing shall be provided for handling devices during examination to promote efficient operation without inflicting damage to the units.

2.1 GaAs device requirements. GaAs devices shall be inspected to all applicable criteria as listed herein. GaAs microwave devices shall also have additional specific criteria as listed and the applicable high power magnification for individual features of GaAs microwave devices shall be selected from the following table.

<table>
<thead>
<tr>
<th>Feature Dimensions</th>
<th>Magnification range</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 5 microns</td>
<td>75 - 150x</td>
</tr>
<tr>
<td>1 - 5 microns</td>
<td>150 - 400x</td>
</tr>
<tr>
<td>&lt; 1 micron</td>
<td>400 - 1000x</td>
</tr>
</tbody>
</table>

2.2 Silicon-on-Sapphire (SOS) device requirements. SOS devices shall be inspected to all applicable criteria specified herein, except where noted. The sapphire portions of the die shall be considered "nonconductive and nonoperational material".

3. PROCEDURE.

a. General. The device shall be examined within the specified magnification range to determine compliance with the requirements of the applicable acquisition document and the criteria of the specified test condition.

The inspections and criteria in this method shall be required inspections for all devices and locations to which they are applicable. Where the criterion is intended for a specific device process or technology, it has been indicated.
b. 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.

When inverted die mounting techniques are employed, the inspection criteria contained herein that cannot be performed after mounting shall be conducted prior to attachment of the die. Devices that fail any test criteria herein are defective devices and shall be rejected and removed at the time of observation.

Visual criteria may be inspected as follows:

1. Prior to die attachment without re-examination after die attachment; 3.1.1.2, 3.1.1.5, 3.1.1.7, 3.1.2, 3.1.4 e and f, 3.1.5, 3.1.6 a-f, 3.2.6.
2. Prior to bonding without re-examination after bonding; 3.2.3.
3. For condition B only; the following criteria may be inspected prior to die attachment at high power, plus low power after die attachment, provided a high-magnification sample to sample size number = 45 accept number C = 0 is performed at precap inspection; 3.1.1.1, 3.1.1.3, 3.1.1.4, 3.1.1.6, 3.1.3, 3.1.4 a-d and g-o, 3.1.6 g and h, 3.1.7. If the sample fails the entire lot shall be reinspected at high magnification for the failed criteria.

c. Inspection control. In all cases except die at incoming inspection, examination prior to final preseal inspection shall be performed under the same quality program that is required at the final preseal inspection station. Care shall be exercised after inspections in accordance with 3b, to insure that defects created during subsequent handling will be detected and rejected at final preseal inspection. During the time interval between visual inspection and preparation for sealing, devices shall be stored in a controlled environment. Devices examined to condition A shall be inspected and prepared for sealing in a Class 5 controlled environment and devices examined to condition B criteria shall be inspected and prepared for sealing in a Class 8 controlled environment (see A.4.8.1.1.7 of appendix A of MIL-PRF-38535), except that the maximum allowable relative humidity in either environment shall not exceed 65 percent. Devices shall be in covered containers when transferred from one controlled environment to another.

d. Magnification. "High magnification" inspection shall be performed perpendicular to the die surface with the device under illumination perpendicular to the die surface. "Low magnification" inspection shall be performed with a metallurgical or stereomicroscope with the device under suitable illumination. Low magnification may be performed at an angle other than 90° to the die surface to facilitate the inspection. The inspection criteria of 3.2.1 may be examined at "high magnification" at the manufacturer's option.

e. Reinspection. When inspection for product acceptance is conducted subsequent to the manufacturer's 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. When suspected defects or deficiencies are noted, additional inspection may be performed at magnifications needed to evaluate or resolve the suspect items.
f. Definitions:

(1) **Active circuit area.** All areas enclosed by the perimeter of functional circuit elements, operating metallization or any connected combinations thereof excluding beam leads.

(2) **Coupling (air) bridge.** A raised layer of metallization used for interconnection that is isolated from the surface of the element.

(3) **Block resistor.** A thin film resistor which for purposes of trimming is designed to be much wider than would be dictated by power density requirements and shall be identified in the approved manufacturer's precap visual implementation document.

(4) **Contact Via.** The Via where dielectric material is etched away in order to expose the Under Bump Metalization (UBM) on the bond pads or solder bump attach pads.

(5) **Channel.** An area lying between the drain and the source of FET structures.

(6) **Controlled environment (Clean Room).** An environment maintained for humidity and atmospheric particle count in accordance with ISO 14644-1. A Class 5 controlled environment has no more than 100 (0.5 µm or greater) particles/cubic-feet of air, a Class 6 controlled environment has no more than 1,000 (0.5 µm or greater) particles/cubic-foot of air, and a Class 8 controlled environment has no more than 100,000 (0.5 µm or greater) particles/cubic-foot of air, except that the maximum allowable relative humidity shall not exceed 65 percent.

(7) **Crazing.** The presence of numerous minute cracks in the referenced material, (e.g., glassivation crazing).

(8) **Detritus.** Fragments of original or laser modified resistor material remaining in the kerf.

(9) **Die Coat.** A thin layer of soft polyimide coating applied to the surface of a semiconductor element that is intended to produce stress relief resulting from encapsulation and to protect the circuit from surface scratches.

(10) **Dielectric isolation.** Electrical isolation of one or more elements of a monolithic semiconductor integrated circuit by surrounding the elements with an isolating barrier such as semiconductor oxide.

(11) **Dielectric layer or layers.** Dielectric layer or layers deposited on the die surface to protect the redistribution metallization, and to create the contact via for solder bump pad.

(12) **Diffusion tub.** A volume (or region) formed in a semiconductor material by a diffusion process (n- or p- type) and isolated from the surrounding semiconductor material by a n-p or p-n junction or by a dielectric material (dielectric isolation, coplanar process, SOS, SOI).

(13) **Foreign material.** Any material that is foreign to the microcircuit or package, or any nonforeign material that is displaced from its original or intended position within the microcircuit package.

(14) **Functional circuit elements.** Diodes, transistors, crossunders, capacitors, and resistors.

(15) **Gate oxide.** The oxide or other dielectric that separates gate metallization (or other material used for the gate electrode) from the channel of MOS structures (see figure 2010-1).

(16) **Glassivation.** The top layer(s) of transparent insulating material that covers the active circuit area, with the exception of bonding pad areas and beam leads.

(17) **Glassivation cracks.** Fissures in the glassivation layer.
(18) **Junction line.** The outer edge of a passivation step that delineates the boundary between "P" and "N" type semiconductor material. An active junction is any P/N junction intended to conduct current during normal operation of the circuit element, (e.g., collector to base).

(19) **Kerf.** That portion of the component area from which material has been removed or modified by trimming or cutting.

(20) **Line of separation.** Visible distance or space between two features that are observed not to touch at the magnification in use.

(21) **MESFET.** (Metal semiconductor field-effect transistor). A field-effect transistor in which a metal semiconductor rectifying contact is used for the gate electrode. Typically the structure is fabricated in gallium arsenide and the term GaAs MESFET may be used. Both depletion-type and enhancement type devices have been manufactured. The acronyms are D-MESFET, and E-MESFET, respectively.

(22) **Metallization nonadherence.** Unintentional separation of material from an underlying substrate excluding air bridges and undercutting by design.

(23) **Multilayered metallization (conductors).** Two or more layers of metal or any other material used for interconnections that are not isolated from each other by insulating material. The term "underlying metal" shall refer to any layer below the top layer of metal (see figure 2010-2).

(24) **Multilevel metallization (conductors).** Two or more levels of metal or any other material used for interconnections that are isolated from each other by insulating material (also referred to as interlevel dielectric) (see figure 2010-3).

(25) **Narrowest resistor width.** The narrowest portion of a given resistor prior to trimming.


(26) **Operating metallization (conductors).** Metal or any other material used for interconnection except metallized scribe lines, test patterns, unconnected functional circuit elements, unused bonding pads, and identification markings.

(27) **Original width.** The width dimension or distance that would have been present, in the absence of the observed abnormality (e.g., original metal width, original diffusion width, original beam width, etc.).

(28) **Package post.** A generic term used to describe the bonding location on the package.

(29) **Passivation.** The silicon oxide, nitride or other insulating material that is grown or deposited directly on the die prior to the deposition of metal or between metal levels on multilevel devices.

(30) **Passivation step.** An abrupt change of elevation (level) of the passivation such as a contact window, or operating metallization crossover.
(31) **Peripheral metal.** All metal that lies immediately adjacent to or over the scribe grid.

(32) **Redistribution Layer (RDL).** Layer added to original wafer/die surface to allow for the redistribution of bond pads into a format more suitable to flip chip.

(33) **Redistribution metalization.** The metal deposited on the RDL to create the electrical conductors which connect the original bond pads to the distributed solder bump pads.

(34) **Shooting metal.** Metal (e.g., aluminum, gold) expulsion of various shapes and lengths from under the wire bond at the bonding pad.

(35) **Solder ball.** Solder ball or sphere attached to the UBM through the contact via after a re-flow process.

(36) **Solder Bump.** Solder that is either electroplated or screened into the photo resist opening. After the photo resist is removed the solder resembles a bump before it is reflowed into ball or sphere.

(37) **Substrate.** The supporting structural material into or upon which or both the passivation, metallization and circuit elements are placed.

(38) **Substrate via.** A small hole formed through the wafer and metallized, causing electrical connection to be made from the frontside (the side on which the circuitry is formed) to the backside of the wafer.

(39) **Thick film.** That conductive/resistive/dielectric system that is a film having greater than 50,000Å thickness.

(40) **Thin film.** That conductive/resistive/dielectric system that is a film equal to or less than 50,000Å in thickness.

(41) **Under Bump Metallization (UBM).** Metals deposited on top of the aluminum bond pads or on the solder bump pads that enhance wetting and protect against intermetallic reactions between the solder and the original metal on the pads.

(42) **Via metallization.** That which connects the metallization of one level to another.

g. **Interpretations.** Reference herein to "that exhibits" shall be considered satisfied when the visual image or visual appearance of the device under examination indicates 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 for confirming that a reject condition does not exist, they shall be approved by the acquiring activity. For inspections performed on the range of 75X to 100X, the criteria of 0.1 mil of passivation, separation or metal can be satisfied by a line of separation or a line of metal visible.

h. **Foreign material control.** The manufacturer shall perform an audit on a weekly basis for (1) the presence of foreign material within incoming piece part lids and bases, and (2) the presence of foreign material on the die surface or within the package of assembled parts.

The audit of assembled parts may be satisfied during routine internal visual inspection. If the presence of foreign material is discovered, the manufacturer shall perform the necessary analysis on a sample of the foreign material on the suspect devices to determine the nature of the material. The manufacturer shall document the results of this investigation and corrective action to eliminate the foreign material and this information will be available to the Government QAR, and the acquiring activity or the qualifying activity, as applicable. A corrective action plan shall be obtained within a maximum of 10 working days of discovery.

The audit of incoming piece part lids and bases shall be performed before parts are assembled, or may be satisfied during routine incoming quality inspection. If the presence of foreign material of a size 1 mil or greater is discovered, the manufacturer will analyze the foreign material to determine its nature and document the results of the analysis. If applicable, these results shall be distributed to the vendor supplying the parts, with the request that the vendor document corrective actions to minimize or eliminate such foreign material. This information will be available to the manufacturer, Government QAR, and the acquiring activity or qualifying activity, as applicable.
NOTE: The piece part audit requirements can be replaced by a piece part cleaning process, approved by the qualifying activity, that is always performed either prior to or during the assembly process and these piece parts are stored in a controlled environment until they are used.

The intent of these procedures is to require investigation and resolution of foreign material problems that do not have an effective screening or detection methodology but that could cause degradation and eventual failure of the device function. Repetitive findings without obvious improvements require escalation to Director of Manufacturing and Director of Quality Assurance to continue processing.

Condition A                  Condition B
Class level S                Class level B

3.1 High power inspection. Internal visual examination as required in 3.1.1 through 3.1.3 shall be conducted on each microcircuit. In addition, the applicable criteria contained in 3.1.4 through 3.1.7 shall be used for the appropriate microcircuit area where glassivation, dielectric isolation or film resistors are used.

NOTE: Unless otherwise specified, for flip chip product the criteria of 3.1 shall apply only to top circuit side inspection. After die mounting, only criteria in 3.1.3i shall apply.

The high magnification inspection shall be within the range of 100X to 200X.

For high magnification inspection of GaAs microwave devices, see table I herein. Also, for < 1 micron features, the manufacturer may implement a sample inspection plan which shall be documented in the manufacturer's internal procedure and approved by the qualifying activity.

3.1.1 Metallization defects. No device shall be acceptable that exhibits the following defects in the operating metallization.

3.1.1.1 Metallization scratches:

a. Scratch in the metallization excluding bonding pads and beam leads that leaves less than 50 percent of the original metal width undisturbed (see figure 2010-4).

NOTE: For GaAs microwave devices, scratches in the gate stripe or gate insertion metallization.

NOTE: For single layer metal products

ACCEPT: SCRATCH WHERE THE REMAINING UNDISTURBED METAL WIDTH (X) IS GREATER THAN d/2 (50 PERCENT).

REJECT: SCRATCH WHERE THE REMAINING UNDISTURBED METAL WIDTH (X) IS LESS THAN d/2 (50 PERCENT).

FIGURE 2010-4. Metallization scratch criteria for class level S.
b. For condition A, see 3.1.1.1a above.

b. For condition B only. Scratch that completely crosses a metallization path and damages the surface of the surrounding passivation, glassivation, or substrate on either side (for MOS devices, the path shall be the (L) dimension) (see figure 2010-6).

NOTE: When standard metallization scratch criterion is applied to the gate area, the dimensions (W) and (L) shall be considered as the original channel width and length respectively.

FIGURE 2010-5. Metallization scratch criteria for class level B.

FIGURE 2010-6. MOS scratch criteria.
Condition A                   Condition B
Class level S                      Class level B

FIGURE 2010-6. MOS scratch criteria - Continued.

C. Scratch in multilayered metallization, excluding bonding pads and beam leads that exposes underlying metal or passivation anywhere along its length and leaves less than 75 percent of the original metal width undisturbed (see figure 2010-7).

C. Scratch in multilayered metallization, excluding bond pads and beam leads that exposes the underlying metal anywhere along its length and leaves less than 25 percent of the original metal width undisturbed (see figure 2010-8).

FIGURE 2010-7. Scratch criteria for class level S.
Condition A  
Class level S  

Condition B  
Class level B  

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FIGURE 2010-8 Scratch criteria for class level B.

NOTE: For condition B only. Criteria 3.1.1.1a, b, and c can be excluded for peripheral power or ground metallization where parallel paths exist such that an open at the scratch would not cause an unintended isolation of the metallization path.

d. Scratch in the metallization over a passivation step that leaves less than 75 percent of the original metal width at the step undisturbed.

NOTE: For condition B only. Criteria 3.1.1.1a, b, c, and d can be excluded for the last 25 percent of the linear length of the contact cut and all metal beyond, on the termination end(s) of the metallization runs. In these cases there shall be at least 50 percent of the contact opening area covered by metallization and at least a continuous 40 percent of the contact opening perimeter covered by undisturbed metallization (see figure 2010-9).

e. Scratch in the metallization, over the
gate oxide (applicable to MOS structures
only) (see figure 2010-10).

e. Scratch in the metallization, over the
gate oxide, that exposes underlying
passivation and leaves less than 50 percent
of the length or width of the metallization
between source and drain diffusion undisturbed
(applicable to MOS structures only) (see figure
2010-11).
Condition A
Class level S

Condition B
Class level B

FIGURE 2010-10.  MOS scratch criteria for class level S.

FIGURE 2010-11.  MOS scratch criteria for class level B.

Reject: Scratch exposing underlying gate oxide where the remaining undisturbed metal width (Y) is less than W/2 (50 percent).
f. Scratch in the metallization that exposes the dielectric material of a thin film capacitor or crossover. (Not applicable to air bridges.)

g. Scratch in the bonding pad or fillet area that reduces the metallization path width connecting the bond to the interconnecting metallization to less than 50 percent of the narrowest entering interconnect metallization stripe width. If two or more stripes enter a bonding pad, each shall be considered separately.

h. Scratch(es) (probe mark(s), etc.) in the bonding pad area that exposes underlying passivation, or substrate, and leaves less than 75 percent of the unglassivated metallization area undisturbed.

i. For GaAs devices only, any tears, peeling, gaps, and lateral displacement of metal.

3.1.1.2 Metallization voids:

a. Void(s) in the metallization that leaves less than 75 percent of the original metal width undisturbed (see figure 2010-12).

Accept: Void exposing underlying metal or passivation where the remaining undisturbed metal width (X) is greater than 3/4 d (75 percent).

Reject: Void exposing underlying metal or passivation where the remaining undisturbed metal width (X) is less than 3/4 d (75 percent).

Underlying NOTE: d = Original metal width
Passivation

X = Undisturbed metal width

Accept: Void exposing underlying metal where the remaining undisturbed metal width (X) is greater than d/2 (50 percent).

Reject: Void exposing underlying metal where the remaining undisturbed metal width (X) is less than d/2 (50 percent).

Underlying NOTE: d = Original metal width
Passivation

X = Undisturbed metal width

FIGURE 2010-12. Void criteria for class level S.

FIGURE 2010-13. Void criteria for class level B.

NOTE: For condition B only. Criteria can be excluded for peripheral power or ground metallization where parallel paths exist so that an open at the void(s) would not cause an unintended isolation of the metallization path.
b. Void(s) in the metallization over a passivation step that leaves less than 75 percent of the original metal width at the step undisturbed.

NOTE: For condition B only. Criteria of 3.1.1.2a and b can be excluded for the last 25 percent of the linear length of the contact cut and all metal beyond on the termination end(s) of metallization runs. In these cases there shall be at least 50 percent of the contact opening perimeter covered by undisturbed metallization (see figure 2010-14).

FIGURE 2010-14. Termination ends.

c. Void(s) in the metallization over the gate oxide that leaves less than 75 percent of the metallization length (L) or width (W) between source and drain diffusions undisturbed (applicable to MOS structures only) (see figure 2010-15).
d. Void(s) that leave less than 75 percent of the metallization area over the gate oxide undisturbed (applicable to MOS structures only).

e. Void(s) that leaves less than 75 percent of the metallization width coincident with the source or drain diffusion junction line undisturbed (applicable to MOS structures only) (see figure 2010-15).

f. Void(s) in the bonding pad area that leaves less than 75 percent of its original unglassivated metallization area undisturbed (see figure 2010-16).

g. Void(s) in the bonding pad or fillet area that reduces the metallization path width connecting the bond to the interconnecting metallization to less than 75 percent of the narrowest entering metallization stripe width. If two or more stripes enter a bonding pad, each shall be considered separately. (see figure 2010-16).
NOTE: When a fillet area exists, it is to be considered as part of the entering/exiting metallization stripe.

h. Void(s) in the metallization area of a thin film capacitor that leave less than 75 percent of the designed metallization area.

i. For GaAs microwave devices only, voids in the gate stripe.

3.1.1.3 **Metallization corrosion.** Any metallization corrosion. Metallization having any localized discolored area shall be closely examined and rejected, unless it is demonstrated to be a harmless film, glassivation interface, or other obscuring effect.

3.1.1.4 **Metallization nonadherence.** Any metallization lifting, peeling, or blistering.

3.1.1.5 **Metallization probing.** Criteria contained in 3.1.1.1 shall apply as limitations on probing damage.
3.1.1.6 **Metallization bridging.**

NOTE: For SOS devices, exclude the insulator scribe lines.

a. Any metallization bridging where the separation between metallization paths is reduced to less than 50 percent of the original design.

b. Any metal that is displaced, as a result of bonding, from its original position on the bonding pad (shooting metal) greater than 1.0 mils or that reduces the separation between unglassivated operating metallization or scribe line and the bonding pad to less than 0.25 mils or 50 percent design separation, whichever is less.

NOTE: For GaAs microwave devices, metallization bridging across spacings of less than 1 μm shall be inspected only in accordance with 3.2 and table I at 400X to 1,000X. If a clear line of separation is not discernible, device functional testing at the wafer level shall suffice.

b. Any metal that is displaced, as a result of bonding, from its original position on the bonding pad (shooting metal) that reduces the separation between unglassivated operating metallization or scribe line and the bonding pad such that a line of separation is not visible.

3.1.1.7 **Metallization alignment.**

a. Contact window that has less than 75 percent of its area covered by metallization.

b. Contact window that has less than a continuous 50 percent of its perimeter covered by metallization.

c. Contact window that has less than 75 percent of its perimeter on two adjacent sides covered by metallization (applicable to MOS structures only).

NOTE: When, by design, metal is completely contained in a contact window or does not cover the entire contact perimeter, criteria 3.1.1.7a, b, or c can be deleted, provided the design criteria is satisfied.

d. A metallization path not intended to cover a contact window that is not separated from the contact window by a line of separation.

e. Any exposure of the gate oxide (i.e., oxide not covered by gate electrode in the area between source and drain diffusions, applicable to MOS structures only) (see figure 2010-17).

3.1.1.8 **Via hole metallization.** For GaAs devices only,

a. Overetched via hole or misaligned via visible around the pad.

b. Poor adhesion (lifting, peeling or blistering).

c. Any cracks originating at the via hole.

d. Evidence of bulging metal over a via hole.

e. Evidence of solder coming up through via hole pad, when die is mounted on a carrier.
3.1.1.9 **Coupling (air) bridge defects *high magnification*.** For GaAs devices only. No element shall be acceptable that exhibits:

a. A void in the coupling (air) bridge metallization that leaves less than 75 percent of the original metallization width undisturbed. (See figure 2010-17A).

b. Nodules or bumps that are greater, in any dimension, than the original coupling (air) bridge metallization width. (See figure 2010-17A)

c. Coupling (air) bridge that contacts underlying operating metallization. (See figure 2010-17A)

d. Attached, conductive foreign material that is greater, in any dimensions, 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 2010-17A)

f. Coupling (air) bridge metallization overhang over adjacent operating metallization, not intended by design, that does not exhibit a visible separation. (See figure 2010-17A)

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

   **NOTE:** Air bridges which are depressed, over operating metallization, due to normal backside processing are not considered mechanically damaged. A visual line of separation still applies in accordance with 3.1.1.9e.
FIGURE 2010-17A. Class level S and Class level B coupling (air) bridge criteria.
h. For MOS structures containing a diffused guard ring, gate metallization not coincident with or not extending over the diffused guard ring (see figure 2010-18).

FIGURE 2010-17. MOS gate alignment.

FIGURE 2010-18. MOS gate alignment.
3.1.2 Diffusion and passivation layer faults. No devices shall be acceptable that exhibits the following:

3.1.2.1 Diffusion faults.

a. Diffusion fault that allows bridging between diffused areas (see figure 2010-19).

b. Any isolation diffusion that is discontinuous (except isolation walls around unused areas or unused bonding pads) or any other diffused area with less than 25 percent (50 percent for resistors) of the original diffusion width remaining (see figure 2010-20).
3.1.2.2 Passivation faults.

NOTE: For SOS devices, exclude defects between first-level conductive interconnect (metallization, polysilicon, etc.) and sapphire areas of the die, where no active circuit elements are present.

a. Either multiple lines or a complete absence of passivation visible at the edge and continuing under the metallization unless by design for GaAs devices. Multiple lines indicate that the fault can have sufficient depth to penetrate down to bare semiconductor material.

NOTE: The multiple line criteria can be excluded when a second passivation layer is applied in a separate operation prior to metallization deposition or for bond pads located in isolated tubs.

b. Active junction line not covered by passivation, unless by design.

c. Contact window that extends across a junction line, unless by design.
3.1.3 **Scribing and die defects.** No device shall be acceptable that exhibits:

- a. Less than 0.25 mil of passivation visible between operating metallization or bond periphery and bare semiconductor material (see figure 2010-22).

  **NOTE:** For GaAs devices only, less than 0.1 mil of substrate visible between operating metallization or bond periphery and edge of the die.

  **NOTE:** Criteria can be excluded for beam leads and peripheral metallization including bonding pads where the metallization is at the same potential as the substrate.

  **NOTE:** Does not apply to SOS devices.

- b. A chipout or crack in the active circuit area (see figures 2010-22 and 2010-38). In addition for GaAs a chipout into or underneath the functional metallization, e.g., bond pads, capacitors, peripheral metallization, etc., but excluding test structures of the device.

  **NOTE:** Criteria can be excluded for peripheral metallization that is at the same potential as the substrate. At least 50 percent undisturbed metallization width shall remain at the chipout.

- c. A crack that exceeds 3.0 mils in length, or comes closer than 0.25 mils to any operating metallization (except for substrate potential peripheral metal) or functional circuit element (see figure 2010-22).

- d. For condition A only. Semicircular crack(s) terminating at the die edge, whose chord is long enough to bridge the narrowest spacing between unglassivated operating material (e.g., metallization, bare semiconductor material, mounting material, bonding wire, etc.) (see figure 2010-22).

- e. Exposed semiconductor material extending over the passivation edge at the point of the beam lead exit from the die (applicable to beam lead structures only) (see figure 2010-38).

- f. Die having attached portions of the active circuit area of another die.

- g. A crack that exceeds 1.0 mil in length inside the scribe line (or semiconductor material edge for beam lead devices) that points toward operating metallization or functional circuit elements (see figure 2010-22).

- h. A crack that comes closer than 0.5 mil to operating beam lead metallization (see figure 2010-38).

  **NOTE:** Criteria of 3.1.3c and h can be excluded for beam lead devices where the chipout or crack does not extend into the semiconductor material.

  **NOTE:** Criteria of 3.1.3e and h do not apply to GaAs devices.
FIGURE 2010-22  Scribing and die defects.
i. For flip chip, cracks, or chipouts in the substrate material that extends beyond 50 percent of substrate thickness or a crack greater than 5.0 mils in length in the substrate material (see figure 2010-23).

j. Any blistering, peeling, delamination, corrosion, or other gross defects in glassivation, metal, interlevel dielectrics or other layers.

FIGURE 2010-23. Scribing and die defects.
3.1.4 **Glassivation defects.** No device shall be acceptable that exhibits (see figure 2010-24):

**NOTE:** For condition B only. Criteria of 3.1.4 can be excluded when the defect(s) is due to laser trimming. In this case, the defects 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 defects, equal to or greater than one half times the narrowest resistor width.

**FIGURE 2010-24.** Laser trimmed glassivation defects.

- a. Glass crazing or glass damage that prohibits the detection of visual criteria contained herein.
- b. Any lifting or peeling of the glassivation in the active areas or which extends more than 1.0 mil distance from the designed periphery of the glassivation.
- c. A glassivation void that exposes two or more active metallization paths, except by design.
- d. Unglassivated areas greater than 5.0 mils in any dimension, unless by design.
- e. Unglassivated areas at the edge of bonding pad exposing bare semiconductor material, except by design.
- f. Glassivation covering more than 25 percent of the designed open contact bonding area.
- g. Crazing over a film resistor.
Condition A | Condition B
---|---
Class level S | Class level B

- Scratch(es) in the glassivation that disturbs metal and bridges metallization paths.
- Crack(s) (not crazing) in the glassivation that forms a closed loop over adjacent metallization paths.
- Glassivation void(s) that exposes any portion of a thin film resistor or fusible link except where the glassivation is opened by design.
- For GaAs devices, voids in the glassivation that extends over the gate channel of the FET.
- For GaAs devices, scratches in the glassivation over the gate channel of the FET.
- For GaAs devices, scratches in the glassivation over the gate insertion of the FET.
- For GaAs devices, cracks in the glassivation which are more than 1.0 mil inside the scribe line, or are more than 50 percent of the distance between the scribe line and any functional or active element (e.g., capacitor, resistor, FET) and which point toward any functional or active element unless the crack terminates at a device feature (e.g., transmission line or dc line).

3.1.5 Dielectric isolation. No device shall be acceptable that exhibits:

- A discontinuous isolation line (typically a black line) around each diffusion tub containing functional circuit elements (see figure 2010-25).
- Absence of a continuous isolation line between any adjacent tubs, containing functional circuit elements (see figure 2010-25).

FIGURE 2010-25. Dielectric isolation defects.
c. A diffused area which overlaps dielectric isolation material and does not exhibit a line of separation to an adjacent tub, or an overlap of more than one diffusion area into the dielectric isolation material (see figure 2010-25).

d. A contact window that touches or overlaps dielectric material, except by design.

NOTE: Metallization scratch and void defects over a dielectric isolation step shall be rejected in accordance with criteria contained in 3.1.1.1d and 3.1.1.2b.

3.1.6 Film resistor. Rejection shall be based on defects found within the actively used portions of the film resistor. Metallization defect criteria of 3.1.1 shall apply as applicable. No device shall be acceptable that exhibits:
Condition A                    Condition B
Class level S                      Class level B

a. Any misalignment between the conductor/resistor in which the actual width X of the overlap is less than 50 percent of the original resistor width.

b. No visible line of contact overlap between the metallization and film resistor (see figure 2010-28).

FIGURE 2010-27. Film resistor contact area.

FIGURE 2010-28. Film resistor contact area.
Condition A  
Class level S

c. Void or necking down that leaves less than 75 percent of the film resistor width undisturbed at a terminal.
d. Inactive resistor inadvertently connected to two separate points on an active circuit.
e. Separation between any two resistors or a resistor and a metallization path that is less than 0.25 mil, or 50 percent of the design separation, whichever is less.
f. Any thin film resistor that crosses a substrate irregularity (e.g., dielectric isolation line, oxide/diffusion step, etc.) (see figure 2010-26).

NOTE: This criteria does not apply to square isolated islands of single crystal silicon in the polysilicon area.
g. Any resistor width reduced to less than one half the narrowest resistor width, resulting from voids or scratches or a combination thereof (see figure 2010-29).

NOTE: Maximum allowable current density requirements shall not be exceeded.

h. Any sharp change in color of resistor material within 0.1 mil of the resistor/connector termination.

3.1.7 Laser-trimmed thin-film resistors. Rejection shall be based on defects found within the actively used portions of the film resistor. No device shall be acceptable that exhibits:

a. A kerf less than 0.1 mil in width, unless by design.

NOTE: Criteria does not apply for edge trimming.

b. A kerf containing particles of detritus.

FIGURE 2010-29. Scratch and void criteria for untrimmed resistors.
c. A kerf containing untrimmed resistor material, unless that material is continuous across the kerf, and is undisturbed for a width greater than one-half times the narrowest resistor width, unless by design (see figure 2010-30).

NOTE: Maximum allowable current density requirements shall not be exceeded.

Top hat trim

FIGURE 2010-30. Resistor Criteria.
Condition A                    Condition B
Class level S                      Class level B


d. Resistor width that has been reduced by trimming to less than one-half the narrowest resistor width, including voids, scratches, or a combination thereof, in the trim area (see figure 2010-31).

NOTE: Trimming of more than 50 percent of a given resistor shunt link is acceptable by design providing that the last shunt link of the resistor adder network is not trimmed greater than 50 percent. All trimmable resistor shunt links shall be defined on the design layout drawing.
**FIGURE 2010-31. Scratch, void and trim criteria for resistors.**

**METHOD 2010.14**

**TOP HAT TRIM**

- Reject: < 1/2 W
- W = Narrowest Resistor Width

**Serpentine Trim**

- Accept: Void or Scratch < 1/2 W
- Reject: < 1/2 W
- W = Narrowest Resistor Width

**Rectangular L Trim**

- Accept: ≥ 1/2 W
- Reject: < 1/2 W
- W = Narrowest Resistor Width

**Two Resistors in Series with Same Current Flowing Through Both**

- Reject: < 1/2 W
- W = Narrowest Resistor Width
Condition A                    Condition B
Class level S                      Class level B

e. Trim path into the metallization except block resistors.

NOTE: This criteria can be excluded for trim paths into terminator ends of metallization runs. Conductors or resistors may be trimmed open for link trims or by design.

f. Trim for block resistors which extends into the metallization (excluding bonding pads) more than 25 percent of the original metal width (see figure 2010-32).

TRIM INTO METAL

ACCEPT - < 1/4 W

REJECT - > 1/4 W

REJECT - NO LASER TRIM INTO RESISTOR FILM

FIGURE 2010-32. Block resistor criteria.

Pits into the silicon dioxide in the kerf which do not exhibit a line of separation between the pit and the resistor material.
3.2 Low power inspection. Internal visual examination as required in 3.2.1 through 3.2.3 shall be conducted on each microcircuit at low magnification range of 30X to 60X. In addition, the applicable criteria contained in 3.2.4 shall be applicable where beam lead assembly technology is used and 3.2.5 shall be inspected at both high and low power as indicated, high power magnification shall be same as 3.1, subject to conditions in 3b.

3.2.1 Lower power wire bond inspection. This inspection and criteria shall be required inspection for the bond type(s) and location(s) to which they are applicable when viewed from above (see figure 2010-33).

NOTE: The criteria applicable for bonds (called "wedgebonds" or "bonds") in this test method refers to the fully or partially deformed area including the tool impression shown as "L" and "W" in figure. The criteria applicable for "bond tails" (or "tails") in this test method refers to resulting length of bonding wire extending beyond the bond shown as "T" in figure 2010-33. Tail is not part of bond.

FIGURE 2010-33. Bond dimensions.
3.2.1.1 **Gold ball bonds.** No devices shall be acceptable that exhibits:

a. Gold ball bonds on the die or package post wherein 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 wire center exit is not within the boundaries of the unglassivated bonding pad area.

3.2.1.2 **Wedge bonds.** No device shall be acceptable that exhibits:

a. Ultrasonic wedge bonds on the die or package post that are less than 1.2 times or more than 3.0 times the wire diameter in width, or less than 1.5 times or more than 6.0 times the wire diameter in length.

b. Thermosonic wedge bonds on the die or package post that are less than 1.5 times or more than 3.0 times the wire diameter in width or are less than 1.5 times or more than 6.0 times the wire diameter in length.

c. Bond width less than 1.0 times the wire diameter for aluminum wires 2.0 mils or greater in diameter.

d. Wedge bonds where the tool impression does not cover the entire width of the wire.

3.2.1.3 **Tailless bonds (crescent, terminating capillary bond).** No device shall be acceptable that exhibits:

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

b. Tailless bonds where tool impression does not cover the entire width of the wire.
3.2.1.4 **General (gold ball, wedge, and tailless)**. As viewed from above, no device shall be acceptable the exhibits (see figure 2010-16):

a. Bonds on the die where less than 75 percent of the bond is within the unglassivated bonding pad area.

b. Bond tails that do not exhibit a line of separation between the tail and unglassivated mettallization, another wire, wire bond, or wire bond tail, excluding common conductors and pads.

c. Bond tails extending over glassivated mettallization where the glass exhibits evidence of crazing or cracking that extends under the tail, excluding common conductors.

d. Wire bond tails: Tails that exceed 2 wire diameters in length on die or on post.

e. Bonds that are not completely within the boundaries of the package post. For glass sealed packages, bonds not within 20 mils of the end of post.

f. Bonds (excluding bond tails) placed so that the horizontal distance between the bond and glassivated or unglassivated noncommon mettallization, scribe lines, another bonding wire or bond is less than .25 mils.

NOTE: When by design, there are multiple bonds on a common bonding pad or post they may not reduce the width of an adjacent bond by more than 25 percent.

NOTE: For SOS devices, exclude the insulator scribe lines.

g. Bonds (excluding tails) placed such that less than 2.0 mils of bond periphery (on glassivated or unglassivated areas) is exposed to an undisturbed die mettallization connecting path to/from the entering/exiting mettallization stripe (see figure 2010-34).

NOTE 1: When bond tails prevent visibility of the connecting path and the mettallization immediately adjacent to the bond tail is disturbed, the device shall be unacceptable.

NOTE 2: When a fillet area exists, it is to be considered as part of the entering/exiting mettallization stripe.

NOTE 3: This criteria is in addition to the bond placement criteria in 3.2.1.4a.
Condition A  
Class level S

Reject: Bond (excluding tails) placed, such that less than 2.0 mils of bond periphery (on glassivated or unglassivated areas) is exposed by an undisturbed die metallization connecting path to/from the entering/exiting metallization stripe.

Reject: When bond tails prevent visibility of the connecting path to the bond periphery and the metallization immediately adjacent to the bond tail is disturbed.

Accept: Bonds (excluding tails) placed, such that there is 2.0 mils or greater of bond periphery (on glassivated or unglassivated areas) exposed by an undisturbed die metallization connecting path to/from the entering/exiting metallization stripe.

Arrows demonstrate the connecting path to the bond periphery.

FIGURE 2010-34. Bonds at entering/exiting metallization stripe.
Condition A                    Condition B
Class level S                      Class level B

h. Bonds where more than 25 percent of the bond is located on die mounting material.
i. Any evidence of repair of conductors by bridging with additional material.
j. Bonds on foreign material.
k. Intermetallic formation extending radially more than 0.1 mil completely around the periphery of that portion of the gold bond located on metal.

3.2.1.5 Rebonding of monolithic devices. Rebonding of monolithic microcircuits, may be done with the following limitations. No device shall be acceptable that exhibits:

a. Rebond over exposed passivation or over metal which shows evidence of peeling. More than one rebond attempt at any design bond location. Rebonds that touch an area of exposed oxide caused by lifted metal.
b. A bond on top of, or partially on top of, another bond, bond wire tail, or residual segment of wire. Bond along side or partially on top of another bond, bond wire tail or residual segment of wire, when the overlap width is greater than 25 percent.
c. Rebond attempts that exceed 10 percent of the total number of bonds in the microcircuit. (e.g., for a 28 lead wire bonded package there are 56 bonds. A bond of one end of a wire shall count as a single attempt. A replacement of a wire bonded at both ends, counts as two rebond attempts.)

NOTE: For class level B only. Bond-offs required to clear the bonder after an unsuccessful first bond attempt are not considered as rebonds provided they can be identified as bond-offs.
d. Missing or extra wires.

3.2.1.6 Flip chip solder bump die. No solder bumped die shall be acceptable that exhibit any of the following characteristics (see figure 2010-34A):

a. missing solder ball from original design position.
b. Solder ball 20% smaller, or larger than design size (nominal).
c. Solder balls bridging.
d. Any attached or embedded foreign material bridging balls, or redistribution metalization.
e. Misaligned solder ball which exposes the UBM on the contact via.
f. Voids in redistribution metalization greater than 50% of the design width.
g. Any redistribution metalization bridging.
h. Any residual unetched UBM bridging balls or redistribution metalization.
i. Mechanical damage to the ball which reduces the original height or diameter more than 20%.
j. Lifting, or peeling or the RDL or dielectric material.

Note: Minor damage to the solder ball and bump misalignment can be reworked by performing a re-flow/refresh of the solder balls.
Figure 2010.34A – FLIP CHIP VISUAL INSPECTION DIAGRAM

- Void in Redistribution greater than 50% of design width
- Redistribution traces (bridging)
- Attached or embedded foreign material (bridging)
- Bond pad
- Misaligned ball exposing UBM
- Solder ball (bridging)
- Top view
- Contact via or solder bump pad
- Solder ball missing
- Solder ball 20% larger or smaller than the design

MIL-STD-883K
w/CHANGE 3

METHOD 2010.14
3 July 2014
3.2.2 **Internal wires.** During inspection for the requirements of 3.2.2, each device shall be viewed at any angle necessary to determine full compliance to this specification, without damaging the device. No device shall be acceptable that exhibits:

- **Condition A**
  - Class level S

  a. Any wire with a separation of less than two wire diameters to unglassivated operating metal, other bonds, another wire (common wires excluded), other package post, unglassivated die area (except for wires or pads which are at the die or substrate potential), or any portion of the package including the plane of the lid to be attached.

- **Condition B**
  - Class level B

  a. Any wire with a separation of less than one wire diameter to unglassivated operating metal, other bonds, another wire (common wires excluded), other package post, unglassivated die area (except for wires or pads which are at the die or substrate potential), or any conductive portion of the package or the plane of the lid to be attached.

  **NOTE:** For condition A only. Within a 5.0 mil radial distance from the perimeter of the bond on the die the separation shall be 1.0 mil minimum.

  **NOTE:** For condition B only. Within a 10.0 mil radial distance from the perimeter of the bond on the die a line of separation must be visible.

**NOTE:** For SOS devices, exclude the unglassivated insulator areas.

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

- c. Tearing at the junction of the wire and bond.

- d. Any wire making a straight line run from a die bonding pad to a package post that has no arc.
Condition A                     Condition B
Class level S                      Class level B

e. Wire(s) crossing wire(s) when viewed from above, (excluding common conductors) except in multitiered packages, where the crossing occurs within the boundary of the lower wire bond tier(s) being crossed or packages with down bond(s). In these situations, the wires that cross are acceptable if they maintain a minimum clearance of two wire diameters (see figure 2010-35).

NOTE: No bond wire shall cross more than one other bond wire and there shall be no more than 4 crossovers or crossovers involving more than 10 percent of the total number of wires, whichever is greater for any single package cavity.

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

3.2.3 Die mounting.

3.2.3.1 Die mounting eutectic. No device shall be acceptable that exhibits:

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

b. Die mounting material (eutectic wetting) not visible around at least two complete sides or 75 percent of the die perimeter, except for transparent die.

c. Transparent die with less than 50 percent of the area bonded.

d. Flaking of the die mounting material.

e. Balling or buildup of the die mounting material that does not exhibit a minimum of 50 percent peripheral fillet when viewed from above or the accumulation of die mounting material is such that the height of the accumulation is greater than the longest base dimension or the accumulation necks down at any point (see figure 2010-36).
FIGURE 2010-35. Class level S criteria for wire(s) crossing wire(s).
FIGURE 2010-36. Balling of die attach material.
3.2.3.2 **Die mounting noneutectic.** No device shall be acceptable that exhibits:

a. Adhesive material immediately adjacent to the die that extends onto or vertically above the top surface of the die.

b. Adhesive fillet not visible along 75 percent of each side of the die.

c. Any flaking, peeling, or lifting of the adhesive material.

d. Separation, cracks, or fissures greater than or equal to 2 mils in width in the adhesive at the cavity wall or cavity floor.

e. Crazing in the adhesive.

f. Adhesive that bridges package posts or is on the post bond area.

g. Any adhesive material that is connected to the fillet or conductive cavity (e.g. metal package base or metallized floor of ceramic package), and extends up the cavity wall to within 1.0 mil of the package post.

h. Transparent die with less than 50 percent of the area bonded.

3.2.3.3 **Die orientation.** No device shall be acceptable that exhibits:

a. Die not located or oriented in accordance with the applicable assembly drawing.

b. Die that appears to be obviously tilted (i.e., more than 10 degrees) with respect to the package cavity.

3.2.4 **Beam lead construction.**

3.2.4.1 **Bonds.** This inspection criteria shall apply to the completed bond area made, using either direct tool contact or a compliant intermediate layer. No device shall be acceptable that exhibits:

a. Bonds where the tool impression does not completely cross the entire beam width.

b. Bonds on thin film substrate metal where the tool impression increases the beam lead width less than 15 percent (10 percent for compliant bonds) or greater than 75 percent of the undeformed beam width.

c. Bonds where the tool impression length is less than 1.0 mil (see figure 2010-37).

d. Bonding tool impression less than 1.0 mil from the die edge (see figure 2010-37).
e. Effective bonded area less than 50 percent of that which would be possible for an exactly aligned beam (see figure 2010-37).

FIGURE 2010-37. Beam lead bond area and location.
f. Cracks or tears in the effective bonded area of the beam greater than 50 percent of the original beam width.

g. Bonds placed so that the separation between bonds and between bonds and operating metallization not connected to them is less than 0.1 mil.

h. Bonds lifting or peeling.

3.2.4.2 **Beam leads.** No device shall be acceptable that exhibits the following:

a. Voids, nicks, depressions, or scratches that leave less than 50 percent of the beam width undisturbed.

b. Beam separation from the die.

c. Missing or partially fabricated beam leads unless by design.

d. Beam leads that are not bonded.

e. Bonded area closer than 0.1 mil to the edge of the passivation layer.

f. Less than 0.1 mil passivation layer between the die and the beam visible at both edges of the beam (see figure 2010-37 and 2010-38).
FIGURE 2010-38. Beam lead die faults.
Method 2010.14
3 July 2014

3.2.5 Foreign material. Die inspections shall be at high magnification. Package and lid inspections shall be at low magnification. Die criteria may be examined at high magnification prior to die mounting provided they are re-examined at low magnification during preseal inspection. No device shall be acceptable that exhibits:

NOTE: Foreign material may be removed, if possible, by subjecting the device to a nominal gas blow (less than 25 psig). After this gas blow off at inspection, all wire bonded devices shall be inspected/reinspected for possible wire damage. Use of a higher psig value is permitted provided that the manufacturer has characterized the process and has data to assure that no damage is done to the wire bonds. This data shall be available upon request to the preparing or acquiring activities.

a. Foreign particle(s) on the surface of the die that is (are) large enough to bridge the narrowest spacing between unglassivated operating material (e.g., metallization, bare semiconductor material, mounting material, bonding wire, etc.).

b. Foreign particle(s) other than on the surface of the die within the package or on the lid or cap that is (are) large enough to bridge the narrowest spacing between unglassivated operating materials and are not the following: Semiconductor material, glass splatter, gold imperfections in the die attach area, gold eutectic material or package ceramic material.

NOTE: As an alternative to 100 percent visual inspection of lids or caps, the lids or caps may be subjected to a suitable cleaning process and quality verification, approved by the qualifying activity. The lids or caps shall subsequently be held in a controlled environment until capping or preparation for seal.

c. Foreign material attached to or embedded in the die surface that appears to bridge the active circuit elements including metallization unless verified as only attached but not embedded by high power dark field illumination.

d. Liquid droplets, chemical stains, ink, or photoresist on the die surface that appear to bridge any combination of unglassivated metallization or bare semiconductor material areas.

e. A particle of gold eutectic material, package ceramic material or semiconductor material, not attached to the die, large enough to bridge the narrowest spacing between unglassivated operating materials, that does not exhibit a minimum of 50 percent cumulative peripheral fillet or whose height is greater than the longest base dimension.

NOTE 1: This criteria shall not be cause for rejection when the assembly process contains a gas blow (less than 60 psig) after die attach and again (less than 25 psig) after wire bond provided rejectable materials (not attached and large enough to bridge) have been removed from the cavity.

NOTE 2: Gold imperfections in the die attach area that do not interfere with proper die attachment, sealing glass splatter (provided it does not suggest inadequately controlled process and does not interfere with the die attach area) or internal glass run out from frit seal (provided it is confined to package walls and does not interfere with the die attach area) are not rejectable.
3.2.5.1 Foreign material, die coated devices. This inspection and criteria shall be required on all devices that receive a die coat during the assembly process. This inspection will be done after die coat cure. No device shall be acceptable that exhibits:

a. Unattached foreign particles on the surface of the die coat or within the package that is (are) large enough to bridge the narrowest spacing between unglassivated operating material (e.g., metallization, bare semiconductor material, mounting material, bonding wire, etc.). Note: Semiconductor particles shall be considered as foreign material.

b. Partially embedded foreign material with an "unembedded portion" that is large enough to bridge the narrowest spacing between unglassivated operating material (e.g., metallization, bare semiconductor material, mounting material, bonding wire, etc.).

c. Foreign material attached to or embedded in the die coat that appears to bridge unglassivated operating material when viewed from above (e.g., bare semiconductor material, bond pads, bonding wire, mounting material, etc.).

d. Embedded foreign particles that penetrate the entire thickness of the die coating.

3.2.5.1.1 Die coating material. No device shall be accepted that exhibits:

a. Surface scratches that penetrate the die coating and expose underlying glassivated metal.

b. Die coating that is lifted or is peeling from the semiconductor surface.

3.2.6 GaAs backside metallization. GaAs inspection shall be performed with low magnification prior to die mounting. (Verification at high magnification is permitted.) With the approval of the acquiring activity, the manufacturer may substitute a sample inspection plan at the wafer level for 100 percent inspection in dice form. The sample inspection plan shall be documented in the manufacturer's baseline documentation and shall be performed to the requirements of test method 5013. No devices shall be acceptable that exhibit the following.

a. Evidence of metal corrosion, lifting, peeling, blistering.

b. Voids or scratches that expose underlying metal or substrate whose cumulative areas are more than 25 percent of the cell area or device area.

   NOTE: Absence of gold in the die separation area (saw street) of devices with electroplated backside metallization is not a cause for rejection. Small voids at edges due to die separation are acceptable if they comprise less than 10 percent of the backside area.

c. Any voids or scratches in the substrate via metallization that effects more than 25 percent of the metallization or cause unintended isolation of the metallization path.

d. Underetched vias.

e. Overetched vias.

4. SUMMARY. The following details shall be specified in the applicable acquisition document.

a. Test condition (see 3).

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 (see 2).

d. Where applicable, specific magnification (see 3).
1. **PURPOSE.** The purpose of this test is to measure bond strengths, evaluate bond strength distributions, or determine compliance with specified bond strength requirements of the applicable acquisition document. This test may be applied to the wire-to-die bond, wire-to-substrate bond, or the wire-to-package lead bond inside the package of wire-connected microelectronic devices bonded by soldering, thermocompression, ultrasonic, or related techniques. It may also be applied to bonds external to the device such as those from device terminals-to-substrate or wiring board or to internal bonds between die and substrate in non-wire-bonded device configurations such as beam lead or flip chip devices.

2. **APPARATUS.** The apparatus for this test shall consist of suitable equipment for applying the specified stress to the bond, lead wire or terminal as required in the specified test condition. A calibrated measurement and indication of the applied stress in grams force (gf) shall be provided by equipment capable of measuring stresses up to twice the specified minimum limit value, with an accuracy of ±5 percent or ±0.3 gf, whichever is the greater tolerance.

3. **PROCEDURE.** The test shall be conducted using the test condition specified in the applicable acquisition document consistent with the particular device construction. All bond pulls shall be counted and the specified sampling, acceptance, and added sample provisions shall be observed, as applicable. Unless otherwise specified, for conditions A, C, and D, the sample size number specified for the bond strength test shall determine the minimum sample size in terms of the minimum number of bond pulls to be accomplished rather than the number of complete devices in the sample, except that the required number of bond pulls shall be randomly selected from a minimum of 4 devices. Bond pulls in accordance with test conditions D, F, G, and H, while involving two or more bonds shall count as a single pull for bond strength and sample size number purposes. Unless otherwise specified, for conditions F, G, and H the sample size number specified shall determine the number of die to be tested (not bonds). For hybrid or multichip devices (all conditions), a minimum of 4 die or use all die if four are not available on a minimum of 2 completed devices shall be used. Where there is any adhesive, encapsulant or other material under, on or surrounding the die such as to increase the apparent bond strength, the bond strength test shall be performed prior to application. The stress required to achieve bond failure shall be observed and the physical location of the point of failure shall be recorded as being in one of the listed categories (see 3.2.1).

When flip chip or beam-lead chips are bonded to substrates other than those in completed devices, the following conditions shall apply:

a. The sample of chips for this test shall be taken at random from the same chip population as that used in the completed devices that they are intended to represent.

b. The chips for this test shall be bonded on the same bonding apparatus as the completed devices, during the time period within which the completed devices are bonded.

c. The test chip substrates shall be processed, metallized, and handled identically with the completed device substrates, during the same time period within which the completed device substrates are processed.

3.1 **Test conditions:**

3.1.1 **Test condition A - Bond peel.** This test is normally employed for bonds external to the device package. The lead or terminal and the device package shall be gripped or clamped in such a manner that a peeling stress is exerted with the specified angle between the lead or terminal and the board or substrate. Unless otherwise specified, an angle of 90 degrees shall be used. When a failure occurs, the force causing the failure and the failure category shall be recorded.

3.1.2 **Test condition C - Wire pull (single bond).** This test is normally employed for internal bonds at the die or substrate and the lead frame of microelectronic devices. The wire connecting the die or substrate shall be cut so as to provide two ends accessible for pull test. In the case of short wire runs, it may be necessary to cut the wire close to one termination in order to allow pull test at the opposite termination. The wire shall be gripped in a suitable device and simple pulling action applied to the wire or to the device (with the wire clamped) in such a manner that the force is applied approximately normal to the surface of the die or substrate. When a failure occurs, the force causing the failure and the failure category shall be recorded.
3.1.3 Test condition D - Wire pull (double bond). This procedure is identical to that of test condition C, except that the pull is applied by inserting a hook under the lead wire (attached to die, substrate or header or both ends) with the device clamped and hook contacting the wire between midspan and loop apex, without causing adverse wire deformation (for forward wedge and ball bonding, this would be between midspan and the die edge: for reverse bonding, this would be between midspan and the package edge) and the pulling force is applied in a perpendicular direction to the die or substrate surface. See Figure 2011-1. When a failure occurs, the force causing the failure and the failure category shall be recorded. The minimum bond strength shall be taken from table I. Figure 2011-2 may be used for wire diameters not specified in table I. For wire diameter or equivalent cross section >0.005 inch, where a hook will not fit under the wire, a suitable clamp can be used in lieu of a hook.

3.1.4 Test condition F - Bond shear (flip chip). This test is normally employed for internal bonds between a semiconductor die and a substrate to which it is attached in a face-bonded configuration. It may also be used to test the bonds between a substrate and an intermediate carrier or secondary substrate to which the die is mounted. A suitable tool or wedge shall be brought in contact with the die (or carrier) at a point just above the primary substrate and a force applied perpendicular to one edge of the die (or carrier) and parallel to the primary substrate, to cause bond failure by shear. When a failure occurs, the force at the time of failure, and the failure category shall be recorded.

3.1.5 Test condition G – Push-off test (beam lead). This test is normally employed for process control and is used on a sample of semiconductor die bonded to a specially prepared substrate. Therefore, it cannot be used for random sampling of production or inspection lots. A metallized substrate containing a hole shall be employed. The hole appropriately centered, shall be sufficiently large to provide clearance for a push tool, but not large enough to interfere with the bonding areas. The push tool shall be sufficiently large to minimize device cracking during testing, but not large enough to contact the beam leads in the anchor bond area. Proceed with push-off tests as follows: The substrate shall be rigidly held and the push tool inserted through the hole. The contact of the push tool to the silicon device shall be made without appreciable impact (less than 0.01 inch/minute (0.254 mm/minute ) and forced against the underside of the bonded device at a constant rate. When failure occurs, the force at the time of failure, and the failure category shall be recorded.

3.1.6 Test condition H – Pull-off test (beam lead). This test is normally employed on a sample basis on beam lead devices which have been bonded down on a ceramic or other suitable substrate. The calibrated pull-off apparatus (see 2) shall include a pull-off rod (for instance, a current loop of nichrome or Kovar wire) to make connection with a hard setting adhesive material (for instance, heat sensitive polyvinyl acetate resin glue) on the back (top side) of the beam lead die. The substrate shall be rigidly installed in the pull-off fixture and the pull-off rod shall make firm mechanical connection to the adhesive material. The device shall be pulled within 5 degrees of the normal to at least the calculated force (see 3.2), or until the die is at 2.54 mm (0.10 inch) above the substrate. When a failure occurs, the force at the time of failure, the calculated force limit, and the failure category shall be recorded.

3.1.7 Wire Ball Bond Shear. Procedure in accordance with JEDEC JESD22-B116 Wire Bond Shear Test Method.

3.2 Failure criteria. Any bond pull which results in separation under an applied stress less than that indicated in table I as the required minimum bond strength for the indicated test condition, composition, and construction shall constitute a failure.

3.2.1 Failure category. Failure categories are as follows: When specified, the stress required to achieve separation and the category of separation or failure shall be recorded.

a. For internal wire bonds:

*  
(a-0) Wire broken or missing prior to test.
(a-1) Wire break at neckdown point (reduction of cross section due to bonding process).
(a-2) Wire break at point other than neckdown.
(a-3) Failure in bond (interface between wire and metallization) at die.
(a-4) Failure in bond (interface between wire and metallization) at substrate, package post, or other than die.
(a-5) Lifted metallization from die.
(a-6) Lifted metallization from substrate or package post.
(a-7) Fracture of die.
(a-8) Fracture of substrate.
(a-9) Break in wire at neckdown on the substrate or package post.

* b. For external bonds connecting device to wiring board or substrate:
   (b-1) Lead or terminal break at deformation point (weld affected region).
   (b-2) Lead or terminal break at point not affected by bonding process.
   (b-3) Failure in bond interface (in solder or at point of weld interface between lead or terminal and the board or substrate conductor to which the bond was made).
   (b-4) Conductor lifted from board or substrate.
   (b-5) Fracture within board or substrate.

c. For flip-chip configurations:
   (c-1) Failure in the bond material or pedestal, if applicable.
   (c-2) Fracture of die (or carrier) or substrate (removal of portion of die or substrate immediately under the bond).
   (c-3) Lifted metallization (separation of metallization or bonding pedestal from die (or carrier) or substrate.

d. For beam lead devices:
   (d-1) Silicon broken.
   (d-2) Beam lifting on silicon.
   (d-3) Beam broken at bond.
   (d-4) Beam broken at edge of silicon.
   (d-5) Beam broken between bond and edge of silicon.
   (d-6) Bond lifted.
   (d-7) Lifted metallization (separation of metallization) from die, separation of bonding pad.
   (d-8) Lifted metallization.

NOTE: RF/microwave hybrids that require extremely flat loops which may cause erroneous wire pull data may use the following formula to determine the proper wire pull value.

\[ V_1 = V_2 \sin \theta \]

Where:
- \( V_1 \) = New value to pull test.
- \( V_2 \) = Table I value for size wire tested.
- \( \theta \) = Greatest calculated wire loop angle (Figure 2011-3).

Also, RF/microwave hybrids that contain wires that cannot be accessed with a pull hook must be duplicated on a test coupon in such a way to allow hook access for purposes of pull testing. These wires are to be bonded at the same time the production hybrids are bonded using the same setup, operator, and schedule. The test coupon wires are to be pull tested in lieu of the tuning or inaccessible wires on the production hybrid. Failures on the test coupon shall be considered as failures to production units and appropriate action is to be taken in accordance with the applicable specification (Figure 2011-4).
**TABLE I. Minimum bond strength.**

<table>
<thead>
<tr>
<th>Test condition</th>
<th>Wire composition and diameter 1/</th>
<th>Construction 2/</th>
<th>Minimum bond strength (grams force)</th>
<th>Pre seal</th>
<th>Post seal and any other processing and screening when applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>---</td>
<td>---</td>
<td>Given in applicable document</td>
<td>Given in applicable document</td>
<td></td>
</tr>
<tr>
<td>C or D</td>
<td>AL 0.0007 in AU 0.0007 in</td>
<td>Wire</td>
<td>1.5</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.0</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>C or D</td>
<td>AL 0.0010 in AU 0.0010 in</td>
<td>Wire</td>
<td>2.5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.0</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>C or D</td>
<td>AL 0.00125 in AU 0.00125 in</td>
<td>Wire</td>
<td>Same bond strength limits as the 0.0013 in wire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C or D</td>
<td>AL 0.0013 in AU 0.0013 in</td>
<td>Wire</td>
<td>3.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.0</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>C or D</td>
<td>AL 0.0015 in AU 0.0015 in</td>
<td>Wire</td>
<td>4.0</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.0</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>C or D</td>
<td>AL 0.0030 in AU 0.0030 in</td>
<td>Wire</td>
<td>12.0</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15.0</td>
<td>12.0</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Any</td>
<td>Flip-clip</td>
<td>5 grams-force x number of bonds (bumps)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G or H</td>
<td>Any</td>
<td>Beam lead</td>
<td>30 grams force in accordance with linear millimeter of nominal undeformed (before bonding) beam width. 3/</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1/ For wire diameters not specified, use the curve of figure 2011-2 to determine the bond pull limit.
2/ For ribbon wire, use the equivalent round wire diameter which gives the same cross-sectional area as the ribbon wire being tested.
3/ For condition G or H, the bond strength shall be determined by dividing the breaking force by the total of the nominal beam widths before bonding.

4. **SUMMARY.** The following details shall be specified in the applicable acquisition document:
   a. Test condition letter (see 3).
   b. Minimum bond strength if other than specified in 3.2 or details of required strength distributions if applicable.
   c. Sample size number and accept number or number and selection of bond pulls to be tested on each device, and number of devices, if other than 4.
   d. For test condition A, angle of bond peel if other than 90°, and bond strength limit (see 3.2).
   e. Requirement for reporting of separation forces and failure categories, when applicable (see 3.2.1).
Figure 2011-1. Bond pull hook placement location.
NOTE: The minimum bond strength should be taken from table I. Figure 2011-2 may be used for wire diameters not specified in table I.


FIGURE 2011-4. Flat loop wire pull testing.
1. **PURPOSE.** The purpose of this examination is to nondestructively detect defects within the sealed case, especially those resulting from the sealing process, 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. It establishes methods, criteria, and standards for radiographic examination of semiconductor and hybrid devices.

**NOTE:** For certain device types, opacity of the construction materials (packages or internal attachment) 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 device when application of this test method is specified.

1.1 **Definitions.** A more complete listing of definitions related to radiography can be found in ASTM E 1316.

1.1.1 **Device Under Test (DUT).** The microelectronic device (monolithic or hybrid) that is the subject of the radiographic examination.

1.1.2 **Digital radiography.** For purposes of this test method, digital radiography is defined as a radiographic examination using x-ray as the source whereby the image is translated into digital data that is passed through an information processing algorithm to be transferred to a viewing media such as a display or monitor. It differs from film radiography, which is a direct transfer of the image onto film.

1.1.3 **DUT lot.** Multiple devices, all of the same type, that have been manufactured in a single production run and sequentially being tested as a group.

1.1.4 **Dynamic Radiography.** The acquisition of images in a continuous, full volumetric fashion where the DUT is placed in motion by a manipulation system to view multiple areas, axes and depths. (This is also referred to as real-time radiography.) Dynamic radiography generally results in a higher radiation dose to the DUT than static radiography due to longer exposure times.

1.1.5 **Image Quality Indicator (IQI).** A device manufactured with known conditions to be used to judge image quality. IQI’s shall conform to ASTM E 801. An IQI is a standard used for the purpose of qualifying/calibrating the apparatus. An IQI has built-in physical properties that can be used to adjust system parameters for best imaging results.

1.1.6 **Qualified Test Personnel.** An individual trained on the apparatus being used for radiography, and who is qualified to image or inspect. Personnel involved in acquisition or interpretation of radiographic images shall have training in radiographic imaging procedures and techniques so that defects revealed by this method can be validly interpreted and compared with applicable standards. Training shall be specific to the radiographic system (film or digital) as well as DUT design and failure criteria. The company employing the test personnel shall have a documented training program and will qualify test personnel internally.

1.1.7 **Radiation Parameters.** The radiation source related variables that can affect the examination outcome for the selected system configuration. Examples are source energy, collimation and intensity, focal spot size, filter in the X-ray beam, range of source to object distance, range of object to detector distance, and source to detector distance.

1.1.8 **Real Time Radiography.** See 1.1.4, Dynamic Radiography.

1.1.9 **Representative Quality Indicator (RQI).** Similar to an IQI, an RQI is a device manufactured with known conditions to be used as a representative object for the DUT. RQI’s shall conform to ASTM E 1817. An RQI is a device manufactured for the purpose of qualifying/calibrating the apparatus. An RQI has built-in physical properties that can be used to adjust system parameters for best imaging results.

1.1.10 **Static Radiography.** The acquisition of images where the DUT is at rest, or fixed in location, resulting in a single distinct image about a predetermined area, axis, and depth.

1.1.11 **System Performance Quality Parameters.** The features of a radiographic image that determine its usefulness in detecting defects. These features include unsharpness, contrast, noise, signal and bad pixels.
1.1.12 **Computed Radiography (CR).** A two-step radiological imaging process; first, a storage phosphor imaging plate is exposed to penetrating radiation; second, the luminescence from the plate’s photo stimulate-able luminescent phosphor is detected, digitized, and presented via an image display monitor. CR is a film replacement technology. Computed Radiography is not recommended for this method due to inherent artifacts present in the imaging plates that will appear as extraneous matter in the DUT.

1.1.13 **Computed Tomography (CT).** A radiological imaging process that provides an image of a selected plane in an object to the relative exclusion of structures that lies outside the plane of interest. CT is used to generate a three-dimensional image of an object from a large series of two-dimensional radiographic images taken around a single axis of rotation.

1.1.14 **Lp/mm.** Abbreviation for line pairs per millimeter

2. **APPARATUS.**

2.1 **Apparatus – Film Based Radiography.** The apparatus and material for this test shall include:

2.1.1 **Radiographic x-ray source.** A radiographic x-ray source with a sufficient voltage range to meet contrast requirements for the inspection of the DUT as defined in paragraph 3.4.1, when used in conjunction with the film required in

2.1.2 The focal distance shall be adequate to resolve a separation of 0.0508 mm (0.002 inch) between two solid objects. A line pair gauge with 20 line pairs per millimeter can be used to verify this resolution.

2.1.2 **Radiographic viewer.** Film systems meeting Class 1, film type B (or better) requirements of Radiographic viewer. The film viewer used shall have the following minimum capability:

a. Luminance - Film viewer shall have a minimum transmitted light (luminance) of 10000 cd/m² for film densities of 2.5 optical density or less.

   NOTE: Film viewers may be tested for luminance using Figure 1 of ASTM E 1742.

b. The viewer shall be located in an area with subdued background lighting, which does not result in glare on the viewing screen. Background ambient light levels shall not exceed 3 foot candles (illuminance) at the surface of the film viewer.

c. Color of light used to illuminate the radiograph shall be white, color temperature of 5000-6250K.

2.1.3 **Light Meter.**

a. Luminance. Calibrated light meters used to test film viewer transmitted light shall measure luminance in candelas per meters squared (cd/m²).

b. Illuminance. Calibrated light meters used to test ambient background light shall measure illuminance in foot candles.

2.1.4 **Magnifiers.** 10X to 40X.

2.1.5 **Holding fixtures.** Holding fixtures may be used if they are capable of holding devices in the required positions without interfering with the accuracy or ease of image interpretation.

2.1.6 **Film holder.** A 1.6 mm (0.0625 inch) minimum lead-topped table or lead-backed film holders to prevent back scatter of radiation.

2.1.7 **Electrostatic Discharge (ESD).** The system and any holding fixtures used shall be ESD safe and used in compliance with applicable ESD protocol. (Note: Film can be placed in an ESD bag to maintain path to ground.)

2.1.8 **Radiographic standards.**

METHOD 2012.11

3 May 2018

2
2.1.9 Quality Indicators. Image Quality Indicators (IQI) or Representative Quality Indicators (RQI) meeting the requirements of ASTM E 801 or ASTM E 1817 are required.

2.1.10 Filters. Filters may be used to harden the x-ray beam to reduce radiation dose. ASTM E 1161 may be consulted for further guidance on filter selection.

2.2 Apparatus – Digital Radiography. The apparatus and material for this test shall include:

2.2.1 Radiographic equipment. The equipment used in this examination will have sufficient voltage, focal spot, and resolution to provide an image of the DUT in accordance with paragraph 3.4.1.

NOTE: Computed radiography is not an acceptable radiographic method for electronic components.

2.2.2 Radiographic parameters. Radiographic parameters of the digital x-ray apparatus shall provide appropriate image quality such that all defects specified in paragraphs 3.10 and 3.11 for particular package types are readily apparent.

2.2.3 Radiographic display monitor. An image display monitor that has the following capability shall be used.

   a. Brightness: The minimum brightness at maximum Digital Driving Level (DDL) shall be 170 cd/m² (luminance),

   b. Contrast: The minimum contrast as determined by the ratio of the screen brightness at the maximum DDL compared to the screen brightness at the minimum DDL shall be 250:1,

   c. High Contrast Resolution: The image display monitor shall be capable of displaying linear patterns of alternating pixels at full contrast (0% and 100% DDL) in both the horizontal and vertical directions without aliasing at the display center and each of the four corners,

   d. Low Contrast Resolution: The image display monitor shall be capable of discriminating the horizontal and vertical low contrast 1% modulation patterns (50% and 51% DDL) at the display center and each of the four corners.

   e. Flicker and Distortion: The image display monitor shall be free of screen flicker or discernible geometric distortion.

   f. Small Contrast Change: The image display monitor shall be capable of displaying a 5% DDL block against a 0% DDL background while simultaneously displaying a 95% DDL block against a 100% background in a manner clearly perceptible to the user.

2.2.3.1 Image Display Monitor Test Pattern. A test pattern shall be used for verifying that the image display monitor meets the requirements of 2.2.3. The test pattern shall automatically adjust to the image display monitor’s resolution and aspect ratio. Alternatively, an image file (lossless file type) may be used. When an image file is used to confirm 2.2.3 c & d, it shall be displayed at 1:1 (100%). If the image as displayed at 1:1 is smaller than the display monitor, the image shall be moved around the monitor display area to meet the location requirements of 2.2.3 c & d. The SMPTE RP 133 test pattern meets the requirements for this verification.

2.2.3.2 Image viewing area. The image viewing area shall be an area with subdued background lighting and shall be arranged to preclude reflective glare from the surface of the image display monitor. Subdued lighting, rather than total darkness, is required in the image viewing room.

   a. Background Ambient Light Level. Background ambient light levels shall not exceed 3 foot candles (illuminance) at the image display monitor used for image analysis and final disposition. Ambient light levels shall be measured at the surface of the image display monitor with the monitor off.

2.2.4 Light Meter.

   a. Luminance. Calibrated light meters used to test image display monitors for brightness and contrast shall measure luminance in candelas per meters squared (cd/m²).

   b. Illuminance. Calibrated light meters used to test ambient background light shall measure illuminance in foot candles.
2.2.5 **Holding fixtures.** Holding fixtures may be used if they are capable of holding devices in the required positions without interfering with the accuracy or ease of image interpretation.

2.2.6 **Electrostatic Discharge (ESD).** The system and any holding fixtures used shall be ESD safe and used in compliance with applicable ESD protocol.

2.2.7 **Quality Indicators.** Image Quality Indicators (IQI) or Representative Quality Indicators (RQI) meeting the requirements of ASTM E 801 or ASTM E 1817.

2.2.8 **Line Pair Gauge.** A Line Pair Gauge with a minimum line pair spacing of 20 line pairs per mm shall be used to judge the quality of the system output.

2.2.9 **Filters.** Filters may be used to harden the x-ray beam to reduce radiation dose. ASTM E 1161 may be consulted for further guidance on filter selection.

3. **PROCEDURE.** The X-ray exposure factors; voltage, current, exposure time and magnification 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.

NOTE: For certain device types, opacity of the construction materials (packages or internal attachment) may effectively prevent radiographic identification of certain types of defects from some or all possible viewing angles. If the best attempt to obtain a clear image results in the inability of the radiographer to clearly see some or all of the reject-able criteria, this shall be noted as an exception on the inspection report and certificate of compliance.

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 may be employed to isolate multiple specimens provided the fixtures or masking material do not block the view from X-ray source to the film or detector of any portion of the body of the device.

3.1.1 **Views.** When the required view(s) show internal feature(s) that require a different viewing axis for verification and disposition of a failure mode specified in this test method, then additional views (either Z or X direction) shall be taken as record of the disposition.

3.1.1.1 **Flat packages, dual-in-line packages, hybrid packages, and single ended cylindrical devices.** Flat packages, dual-in-line packages, hybrid packages, and single ended cylindrical devices, unless otherwise specified, shall have one view taken with the X-rays penetrating in the Y direction as defined on figures 1 and 2 of MIL-STD-883, GENERAL REQUIREMENTS. The die/cavity interface shall be positioned in such a manner relative to the film or detector to avoid image distortion.

3.1.1.2 **Stud-mounted and cylindrical axial lead devices.** Stud-mounted and cylindrical axial lead devices, unless otherwise specified, shall have one view taken with the X-rays penetrating in the X direction as defined in figures 1 and 2 of MIL-STD-883, GENERAL REQUIREMENTS. The die/cavity interface shall be positioned in such a manner relative to the film or detector to avoid image distortion.

3.1.1.3 **Additional views.** When required, additional views may be used to resolve internal features.

3.2 **Image Quality Indicators.** Image Quality Indicators in accordance with ASTM E 801 shall be used. As an alternative, Representative Quality Indicators in accordance with ASTM E 1817 may be used.

3.2.1 **Film.** IQIs or RQIs bracketing the film density of the area of interest, and prescribed in the DUT Specific Technique (see 3.4.1), shall be positioned at the outer edges of the film, in opposite corners, and shall not block the view from X-ray source to the film of any portion of the body of the device.

3.2.2 **Digital.** Prior to performing imaging on a DUT Lot, the radiographic examination system shall be sampled using the IQIs or RQIs prescribed in the DUT Specific Technique (see 3.4.1). These images collected prior to the DUT Lot imaging shall be saved for comparison with images of the same IQIs or RQIs taken following the DUT Lot imaging. Grayscale values of the IQI/RQI images collected post-DUT Lot imaging shall be within ±15% of the grayscale values of the reference image.
collected prior to DUT Lot imaging and all features of interest in the IQI or RQI shall be visible in the images collected before and after DUT Lot imaging. If the IQI/RQI images collected before and after DUT Lot imaging do not meet these requirements, it shall be presumed that the radiographic examination system conditions have been altered from the pre-DUT Lot imaging set up and the DUT Lot imaging shall be performed again after proper adjustments are made.

3.2.2.1  DPA/FA IQI/RQI Samples. Post inspection images of IQI or RQI is not required, however, when the imaging equipment is shut down for any reason (e.g., end of shift), additional IQI or RQI images shall be captured prior to continuing inspections.

3.3  Radiographs and marking.

3.3.1  Radiographs/Radiographic Images. Procedures and techniques developed from the DUT specific technique (see 3.4.1) shall be used for radiographic exposure/imaging.

3.3.1.1  Film. The radiographic film shall be in a film holder backed with a minimum of 1/16 inch lead or the holder shall be placed on the lead topped table. The film shall be identified using techniques that print the following information, either photographically, or created as an image using lead numbers or other means on the radiograph:

a. Device manufacturer's name or code identification number.
b. Device type or Part or Identifying Number.
c. Production lot number or date code or inspection lot number.
d. Radiographic film view number.
e. Date.
f. Device serial or cross reference numbers, when applicable.
g. X-ray laboratory identification, if other than device manufacturer

3.3.1.2  Digital. Images shall be acquired using static radiography, unless dynamic (real-time) radiography is specified in the contract. Images shall be maintained and stored for archive in an electronic data file format that does not reduce the resolution or bit depth of the original image (loss-less file type). The following information shall be permanently associated with the archived image file. This may be achieved by annotating the image with the information, by including all information in the file name, or by including a reference text file with image file correlation.

a. Device manufacturer's name or code identification number.
b. Device type or Part or Identifying Number.
c. Production lot number or date code or inspection lot number.
d. Radiographic view (axis).
e. Date.
f. Device serial or cross reference numbers, when applicable.
g. X-ray laboratory identification, if other than device manufacturer

3.3.2  Serialized devices. When device serialization is required, each device shall be readily identified by a serial number. When multiple devices are radiographed in a single image, they shall be arranged in consecutive, increasing serial order. When a device is missing, the blank space shall contain either the serial number or other X-ray opaque object to readily identify and correlate X-ray data. When large skips occur within serialized devices, the serial number of the last device before the skip and the first device after the skip may 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 1.6 mm (0.0625 inch) 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 **Test Plans.** A technique for each DUT lot will be generated to ensure repeatability of the examination.

3.4.1 **DUT Specific Technique.** The DUT specific technique shall be generated to address the unique qualities for that device type, and how that device type is subjected to the radiographic examination, including all information needed to perform a repeatable examination. The DUT Specific Technique shall reference internal operating procedures, if applicable, and acceptance criteria used in the inspection. The plan shall include:

- The specific device or devices to be examined by manufacturer and part number,
- Radiographic system (apparatus) used and support equipment, such as the IQIs/RQIs used to bracket the DUT.
- DUT views (axes). When necessary a drawing, sketch or photograph of the DUT showing the radiation beam axis position(s) of the detector for each and all variations of the DUT orientation and x-ray beam angle.

3.4.1.1 **Test Parameters.** For each view, the following parameters shall be defined: kV, Current/Power, the IQI(s) selected representing the grayscale value of the area(s) interest of the DUT or the RQI associated with the DUT. For film radiography, set up geometry and exposure time shall be recorded. For digital radiography, parameters can vary with the selected test equipment. The tester shall define those parameters for the particular test set being used. Examples of required parameters include focal spot size, frame averaging, s, set up geometry and geometric magnification, detector settings (e.g., frames per second, gain, binning, etc.) and image evaluation settings (e.g., digital zoom, window width/level, image enhancement, etc.), as applicable to the selected apparatus. Radiographs/radiographic images shall be made for each view required (see 3.1.1).

- **Film.** The DUT Specific Technique shall define test parameters such that the resulting radiographs achieve resolution sufficient to resolve a wire 0.0254 mm (0.001 inch) in diameter, a bead 0.0508 mm (0.002 inch) in diameter, exhibit less than 10 percent distortion and an "H" and "D" film density between 1.0 and 2.5 in the area of interest of the device image and the IQI.

- **Digital.** The X-ray exposure factors and image file resolution shall be selected to resolve a wire 0.0254 mm (0.001 inch) in diameter, a bead 0.0508 mm (0.002 inch) in diameter, a separation of 0.0508 mm (0.002 inch) between two solid objects and shall result in an image with a minimum pixel value of 15% of the bit depth range and maximum pixel value of 90% of the saturation limit of the detector. The flow chart presented in Figure 2012-1 provides a suggested method of determining appropriate test parameter selection. One image shall be taken of the overall component. If that image meets the resolution requirements, no further images are required. If that image does not meet the resolution requirements, additional images of higher geometric magnification shall be collected, providing full coverage of the device area (i.e., overlapping views), at the lowest geometric magnification which meets the resolution requirements, unless otherwise specified.

**NOTE:** For both film and digital radiography, multiple exposure factors and test parameter settings may be required to be able to fully inspect the DUT.
3.4.1.2 Further required details. When applicable, the following items are part of the DUT Specific Test Plan.

a. **Film specific requirements.** Part masking; added radiation source collimation; allowable range of radiation energy and x-ray beam current, and the focal spot size for each view; beam filtration; examination geometry and coverage of each view; all system settings that can be changed by the operator to affect the outcome of the radiographic examination such as film processing variables.

b. **Digital specific requirements.** Classification of the DUT into zones for radiographic examination, detector field of view; all system and software settings that can be changed by the operator to affect the outcome of the radiographic examination such as display settings and image processor variables; and the recording media and image file format.

3.4.2 ESD Precautions. ESD precautions shall be maintained at all times during handling and inspection, as appropriate for the ESD sensitivity of the DUT.
3.4.3 Radiation Dose Control. Semiconductor materials may be sensitive to radiation. Precautions should always be taken to minimize radiation dose; however, precautions shall always be taken to minimize dose when devices are designated as radiation sensitive. Precautions may include, but are not limited to, minimizing exposure time, maximizing distance from the x-ray source, employing filtering or shielding and minimizing the number of devices placed in the cabinet during exposure. When dose characterization of the equipment is to be performed, it should mimic all conditions the DUT will be subjected to, including any shielding techniques employed for reducing secondary exposure. Secondary radiation dose to devices outside or adjacent to the DUT must be recognized and considered when calculating total dose during x-ray equipment characterization. ASTM E 1161 may be consulted for processing techniques.

3.5 Film Processing and Image Processing/Enhancement.

3.5.1 Film 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, etc.

3.5.2 Digital Image Evaluation. Image evaluation adjustments for image zoom, window width and level settings (contrast and brightness) and any image processing/enhancement shall be performed in a manner consistent with the DUT Specific Technique and shall not reduce the ability to identify required features in the image of the DUT and IQIs/RQIs.

   a. Window Width (Contrast) and Level (Brightness). The initial image evaluation window width and level settings shall be documented in the DUT specific technique, either with quantitative values or by defined viewing presets. This includes any multiple window width and level values or viewing presets required due to changes in the DUT thickness or material.

   b. Image processing (i.e., enhancement filters). Image processing used for final product acceptance shall be verified by adequately displaying the pertinent features of the DUT and IQI/RQI and shall be documented on the approved DUT specific radiographic examination technique.

      Since some image processing filters can increase image noise and/or generate artifacts, the image interpreter may remove the filter for the purpose of evaluating whether an indication is false, relevant or non-relevant, however, initial image review shall be performed with the filter applied when required by the DUT specific technique.

   c. Digital Magnification (Image Zoom). Digital magnification shall be based on the minimum size of the feature of interest, and the size and resolution of the image display monitor. Images shall not be inspected at less than 100% display size, as reduction of image size below 100% results in loss of displayed data due to pixilation. For the purpose of making measurements or a correct disposition, the image may be digitally magnified beyond that specified in the DUT specific technique.

3.6 Qualified Personnel. The radiographic examination shall be performed only by Qualified Test Personnel as defined in paragraph 1.2.f, following the test procedures provided in the DUT Specific Technique; or performed by someone who is both under the control and supervision of Qualified Test Personnel and is trained on the apparatus being used. The following minimum vision requirements shall apply for personnel evaluating radiographic images:

   a. Distant vision shall equal at least 20/30 Snellen in at least one eye, corrected or uncorrected.

   b. Near vision shall equal at least 20/25 Snellen at 16 inches (±1 inch) in at least one eye, corrected or uncorrected or such that the operator can read Jaeger No. 1 at a distance of not less than 12 inches in at least one eye.

   c. Vision tests shall be performed by an oculist, optometrist, or other professionally recognized personnel at least once a year. Personnel authorized to conduct radiographic tests shall be required to pass the vision tests specified in 3.6 a and b.

3.7 Safety. The premises and equipment shall present no hazards to the safety of personnel or property. NCRP 49, NCRP 116 and NCRP 151 may be used as guides to ensure that radiographic procedures are performed so that personnel shall not receive a radiation dosage exceeding the maximum permitted by city, state, or national codes.
3.8 Interpretation of radiographs/radiographic images. Utilizing the equipment specified herein, radiographs shall be inspected to determine that each device conforms to this standard and defective devices shall be rejected.

3.8.1 Film. 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. Inspection shall be performed at a magnification between 10X and 40X.

3.8.2 Digital. Geometric magnification for image collection shall be determined as specified in 3.4.1.1.b. Magnification at the time of inspection is dependent on the spatial resolution of the detector. Inspection magnification may be achieved through a combination of geometric magnification and increasing image display size, until image pixilation occurs or IQI/line pair resolution is lost. Images shall not be inspected at less than 100% display size, as reduction of image size below 100% results in loss of displayed data due to pixilation. All images shall contain a feature of known dimension, from which displayed magnification can be calculated; examples include gold bond wires, the overall package (if dimensions are recorded) or marker bars inserted using calibrated imaging software.

3.9 Reports of records.

3.9.1 Reports of inspection. For class S 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 and which devices utilize the note in 3.10.2.1. For each rejected device, the PIN, the serial number, when applicable, and the cause for rejection shall be listed.

3.9.2 Radiograph submission.

3.9.2.1 Film. Photographic reproduction of complete radiographs may be submitted as long as image quality is not reduced from the original radiograph, but artistic renditions are not acceptable.

3.9.2.2 Digital. An archive of data from each radiographic examination shall be kept and stored in a proper repository for the period specified. The archive shall include the DUT Specific Technique, a complete set of radiographic images of the DUT and IQI/RQIs, and the signed examination reports and/or tabulated results. Data file format is to follow the guidance of 3.3.1.2. It is the responsibility of the radiography service provider to ensure that adequate controls are in place to maintain the fidelity of identifying information and of the original images.

3.9.3 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.

3.10 Examination and acceptance criteria for monolithic devices.

3.10.1 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.

3.10.2 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, bond of lead or whisker to semiconductor element and lead or whisker to terminal post, semiconductor metallization pattern, and mounting of semiconductor element. Any device for which the radiograph reveals any of the following defects shall be rejected:

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

- Any foreign particle, lose or attached, greater than 0.025 mm (0.001 inch) (see figure 2012-2), or of any lesser size which is sufficient to bridge non-connected conducting elements of the semiconductor device.
- Any wire tail extending beyond its normal end by more than two wire diameters at the semiconductor die pad or by more than four wire diameters at the semiconductor package post (see figure 2012-2).
- Any burr on a post (header lead) greater than 0.08 mm (0.003 inch) in its major dimension or of such configuration that it may break away.
d. Excessive semiconductor element bonding material build-up:

(1) A semiconductor element shall be mounted and bonded so that it is not tilted more than 10° from the normal mounting surface. The bonding agent that accumulates around the perimeter of the semiconductor element whether or not it touches the side of the semiconductor element shall not accumulate to a thickness greater than the height of the semiconductor element (see figures 2012-3 and 2012-4), or any lead or post, or be separated from the main bonding material area (see figure 2012-10).
FIGURE 2012-4. Extraneous bonding material build-up.

DETAIL A

HEIGHT BUILDUP \leq 1X SEMICONDUCTOR ELEMENT HEIGHT

UNACCEPTABLE PEDESTAL (EXHIBITS NECK DOWN AND HAS HEIGHT GREATER THAN WIDTH)

ACCEPTABLE (WIDTH IS GREATER THAN HEIGHT AND BUILDUP DOES NOT NECK DOWN)

UNACCEPTABLE (EXHIBITS HEIGHT GREATER THAN WIDTH)

HEIGHT BUILDUP > 1X SEMICONDUCTOR ELEMENT HEIGHT IS UNACCEPTABLE

NOTE: DIE AND WIRE ARE NOT NECESSARILY VISIBLE.
(2) There shall be no visible extraneous material 0.025 mm (0.001 inch) or larger in the major dimension inside the semiconductor device. Loose bonding material will be considered extraneous material. Excessive (but not loose) bonding material will not be considered extraneous unless it fails to meet the requirements of 3.10.2.1.d.(1) or unless the accumulation of bonding material is such that the height of the accumulation is greater than the width of its base or that the accumulation necks down at any point (see figures 2012-3 and 2012-4).

NOTE: Devices with suspect foreign particles or extraneous material (in accordance with 3.10.2.1a and 3.10.2.1d(2) may be verified as acceptable provided the following conditions are met:

i. A visual inspection of the die attach area at 30X to 60X shall have been conducted prior to die attach sufficient to assure there are no anomalies in the die attach area which could interfere with effective die attach.

ii. The precap inspection shall have been conducted 100 percent to condition A of method 2010 of MIL-STD-883 and the devices shall have been inspected and prepared for sealing in a class 100 environment.

iii. All devices with X-ray defects to other criteria of 3.10 shall have been removed from the lot.

iv. Serialized devices with less than 5 suspect foreign particles and extraneous material shall be vibrated and shocked in accordance with PIND method 2020, condition A with the detector off.

v. A second X-ray examination of the failed view of the serialized devices after the PIND vibration/shock shall be conducted and each individual device shall be compared to its previous X-ray record.

vi. Any evidence of the suspect particle(s) having moved or having disappeared from their original location shall cause the device to be rejected. If the particle(s) exhibit no evidence of movement, the device may be accepted.

vii. The manufacturer doing the reinspection for suspect foreign particles or extraneous material shall implement a process monitor visual inspection of the cavity of the reinspected devices to assure that accepted devices do not have actual rejectable foreign particles or extraneous material (see 3.2.3.1a, 3.2.3.1d, and 3.2.3.1e, 3.2.3.2a, 3.2.3.2c, 3.2.3.2f, 3.2.3.2g, 3.2.3.2h, and 3.2.5 of method 2010). If any reinspected device fails the process monitor visual inspection, then all reinspected devices in the lot that have been inspected are subject to disposition. Corrective action, when appropriate, must be instituted. A procedure is required for the traceability, recovery, and disposition of all reinspected units accepted since the last successful monitor. The records for this monitor shall include identification of all lots which are reinspected to this note, identification of those lots which are monitored by this visual inspection, sample size, frequency of sampling, results of the visual inspections, and the package types reinspected.

viii. In the case of a failed monitor, the records must identify all lots affected, their final disposition and a rationale for their disposition. Additionally, for a failed monitor, the records must also contain a description of any instituted corrective action together with its rationale. Records of this type shall be made available to the qualifying activity upon request.

e. Gold 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.
3.10.2.2 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. 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 2012-5).

1. Contact area voids in excess of one-half of the total contact area.

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

b. Wires present, other than those connecting specific areas of the semiconductor element to the external leads. Device designs calling for the use of such wires including jumper wires necessary to trim load resistors are acceptable (see figure 2012-2).

c. Cracks, splits, or chips of the electrical elements.

d. Excessive undercutting of the electrical elements (X and Z plane only, see figure 2012-6).
e. 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. Width reduction to less than 75% may be the result of either a single void or a combination of voids in the same width area (see figure 2012-7). 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 (i.e., where the base support least dimension is smaller than the dimension it is supposed to support).

f. Inadequate clearance: Acceptable devices shall have adequate internal clearance to assure that the elements cannot contact one another or the case. No crossover shall be allowed except as permitted by 3.2.2e of method 2010 (condition A). Depending upon the case type, devices shall be rejected for the following conditions:

![Figure 2012-7: Lid seal voids and rejection criterion.](image)

**NOTE:** Any of the following criteria for bond wires shall not apply, if the wires are not visible in the X-ray.

1. Flat pack and dual-in-line (see figure 2012-8).
   i. Any lead wire that appears to touch or cross another lead wire or bond, (Y plane only).
   ii. Any lead wire that deviates from a straight line from bond to external lead and appears to be within 0.05 mm (.002 inch) of another bond or lead wire (Y plane only).
   iii. Lead wires that do not deviate from a straight line from bond to external lead and appear to touch another wire or bond, excluding common wires, (Y plane only).
   iv. Any lead wire that touches or comes within 0.05 mm (0.002 inch) of the case or external lead to which it is not attached (X and Y plane).
   v. Any bond that is less than 0.025 mm (0.001 inch) (excluding bonds connected by a common conductor) from another bond (Y plane only).
vi. Any wire making a straight line run from die bonding pad to package post that has no arc.

vii. Lead wires that sag below an imaginary plane across the top of the die bond (X plane only) except by design.

FIGURE 2012-8. Clearance in dual-in-line or flat pack type device.

2. Round or "box" transistor type (see figure 2012-9).

i. Any lead wire that touches or comes within 0.05 mm (0.002 inch) of the case or external lead to which it is not attached (X and Y plane).

ii. Lead wires that sag below an imaginary plane across the top of the die bond (X plane only) except by design.

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

iv. Any lead wire that deviates from a straight line from bond to external lead and appears to touch or to be within 0.05 mm (0.002 inch) of another wire or bond (Y plane only).

v. Any bond that is less than 0.025 mm (0.001 inch) (excluding bonds connected by a common conductor) from another bond (Y plane only).

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

vii. 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.
viii. Where a low profile case (such as TO-46) is used, any post 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. In devices which have the semiconductor element vertical to the header, any device where the semiconductor element comes closer than 0.05 mm (0.002 inch) to the header or to any part of the case.

ix. Any case which does not have a header design incorporating a header edge or other feature (e.g., a “splash ring”) to prevent solder or weld splash from entering the interior of the case.
3. Cylindrical axial lead type (see figure 2012-11).
   
i. Whisker to case distance less than one-half of the diameter of the external lead wire.
   
ii. Distance from case to semiconductor die or to any eutectic bonding material less than 0.05 mm (0.002 inch).
   
iii. Whisker tilted more than 5° in any direction from the device lead axis or deformed to the extent that it touches itself.
   
iv. C and S shaped whisker with air gap between any two points on it less than twice the diameter or thickness of the whisker wire. 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 2012-11 (a) is maintained.
   
v. Whiskerless construction device with anode and cathode lead connections displaced more than 0.25 mm (0.01 inch) with respect to the central axis of the device.
   
vi. Semiconductor element mounting tilted more than 15° from normal to the main axis of the device.
   
    vii. Die hanging over edge of header or pedestal more than 10 percent of the die area.
   
m. Less than 75 percent of the semiconductor element base area is bonded to the mounting surface.
   
ix. Voids in the welds, from any edge, between the leads and the heat sink slugs greater than 15 percent of the lead wire diameter. Any voids whatever in the central part of the area that should be welded.
   
  x. Devices with package deformities such as, body glass cracks, incomplete seals (voids, position glass, etc.), die chip outs and severe misalignment of S and C shaped whisker connections to die or post.
3.11 Examination and acceptance criteria for hybrid devices.

3.11.1 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.

3.11.2 Individual device defects. The individual device examination shall include, but not be limited to, extraneous matter, location and orientation of elements, cracks in the substrate that exceed 0.127 mm (0.005 inch) in length or point toward active metallization, adhesive build-up, solder splashes, placement of wires, voids in the lid seal (this may not apply to power hybrid devices), and improper wetting between the substrate(s) and the package. Any device for which the radiograph reveals any of the following defects shall be rejected:

3.11.2.1 Presence of extraneous matter (foreign particles).

a. Unattached foreign material greater than 0.025 mm (0.001 inch), or of any lesser size which is sufficient to bridge metallization or nonconnected conducting elements, that appears to be on the surface of the die, component, substrate, or within the package.

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

NOTE: Attached or unattached material may be verified by comparing two identical views with a mild mechanical shock, such as PIND test, between the two views.

c. Wire tails or extra wires which make contact with any metallization not connected to the wire, or which exceed four wire diameters in length at the substrate pad or package post, or two wire diameters at the top of a die or component.

d. Any evidence of solder, alloy, or conductive adhesive that appears to bridge noncommon metallization (i.e., wire(s), bonding post, active metallization or any combination thereof) not intended by design.

e. Gold flaking on the bonding post or anywhere inside the case.

3.11.2.2 Unacceptable construction.

a. Voids in substrate or component attachment medium.

1. Contact area voids in excess of one-half of the total contact area.

2. A single void which traverses either the length or width of the substrate or semiconductor element and whose area exceeds 10 percent of the total intended contact area.

   NOTE: To obtain, and/or verify substrate attachment the use of a thermal resistance analyzer, which measures the thermal characteristics (heat dissipation), is strongly recommended.

b. Wires present, other than those connecting specific areas as per the drawing, except wires designated as tuning devices on the bonding diagram, and except where bond-offs are allowed.

c. Improper component placement.

d. Cracks, splits, or chips in the component or substrate which enter the active circuit area.

e. Voids in the lid seal in which the seal is not continuous or is reduced from its design sealing width by more than 75 percent.

   NOTE: Sealing voids may not be detectable within power hybrid packages.
f. Inadequate clearance.

1. Any wire that comes closer than 0.025 mm (0.001 inch) to another wire (excluding common wires) within a spherical radial distance from the bond perimeter of 0.127 mm (0.005 inch) for ball bonds, or 0.254 mm (0.010 inch) for ultrasonic and thermocompression wedge bonds.
   NOTE: Insulated wires defined in the device specification/drawing are excluded from this criteria.

2. Excessive loop or sag in any wire so that it comes closer than two wire diameters to another wire, package post, unglassivated operating metallization, die, or portion of a package after a spherical radial distance from the bond perimeter of 0.127 mm (0.005 inch) for ball bonds or 0.254 mm (0.010 inch) for ultrasonic and thermocompression wedge bonds.
   NOTE: Insulated wires defined in the device specification/drawing are excluded from these criteria.

3. Missing or extra wire(s) or ribbon(s) not in conformance with the bonding diagram except those wire(s) or ribbon(s) designated as microwave tuning devices on the bonding diagram.
   NOTE: Extra wires added for statistical process control lot or lot sample bond strength/process machine/operator evaluation in accordance with MIL-PRF-38534 is excluded from this criteria.

4. Any wire that has no arc and makes a straight line run from die bonding pad to package post.

5. Wires crossing wires except common conductors or as allowed in 3.2.2e of method 2010 (condition A).

6. Excessive height in any component or wire loop such that it is closer than 0.127 mm (0.005 inch) to the lid when installed.

7. Any wires which are broken.
   NOTE: Wire bond tails, as defined by method 2017, are excluded from this criteria.

8. Excessive sag where the wire lies on the substrate for a distance greater than 1/2 the distance between the edge of the substrate bonding pad and the chip to which the wire is bonded, or comes closer than 0.025 mm (0.001 inch) to runout of any conductive epoxy which mounts the chip.

9. Bonds placed so that the wire exiting from the bond crosses over another bond, except for common bonds.
   NOTE: For RF/microwave devices, bonds placed so that the wire exiting from a bond crosses over another bond, except by design, in which case the clearance shall be two wire diameters minimum (common bonds are excluded from this criteria).
FIGURE 2012-10. Acceptable and unacceptable excess material.
FIGURE 2012-11. Clearance in cylindrical axial lead type device.
4. **SUMMARY.** The following details shall be specified in the applicable acquisition document:

4.1 **Film.**

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

b. Radiograph submission, if applicable (see 3.9.2).

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. Defects to be sought in the samples and criteria for acceptance or rejection, if other than indicated in 3.10 or 3.11.

e. Radiograph and report retention, if applicable (see 3.9.3).

f. Test reports when required for class level B.

4.2 **Digital.**

a. Number of views, if other than indicated in 3.1.1. Any requirements that cause a need for differing angle of axis, depth of view, or area of vision from those required by Film Radiography.

b. Radiograph submission, if applicable (see 3.9.2).

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. Defects to be sought in the samples and criteria for acceptance or rejection, if other than indicated in 3.10 or 3.11.

e. Radiograph and report retention, if applicable (see 3.9.3).

f. Test reports when required for class level B.

g. If Dynamic (Real Time) Radiography will be used.

h. Archiving requirements including software, recording media, image handling, and records retention period not in accordance to those specified herein.
FEDERAL STANDARDS

Required standards:
FED-STD-595/15102 – 15123 Blue, Gloss
FED-STD-595/25102 – 25109 Blue, Semi-gloss

(Copies of these documents are available online at http://quicksearch.dla.mil.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

Required standards:
ASTM E 801 Standard Practice for Controlling Quality of Radiological Examination of Electronic Devices.
ASTM E 1817 Practice for Controlling Quality of Radiological Examinations by Using Representative Quality

Recommended for reference only:
ASTM E 94 Standard Guide for Radiographic Examination
ASTM E 1161 Standard Practice for Radiologic Examination of Semiconductors and Electronic Components
ASTM E 1255 Standard Practice for Radioscopy.
ASTM E 1316 Standard Terminology for Nondestructive Examinations
ASTM E 1742 Standard Practice for Radiographic Examination
ASTM E 1815 Standard Test Method for Classification of Film Systems for Industrial Radiography
ASTM E 2597 Standard Practice for Manufacturing Characterization of Digital Detector Arrays
ASTM E 2698 Standard Practice for Radiological Examination Using Digital Detector Arrays

(Copies of these documents are available online at https://www.astm.org or from the American Society for Testing and Materials, P O Box C700, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS® (SMPTE®)

Recommended for reference only:
SMPTE RP 133 Specifications for Medical Diagnostic Imaging Test Pattern for Television Monitors and Hard-Copy Recording Cameras

(Copies of this document is available online at https://www.smpte.org or from the Society of Motion Picture and Television Engineers, 3 Barker Ave., 5th Floor, White Plains, NY 10601)

NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS (NCRP)

Recommended for reference only:
NCRP 49 Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma-Rays up to 10 MeV
NCRP 116 Limitation of Exposure to Ionizing Radiation (Supersedes NCRP Report No. 91)
NCRP 151 Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities

(Copies of these documents are available online at http://www.ncrponline.org or from the National Council on Radiation Protection and Measurements, NCRP Publications, 7910 Woodmont Avenue, Suite 400, Bethesda, MD 20814-3095)
MIL-STD-883K
w/CHANGE 3

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INTERNAL VISUAL INSPECTION FOR DPA

1. PURPOSE. This is an internal visual inspection for use in destructive physical analysis (DPA) procedures. The purpose of this destructive test is to examine devices opened for post test evaluation to verify that there is no evidence of defects or damage resulting from prior testing.

2. APPARATUS. The apparatus required for the performance of this test shall include binocular normal-incident illumination microscopes capable of 30X to 60X and 75X to 150X magnification with both light and dark field illumination, and any visual or mechanical standards to be used for measurements or comparison.

3. PROCEDURE. The device shall be opened using a technique which does not damage or contaminate the internal structure or in any way impair the ability to observe defects in the devices or the effects of preceding test exposures. The device(s) shall be examined microscopically at 30X to 60X for particles other than those produced by opening. After examination for particles is complete, the opened device(s) shall be blown off with a nominal gas blow (approximately 20 psig) to remove unattached material from the delidding process. The device shall then be microscopically examined to determine the existence of other visual defects as described in 3.1 and 3.2.

3.1 Low magnification defects (30X to 60X). No device shall be acceptable that exhibits the following defects:
   a. Improper substrate or bonding post plating material.
   b. Improper bond wire material or size.
   c. Metallic contamination or foreign material (see method 2010).
   d. Lifted or broken wires.
   e. Lifted, cracked, or broken die/substrate.
   f. Improper die mounting (see method 2010).
   g. Excessive lead wire loop or sag (see method 2010).
   h. Improper bond technique and size (see method 2010).
   i. Improper assembly die location and orientation as compared to the applicable assembly drawing.
   j. Particles (see method 2010) other than those introduced during opening.

3.2 High magnification defects (75X to 150X). No device shall be acceptable that exhibits the following defects:
   a. Metallization voids, corrosion, peeling, lifting, blistering, or scratches (see method 2010).
   b. Bond intermetallics extending radially more than 0.1 mil beyond the bond periphery in any direction.
   c. Improper die or substrate metallization design layout topography or identification.
   d. Die cracks (see method 2010).
4. **SUMMARY.** The following details shall be specified in the applicable acquisition document:

   a. Where applicable, gauges, drawings, or photographs to be used as standards for the operator comparison (see 2).

   b. Any applicable requirements for materials, design, or construction.

   c. Requirement for photographic record, if applicable, and disposition of the photographs.

   d. Where applicable, any additions or modifications to the specified procedure and criteria.
METHOD 2014
INTERNAL VISUAL AND MECHANICAL

1. PURPOSE. The purpose of this examination is to verify that internal materials, design and construction are in accordance with the applicable acquisition document. This test is destructive and would normally be employed on a sampling basis in qualification or quality conformance inspection of a specific device type to demonstrate compliance with the acquisition document and to reveal any undocumented changes to the part type.

2. APPARATUS. Equipment used in this examination shall be capable of demonstrating conformance to the requirements of the applicable acquisition document and shall include optical equipment capable of magnification sufficient to verify all structural features of the devices.

3. PROCEDURE. The device shall be examined under a sufficient magnification to verify that all the internal materials, design and construction are in accordance with the requirements of the applicable design documentation or other specific requirements (see 4). Specimens of constructions which do not contain an internal cavity (e.g., encapsulated or embedded devices) or those which would experience destruction of internal features of interest as a result of opening, may be obtained by interception during manufacturing prior to encapsulation. Specimens of constructions with an internal cavity shall be selected from devices which have completed all manufacturing operations and they shall be delidded or opened or both taking care to minimize damage to the areas to be inspected. When specified by the applicable acquisition document, the interception procedure may be used to obtain specimens of constructions with an internal cavity.

3.1 Photographs of die topography and intraconnection pattern. When specified, an enlarged color photograph or transparency shall be made showing the topography of elements formed on the die or substrate and the metallization pattern. This photograph shall be at a minimum magnification of 80X except that if this results in a photograph larger than 8 inches x 10 inches, the magnification may be reduced to accommodate an 8 inches x 10 inches view.

3.2 Failure criteria. Devices which fail to meet the detailed requirements for materials, design and construction shall constitute a failure.

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

a. Any applicable requirements for materials, design and construction.

b. Allowance for interception procedure of internal cavity devices, when applicable (see 3).

c. Requirement for photographic record, if applicable (see 3.1), and disposition of photographs.
RESISTANCE TO SOLVENTS

1. **PURPOSE.** The purpose of this test is to verify that the markings will not become illegible on the component parts when subjected to solvents. The solvents will not cause deleterious, mechanical or electrical damage, or deterioration of the materials or finishes.

1.1 **Formulation of solvents.** The formulation of solvents herein is considered typical and representative of the desired stringency as far as the usual coatings and markings are concerned. Many available solvents which could be used are either not sufficiently active, too stringent, or even dangerous to humans when in direct contact or when the fumes are inhaled.

1.2 **Check for conflicts.** When this test is referenced, care should be exercised to assure that conflicting requirements, as far as the properties of the specified finishes and markings are concerned, are not invoked.

2. **MATERIALS.**

2.1 **Solvent solutions.** The solvent solutions used in this test shall consist of the following: 1/

   a. At 20-30°C a mixture consisting of the following:
      
      (1) One part by volume of an aliphatic alcohol and/or aliphatic ester, USP grade or better.

      (2) Three parts by volume of mineral spirits in accordance with MIL-PRF-680, type II, previously designated as TT-T-291, type II, grade A, or three parts by volume of a mixture of 80 percent by volume of kerosene and 20 percent by volume of ethylbenzene.

   b. A semiaqueous or nonaqueous based organic solvent e.g., a terpene or heterocyclic compound. 2/

   c. This solvent has been deleted. When a suitable replacement for this solvent has been found, it will be added as solution c.

   d. At 63°C to 70°C, a mixture consisting of the following: 1/
      
      (1) 42 parts by volume of deionized water.

      (2) 1 part by volume of propylene glycol monomethyl ether.

      (3) 1 part by volume of monoethanolamine or equivalent inorganic base to achieve the same pH.

2.1.1 **Solvent solutions, safety aspects.** Solvent solutions listed in a through d above exhibit some potential for health and safety hazards. The following safety precautions should be observed:

   a. Avoid contact with eyes.

   b. Avoid prolonged contact with skin.

   c. Provide adequate ventilation.

   d. Avoid open flame.

   e. Avoid contact with very hot surfaces.

1/ Normal safety precautions for handling these solutions (e.g., same as those for diluted ammonium hydroxide) based on OSHA rules for Monoethanolamine or other precautionary measures with regard to flash point, toxicity, etc.

2/ Or any EPA demonstrated equivalent. When using EPA approved alternative solutions for test, the device manufacturer should consider the recommended temperature for cleaning specified by the solvent supplier.
2.2 Vessel. The vessel shall be a container made of inert material, and of sufficient size to permit complete immersion of the specimens in the solvent solutions specified in 2.1.

2.3 Brush. The brush shall be a toothbrush with a handle made of a nonreactive material. The brush shall have at least three long rows of hard (or firm) bristles, the free ends of which shall lie substantially in the same plane. The toothbrush shall be used exclusively with a single solvent and when there is any evidence of softening, bending, wear, or loss of bristles, it shall be discarded.

3. PROCEDURE. The specimens subjected to this test shall be divided into three equal groups. Each group shall be individually subjected to one of the following procedures:

Note: Metal lidded leadless chip carrier (LCC) packages shall be preconditioned by immersing the specimens in room temperature flux type symbols “A” or “B” (flux types “LO” or “L1”) in accordance with IPC J-STD-004 previously designated as RMA flux in accordance with MIL-F-14256, for 5 to 10 seconds. The specimens shall then be subjected to an ambient temperature of 215 °C ±5°C for 60 seconds ±5, -0 seconds. After the preconditioning, each device lid shall be cleaned with isopropyl alcohol.

a. The first group shall be subjected to the solvent solution as specified in 2.1a maintained at a temperature of 25°C ±5°C.

b. The second group shall be subjected to the solvent solution as specified in 2.1b maintained at a suitable temperature.

c. This solution has been deleted, (see 2.1c).

d. The fourth group shall be subjected to the solvent solution as specified in 2.1d maintained at a temperature of 63°C to 70°C.

The specimens and the bristle portion of the brush shall be completely immersed for 1 minute minimum in the specified solution contained in the vessel specified in 2.2. Immediately following emersion, the specimen shall be brushed with normal hand pressure (approximately 2 to 3 ounces) for 10 strokes on the portion of the specimen where marking has been applied, with the brush specified in 2.3. Immediately after brushing, the above procedure shall be repeated two additional times, for a total of three immersions followed by brushings. The brush stroke shall be directed in a forward direction, across the surface of the specimen being tested. After completion of the third immersion and brushing, devices shall be rinsed and all surfaces air blown dry. After 5 minutes, the specimens shall be examined to determine the extent, if any, of deterioration that was incurred.

3.1 Optional procedure for the fourth group. The test specimens shall be located on a test surface of known area which is located 15 ±2.5 centimeters (6 ±1 inches) below a spray nozzle(s) which discharges 0.6 ±0.02 liters/minute (0.139 gpm) of solution (2.1d) per 6.5 square centimeters (1 in²) surface area at a pressure of 140 ±30 kilopascal (20 ±5 psi). The specimens shall be subjected to this spray for a period of 10 minutes minimum. After removal and within 5 minutes the specimens shall be examined in accordance with 3.1.1. The specimens may be rinsed with clear water and air blow dried prior to examination.

3.1.1 Failure criteria. After subjection to the test, evidence of damage to the device and any specified markings which are missing in whole or in part, faded, smeared, blurred, or shifted (dislodged) to the extent that they cannot be readily identified from a distance of at least 15.0 cm (6 inches) with normal room lighting and without the aid of magnification or with a viewer having a magnification no greater than 3X shall constitute a failure.

4. SUMMARY. The following detail shall be specified in the individual specification: The number of specimens to be tested (see 3).
1. **PURPOSE.** The purpose of this examination is to verify that the external physical dimensions of the device are in accordance with the applicable acquisition document.

2. **APPARATUS.** Equipment used in this examination shall include micrometers, calipers, gauges, contour projectors, or other measuring equipment capable of determining the actual device dimensions specified in the applicable acquisition document.

3. **PROCEDURE.** Unless otherwise specified, the physical dimensions on the case outline drawing shall be measured.

3.1 **Failure criteria.** Any device which exhibits a dimension or dimensions outside the specified tolerances or limits shall constitute a failure.

4. **SUMMARY.** The following detail shall be specified in the applicable acquisition document:

External dimensions which are capable of physically describing the device (see 3). Dimensions to be considered shall include case outline dimensions; special lead shapes (e.g., required bend positions, angles of bend), where applicable; dimensions of any projecting or indented features used for coding of lead arrangement, automatic handling and similar purpose; and any other information which affects the installed size or orientation of the device in normal applications.
INTERNAL VISUAL (HYBRID)

METHOD 2017.13

1. PURPOSE. The purpose of this test is to visually inspect the internal materials, construction, and workmanship of hybrid, multichip and multichip module microcircuits.

1.1 Scope. This test is for both Class H (Class level B) and Class K (Class level S) quality levels, Surface Acoustic Wave (SAW) and hybrid/multichip/multichip module microcircuits. The following types of microcircuits may be inspected:


b. Active thin and thick film circuits.

c. Multiple circuits, including combinations, stacking or other interconnections of 1.1.a and 1.1.b.

This test is performed on microelectronic devices after completion of all assembly operations, prior to seal, encapsulation, or final acceptance on a 100 percent inspection basis (or as specified in controlling documents) to detect and eliminate devices with one or more internal defects. It may also be employed as an in-process inspection on a sampling basis to determine the effectiveness of the manufacturing processes and handling procedures.

2. APPARATUS. The apparatus for this test shall include optical equipment capable of the specified magnification(s) and visual standards/aids (gages, 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. Fixtures, if needed, shall be provided for handling devices during examination to promote efficient operation without inflicting damage to the units.

3. PROCEDURE.

a. 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. Devices may be examined at any magnification within the specified range for each criterion. However, the product must be capable of passing each criterion at all magnifications within that criterions specified range. The inspection criteria shall include all criteria of this test method and the applicable test methods referenced in paragraph 3.1.1. For Class H hybrids, the inspection criteria of 3.1.1 may be performed prior to element attachment, at the option of the manufacturer. For Class K hybrids, the inspection criteria of 3.1.1 shall be employed following element attachment and wirebonding, or at final preseal inspection.

b. Sequence of inspection. The order in which criteria are presented is not the required order of examination and may be varied. Where obscuring mounting techniques (e.g., beam lead devices, stacked substrates, components mounting in holes or cutaways, flip chip devices, packaged devices) are employed, the inspection criteria contained herein that cannot be performed after mounting shall be conducted prior to mounting the element or substrate. However, unless obscuring mounting techniques (e.g., beam lead devices, stacked substrates, components mounting in holes or cutaways, flip chip devices, packaged devices) are employed, only in these cases, the obscured details shall be compliant to section 3.1 at the last operation before the details become obscured.

c. Inspection control. In all cases, examination prior to final preseal inspection shall be performed under the same quality program that is required at the final preseal inspection station. Care shall be exercised after inspections (see 3.b), to ensure that defects created during subsequent handling will be detected and rejected at final preseal inspection. Devices examined to 3.1 criteria shall be inspected and prepared for sealing in a 100,000 (0.5 µm or greater) particles/cubic foot controlled environment (class 8 of ISO 14644-1) for Class H and 100 (0.5 µm or greater) particles/cubic foot controlled environment (class 5 of ISO 14644-1) for Class K, except that the allowable relative humidity shall be less than 65 percent. During the time interval between internal visual inspection and preparation for sealing, devices shall be stored in a 1000 (0.5 µm or greater) particles/cubic foot controlled environment (class 6 of ISO 14644-1). Devices shall be in covered containers when transferred from one controlled environment to another.

Change 3 resulted in the revision 2017.13 of this method.
3 May 2018
d. **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 percent re-inspection, the sampling plans of MIL-PRF-38534 or Appendix A of MIL-PRF-38535 shall apply.

e. **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.

f. **Definitions.**

1. **Active circuit area** includes all areas of functional circuit elements, operating metallization or connected combinations thereof excluding beam leads.

2. **Add-on substrate** is a 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. **Adhesive** is a polymeric mixture that bonds elements together. It may be filled with conductive or non-conductive particles.

4. **Attachment media** is defined as the material used to effect the attachment of an element to an underlying surface (e.g., adhesive, solder, braze, or other eutectic material system).

5. **Bonding site** is a metallized area on a substrate or element intended for a wire or ribbon interconnecting bond.

6. **Cold solder joint** is defined as a solder joint whose appearance is "grainy" or "dull". Where a "grainy" or "dull" appearance is characteristic of certain solder materials (e.g., AuSn, etc.), this criteria shall not be rejectable for these materials.

7. **Compound bond** is one bond, of any type on top of another bond of any type on an element. For example, ball on top of a ball.

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

9. **Crack** is a separation in the mounting material that is measurable in length, width and depth. It is not pullback of the fillet or shrinkage due to the curing process.

10. **Dendrites** form in fern-like or snowflake-like patterns growing along a surface (x-y plane) rather than outward from it. The growth mechanism for dendrites requires some type of moisture capable of dissolving the metal (e.g., tin) into a solution of metal ions which are then redistributed by electromigration in the presence of an electromagnetic field.

11. **Dielectric attach** is the process and materials used for attachment that does not provide electrical contact or thermal dissipation considerations.

12. **Edge metallization** is the metallization that electrically connects the metallization from the top surface to the opposite side of the substrate; also called wrap around metallization.

13. **Element** is a constituent of a hybrid microcircuit; such as integral deposited or screened passive elements, substrates, discrete or integrated electronic parts including dice, chips and other micro-components; also mechanical piece parts as cases and covers; all contributing to the operation of a hybrid microcircuit.

14. **Electrically common** is satisfied when two or more conductive surfaces or interconnects are of equal DC voltage/signal potential.
(15) **End terminated or wrap around elements** are those elements which have electrical connections on the ends (sides) and/or bottom of their bodies.

(16) **Eutectic** is a mixture of two or more metals in such proportion that their combined melting point is the lowest attainable. At the eutectic, the solidus and liquidus temperatures on the equilibrium phase diagram are the same. For example: AuSi eutectic M.P. = 363°C.

(17) **Fissure** is a hair-line fracture that does not have significant measurable dimension. For example; a fissure may be several mils in length but would not have a measurable width or depth.

(18) **Foreign material** is defined as any material that is foreign to the microcircuit or any non-foreign material that is displaced from its original or intended position within the microcircuit package. Conductive foreign material is defined as any substance that appears opaque under those conditions of lighting and magnification used in routine visual inspection. Particles shall be considered embedded in glassivation when there is evidence of color fringing around the periphery of the particle.

(19) **Glassivation** is the top layer(s) of transparent insulating material that covers the active area including metallization, except bonding pads and beam leads.

(20) **Insulating layer** is a dielectric layer used to isolate single or multilevel conductive and resistive material or to protect top level conductive and resistive material.

(21) **Intermetallics** (Purple Plague) is one of several gold-aluminum compounds formed when bonding gold to aluminum and activated by re-exposure to moisture and high temperature (>340°C). Purple plague is purplish in color 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.

(22) **Mechanical strength tests** are tests, such as Mechanical Shock or Constant Acceleration, which demonstrate adequate attachment process and materials.

(23) **Non-monometallic compound bond** consists of 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 are made up of dissimilar metals such as an aluminum lead bond stacked on top of a gold lead bond or vice-versa).

(24) **Operating metallization** (conductors) is all metal or any other material used for interconnections except metallized scribe lines, test patterns, unconnected functional circuit elements, unused bonding pads and identification markings.

(25) **Original design separation** is the separation dimension or distance that is intended by design.

(26) **Original width** is the width dimension or distance that is intended by design (i.e., original metal width, original diffusion width, original beam width, etc.).

(27) **Passivation** is the 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.

(28) **Reinforcement Bond** is a ball placed on the heel of a tailless or crescent bond intended to reinforce the initial bond. A reinforcement bond is a type of compound bond.

(29) **Security Bond** is also known as a reinforcement bond.

(30) **Separation barrier** is non-conductive adhesive deposited between end terminations and is designed to improve the strength of the element attach and separate the conductive adhesive applied to the end terminations.

(31) **Surface Acoustic Wave (SAW)** element is a planar element fabricated typically using thin film manufacturing techniques on various substrate materials. Size varies as a function of frequency and design features include interdigitated fingers.
(32) **String** is a filamentary run-out or whisker of polymer material.

(33) **Substrate** is the supporting structural material into and/or upon which the passivation, metallization, and circuit elements are placed.

(34) **Tuning** is the adjustment of signals from an RF/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.

(35) **Through hole metallization** is the metallization that electrically connects the metallization on the top surface of the substrate to the opposite surface of the substrate.

(36) **Thermocompression bond** is a wirebond interconnect formed using heat and pressure.

(37) **Thermosonic bond** is a wirebond interconnect formed using heat, pressure and ultrasonic energy.

(38) **Ultrasonic bond** is a bond formed with pressure and ultrasonic energy with no added heat.

(39) **Unused component or unused deposited element** is one not connected to a circuit or connected to a circuit path at one and only one point. A connection may be made by design or by visual anomaly.

(40) **Void** is any region in a material (interconnects, bonding sites, etc.) where an underlying material is exposed and it was not caused by a scratch.

(41) **Visible line** is defined as 0.5 mil at 60X magnification.

(42) **Whisker** is a spontaneous columnar or cylindrical filament, usually of monocrystalline metal, emanating from the surface of a finish.

**NOTE:** For the purpose of this document, whiskers have the following characteristics:

- An aspect ratio (length/width) greater than 2
- Can be kinked, bent, or twisted
- Usually have a uniform cross-section shape
- May have striations along the length of the column and or rings around the circumference of the column
- Length of 10 microns or more. Features less than 10 microns may be deemed important for research but are not considered significant for this test method.

(43) **Whisker Length** is the straight line distance from the point of emergence of the whisker to the distant point on the whisker (i.e., the radius of a sphere containing the whisker with its center located at the point of emergence).

**g. Interpretations.** References herein to "that exhibits" shall be considered satisfied when the visual image or visual appearance of the device under examination indicates 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.

**h. Foreign material control.** The manufacturer shall perform an audit on a weekly basis for the presence of foreign material on the die surface, or within the package. This audit may be satisfied during routine internal visual inspection. If the presence of any type of foreign material/contamination is discovered, the manufacturer shall perform the necessary analysis to determine the nature of the foreign material. The manufacturer shall document the results of the investigation and corrective actions taken. The intent of this procedure is to require investigation and resolution of foreign material/contamination problems which do not have effective screening or detection methodology, but that could cause degradation and eventual failure of the device function. Repetitive findings without obvious improvements require escalation to Director of Manufacturing and Director of Quality before processing.
3.1 Examination. Internal visual examination as required in 3.1.1 through 3.1.9 shall be conducted on each SAW, hybrid/multichip microcircuit, or microwave hybrid microcircuit. The magnifications required for each inspection shall be those identified in the particular test method used (i.e., 2010, 2017, or 2032 of MIL-STD-883 and 2069, 2070, 2072, or 2073 of MIL-STD-750).

3.1.1 Active and passive elements. All integrated circuit elements shall be examined in accordance with MIL-STD-883, method 2010.

Method 2010; Paragraph 3.1.1: Metallization defects.

Method 2010; Paragraph 3.1.2: Diffusion and passivation layer(s) faults.

Method 2010; Paragraph 3.1.3: Scribing and die defects.

Method 2010; Paragraph 3.1.4: Glassivation defects.

Method 2010; Paragraph 3.1.6: Film resistors defects.

Method 2010; Paragraph 3.1.7: Laser trimmed film resistor defects.

Method 2010; Paragraph 3.2.1.6: Flip chip solder bump die.

Transistor, diode, power MOS FET and microwave transistor elements shall be examined in accordance with the identified paragraphs of MIL-STD-750, methods 2069, 2070, 2072 and 2073 as indicated in Table I. below. Passive elements (including substrates) shall be examined in accordance with MIL-STD-883, method 2032.

Table I. Element test method paragraph references.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
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<td>3.4.1, 3.4.2, 3.4.3, 3.4.4, 3.4.5, 3.4.6</td>
<td>3.2.1, 3.3</td>
<td>4.1.1</td>
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<td>Diffusion and Passivation Layer(s)</td>
<td>3.4.7</td>
<td>3.8, 3.9.4, 3.9.5</td>
<td>4.1.2</td>
<td>4.1.1</td>
<td>3.1.2</td>
</tr>
<tr>
<td>Scribing and Die Defects</td>
<td>3.4.8</td>
<td>3.4</td>
<td>4.1.3</td>
<td>4.1.1</td>
<td>3.1.3</td>
</tr>
<tr>
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<td>3.4.9</td>
<td>3.2.2</td>
<td>4.1.7</td>
<td>N/A</td>
<td>3.1.4</td>
</tr>
<tr>
<td>Foreign Material</td>
<td>3.3.1</td>
<td>3.6.1</td>
<td>4.1.6</td>
<td>4.3</td>
<td>3.2.5</td>
</tr>
</tbody>
</table>
3.1.2 Element attachment (assembly), "magnification 10X to 60X". Figures 2017-1 and 2017-2 are example visual representations of attachment media types.

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

NOTE: Ultrasonic Inspection (TM 2030) or Radiography (TM 2012) may be used to verify attachment in lieu of visual criteria. If so the maximum void acceptance criteria specified in TM 2012 or TM 2030 shall not be exceeded.
3.1.2.1 **Element mounting adhesive.** No device shall be acceptable that exhibits:

* **NOTE:** The criteria of paragraph 3.1.2.1.a and b shall not apply when attachment adhesive is applied directly to more than 75 percent of the element attach area by use of a controlled process (such as utilizing preforms, screen printing or automated dispense).

a. For non-end terminated elements, attachment adhesives not visible around at least 50 percent of the element’s perimeter unless it is continuous on two full nonadjacent sides of the element (see Figures 2017-3 and 4).

![Reject less than 50% of perimeter](Figure 2017-3)

![Minimum Accept two full non-adjacent sides](Figure 2017-4)

b. Glass substrates or transparent die, when viewed from the top or bottom, which exhibits attach area coverage less than 75 percent.

**NOTE:** This criterion may be employed in lieu of 3.1.2.1.a.
c. End terminated elements that do not have adhesive attachment to bonding pads that is visible around at least 75 percent of each end termination (see Figures 2017-5, 2017-6 and 2017-7).

![Figure 2017-5](image1) ![Figure 2017-6](image2) ![Figure 2017-7](image3)

* d. Evidence of conductive adhesive under the body of the element that reduces the spacing between attached metallization by more than 50% as viewed from the side (this applies whether or not staking adhesive is used).

**NOTE:** For end terminated elements with added staking adhesive designed as a separation barrier the staking material must clearly attach to the body of the element. (see Figure 2017-8).

![Figure 2017-8](image4)

* e. Flaking, peeling, or lifting of the attachment adhesive material.
f. Die mounting adhesive that extends onto the top surface or extends vertically above the top surface of the die.

g. Conductive attachment adhesive or resin which comes closer than 1.0 mil to any functional metallization or element which is not electrically common (see Figure 2017-9 and 10).

h. Any crack in the surface of the attachment adhesive greater than 5.0 mils in length or 10 percent of the contact periphery (see Figure 2017-11).

NOTE: Irregularities such as fissures or pullback at the edges of the adhesive are not considered cracks (see Figure 2017-11a).
i. Adhesive strings where the diameter of the string at the point of attachment is less than 50 percent of the maximum length of the string (see Figure 2017-11b).
3.1.2.2 **Element mounting eutectic and solder.** No device shall be acceptable that exhibits:

NOTE: As a guide and for further information about solder related defects refer to IPC-STD-610 Class 3.

- **a.** Die mounting material buildup that extends onto the top surface, or extends vertically above the top surface of the die, or comes closer than 1.0 mil to any functional metallization or element which is not electrically common.

- **b.** Die mounting attachment material not visible around at least 50 percent of the element’s perimeter unless it is continuous on two full nonadjacent sides of the element; except for transparent die (refer to section 3.1.2.1.a).

- **c.** Glass substrates or transparent die, when viewed from the bottom, which exhibits an attach area less than 75 percent.

- **d.** Cold solder joint.

- **e.** Fractured solder connections.

- **f.** Solder bridging except by design.

- **g.** Flaking of the eutectic or solder mounting material.

- **h.** Balling of the eutectic or solder mount material that does not exhibit a minimum of 50 percent peripheral fillet when viewed from above or the accumulation of material is such that the height of the accumulation is greater than the longest base dimension or the accumulation necks down at any point (see figure 2017-12 a & b).

![Diagram](attachment:figure2017_12a.png)

Reject if \( h > b \)

Figure 2017-12a.
i. Solder or eutectic material that extends beyond the intended attach pad or extends above the top plane of the element. (see Figure 2017-13 a and b)

Reject: Build-up of the solder or eutectic attach material above the top plane of the element

Figure 2017-13a.

Acceptable fillet

Figure 2017-13b.
3.1.3 Substrate mounting. No device shall be acceptable that exhibits:

a. Substrate attachment material not visible around at least 50 percent of the element’s perimeter unless it is continuous on two full nonadjacent sides of the element, except for transparent die (refer to section 3.1.2.1.a).

NOTE: The criteria of paragraph 3.1.3.a shall not apply when attachment media is applied directly to more than 75 percent of the substrate attach area by use of a method such as preforms or printing.

b. Conductive attachment media which comes closer than 1.0 mil to any functional metallization (e.g. post) or element which is not electrically common.

c. Conductive attachment media buildup that extends onto the top substrate surface and comes closer than 1.0 mil to any element or conductor which is not electrically common.

3.1.4 Element orientation. No device shall be acceptable that exhibits:

a. Element not located or oriented in accordance with the applicable assembly drawing of the device, which would affect the device performance or reliability.

NOTE: Elements whose bond and electrical configuration is symmetrical may be rotated unless otherwise stated in the assembly drawings. (see Figure 2017-14)

![Figure 2017-14. Acceptable Symmetrical Element Orientation.](image)

b. Elements that overhang the edge of the substrate.

c. Clearance less than 1.0 mil between any un-insulated portion of the element and any non-common conductive surface.
3.1.5 **Bond inspection, magnification 30X to 60X.** 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.

Note: Wire tail shall not be considered part of the bond when determining physical bond dimensions.

3.1.5.1 **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 (see Figure 2017-15a).

![Reject wire exit not within periphery of ball](image)

Figure 2017-15a.

c. Ball bonds where the wire center exit is not within the boundaries of the bonding site (see Figure 2017-15b).

![Reject: wire center exit not within boundary of bond pad. Additionally, reject because ball is shorted to adjacent metal run.](image)

Figure 2017-15b.
d. Ball bonds where the ball is placed on more than 50% disturbed metal (see Figure 2017-15c and d).

Accept
ball on <50% disturbed metal

Reject
ball on >50% disturbed metal

Figure 2017-15c.
Figure 2017-15d.

3.1.5.2 Tailless bond (crescent). No device shall be acceptable that exhibits:

NOTE: The dimensions of an acceptable gold crescent or tailless bond are shown in Figure 2017-16a.

a. Tailless bonds that are less than 1.2 times or greater than 5.0 times the wire diameter in width (see Figure 2017-16b).

Figure 2017-16a. Tailless (crescent) Bond Dimensions.
Figure 2017-16b. Tailless Bond Criteria.

b. A tailless bond of a gold wire bonded on the aluminum pads of a die.
3.1.5.3 **Wire wedge bonds.** No device shall be acceptable that exhibits:

a. Fine wire criteria (4 mils or less wire diameter): Ultrasonic, thermosonic and thermocompression bonds that are less than 1.2 times or greater than 2.0 times the wire diameter in width or less than 0.5 times the wire diameter in length or no evidence of tool impression (see Figure 2017-16a).

b. Heavy wire criteria (greater than 4 mils diameter): Ultrasonic aluminum bonds that are less than 1.0 times or greater than 2.0 times the wire diameter in width or less than 0.5 times the wire diameter in length or no evidence of tool impression.

![Figure 2017-16a. Bond Dimensions.](image)
3.1.5.4 Compound bonds including reinforcement/security bonds (ball on crescent). No device shall be acceptable that exhibits the following:

NOTE: For both compound bonds and reinforcement bonds; broken or lifted bonds as a result of electrical troubleshooting or tuning shall be considered rework and shall not apply to the 10 percent repair limitation.

a. More than one bond on top of original bond including a second ball bond on top of a reinforcement ball.
b. Where the contact area of the second bond is less than 75 percent of the bond area of the original bottom bond.
c. Non-monometallic compound bond (i.e., between dissimilar metals) excluding the bond pad metallization.
d. One reinforcement bond used to secure two common wires (see Figure 2017-17).

3.1.5.5 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 75 percent 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 (i.e., split tip, tool on a gap welder, etc.), are acceptable provided the total of all gaps does not exceed 25 percent 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 50 percent of the original beam width.
e. Bonding tool impression less than 1.0 mil from the die edge (see Figure 2017-18a).
f. An absence of visible separation between the bond and the edge of the passivation layer (see Figure 2017-18a).

FIGURE 2017-17. One bond to secure two common wires.
g. Bonds where the tool impression length is less than 1.0 mil (see Figure 2017-18b).

h. Effective bonded area less than 50 percent of that which would be possible for an exactly aligned beam (see Figure 2017-18b).
i. 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 percent the beam width (see Figure 2017-19).

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

FIGURE 2017-19. Accept/Reject tears or voids in beam lead/ribbon weld area.
3.1.5.6 **Mesh bonding.** No device shall be acceptable that exhibits the following:

a. Less than 50 percent of the bond is on substrate metallization.

b. The number of continuous strands along the mesh is less than 50 percent of lengthwise strands through each section (see Figure 2017-20a).

![Figure 2017-20a. Criteria for strands along the mesh.](image)

Reject

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

Figure 2017-20a. **Criteria for strands along the mesh.**

![Figure 2017-20b. Criteria for strands along the mesh.](image)

Accept

2 (half) or more of the lengthwise strands are continuous through each section

Figure 2017-20b. **Criteria for strands along the mesh.**
c. Less than one continuous conducting path(s) through a bond (see figure 2017-20c).

d. Class K: Less than two continuous conducting path(s) through a bond (see Figure 2017-20c).

3.1.5.7 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 (see Figure 2017-19).

b. Bonds which do not exhibit 75 percent 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 (i.e., split tip tool on parallel gap welder, etc.) are acceptable provided the total of all gaps do not exceed 25 percent of the ribbon width.

c. Effective bonded area less than 50 percent of that which would be possible for an exactly aligned ribbon.

d. Bond tails longer than one ribbon width or 10.0 mils, whichever is less, or bridging adjacent metallization.

e. The unbonded end of a ribbon bond tuning stub longer than one ribbon width or 10.0 mils, whichever is less, which is not secured by polymer adhesive.
3.1.5.8 General. No device shall be acceptable that exhibits:

a. Bonds on the die where less than 50 percent of the bond is within the unglassivated bonding site.

NOTE: For Class K, monometallic bonds on the die where less than 50 percent of the bond is within the unglassivated bonding site. Bimetallic bonds on the die where less than 75 percent of the bond is within the unglassivated bonding site, except where due to geometry, and if by design, the bonding pad is smaller than the bond, then the criteria shall be 50%.

b. Any metal that is displaced as a result of bonding from its original position on the bonding pad (shooting metal) that reduces the separation between unglassivated operation metallization or scribe line to less than 1 mil or 50 percent design separation, whichever is less.

c. 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 percent of the bond is within the bonding site.

d. 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 criteria).

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

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

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

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

i. Bonds on element attach adhesive or on contaminated or foreign material (see figure 2017-20d).

Reject: Bond on element attach adhesive

Figure 2017-20d.
j. Any lifted or peeling bond.

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

l. Wedge, crescent or ball 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: Criteria of 3.1.5.8 (l) can be excluded when the entering conductor is >2 mils in width and the bond pad dimension on the entering conductor side is >3.5 mils.

   NOTE: For Class H only, the requirements for a visual line of metal can be satisfied when an acceptable wire tail obscures the area of concern, provided the following condition exists. Bond is located more than 0.1 mils 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: Criteria 3.1.5.8 (l) 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.

m. Polymeric adhesive which may be material or residue as evidenced by discoloration within 5.0 mils of the outer periphery of a wire bond.

n. Polymeric adhesive anywhere on a bond wire unless by design.

o. Tearing or cracks at the junction of the wire and bond (see figure 2017-20e). The junction is the line of deformation of the wire at the bonding site.
3.1.6 Internal leads (e.g., wires, ribbons, beams, wire loops, ribbon loops, beams, etc.), "magnification 10X to 60X". No device shall be acceptable that exhibits:

* a. Within the first 5.0 mils of wire from the die surface for ball bonds, or 10.0 mils for wedge bonds, any wire that comes closer than 1.0 mil to any non-common conductive surface (e.g., unglassivated operating metallization, unpassivated edge of conductive die). After 5 mils, or 10 mils for wedge bonds, the clearance shall be 2 wire diameters.

   NOTE: Insulated wires and electrically common wires are excluded from these criteria.

b. Nicks, cuts, crimps, scoring, or neckdown in any lead that reduces the lead diameter/width by more than 25 percent.

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

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

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

e. Wire(s) crossing wire(s) with a separation of less than 2 lead widths. Common or insulated conductors and insulated wires are excluded.

f. Complete or partial separation of the lead from the body of the element.

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

3.1.7 Screw tabs and through hole mounting, magnification 3X to 10X. 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.

3.1.8 Connector and feedthrough center contact soldering, magnification 10X to 30X. No device shall be acceptable that exhibits:

a. Less than 50 percent of center contact overlaps onto metallized pattern (see Figure 2017-21).

b. Center contact to substrate protrudes over onto circuit less than 1 diameter of a round pin or the width of a flat pin (see Figure 2017-22).

c. Voids in solder (see Figure 2017-23a).

d. Cracked solder joint (see Figure 2017-23b).

e. Poor adhesion, insufficient and un-smooth fillet, of solder to center line contact or substrate (see Figure 2017-23b).

f. Insufficient or excess solder (see Figures 2017-23c through 2017-23e).

g. Less than full coverage of solder along the length of the center contact and the metallization.
FIGURE 2017-21. Center contact orientations to substrate.

FIGURE 2017-22. Center contact overlap to substrate.
FIGURE 2017-23a. Void criteria.

FIGURE 2017-23b. Crack/adhesion criteria.

FIGURE 2017-23c. Excess solder criteria.

FIGURE 2017-23d. Insufficient solder criteria.

FIGURE 2017-23e. Solder criteria.
3.1.9 Package conditions, "magnification 10X to 60X". No device will be acceptable that exhibits:

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

NOTE: 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 percent of the closest unglassivated conductive spacing shall be accomplished by a light touch with an appropriate mechanical device (i.e., needle, probe, pick, etc.). Verification of attachments of smaller material can be satisfied by suitable cleaning process approved by the acquiring or qualifying activity. All foreign material or particles may be removed, if possible, with a nominal gas blow (approximately 20 psig).

NOTE: Semiconductor chips shall be considered foreign particles.

b. Attached foreign material that bridges metallization paths, two 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 or unpassivated active circuit areas.

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

e. Presence of any residual flux.

NOTE: Use 10X to 15X magnification.

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

NOTE: As a guide, and for further information about package related defects, refer to JESD9.

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

a. Test condition (see 3).

b. Where applicable, gages, drawings and photographs that are to be used as standards for operator comparison (see 2).

c. Where applicable, specific magnification if other than that specified.