METHOD 2004.5

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 B_1 provides for application of bending stresses to determine integrity of leads, seals, and lead plating while B_2 employs multiple application of bending stresses primarily to determine the resistance of the leads to metal fatigue under repeated bending. Test conditions C_1 and C_2 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. It is recommended that this test 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).

2. APPARATUS. See applicable test condition.

3. 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.

4. 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 10X magnification after removal of the stress, any evidence of breakage, loosening, or relative motion between the lead (terminal) and the device body 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 B_1 - BENDING STRESS

1. PURPOSE. This test is designed to check the capability of the leads, lead finish, 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 force sufficient to bend the lead as specified in 3.1 through 3.5, as applicable. Any number or all of the leads of the test device may be bent simultaneously. Rows of leads may be bent one row at a time. Each lead shall be bent through one cycle as follows: Bend through the specified arc in one direction and return to the 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 normal position.

3.2 Procedure for initial conditioning of formed leads. When normally straight leads are supplied in a formed condition (including the staggered lead dual-in- line configuration), the lead forming operation shall be considered acceptable initial conditioning 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. A lead shall be considered flexible if its section modulus (in the least rigid direction) is less than or equal to that of a 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. Flexible leads shall be bent through an arc of at least 45° measured at a distance 3.05 ±.76 mm (0.120 ±0.03 inch) along the lead from the seal unless otherwise specified.

3.3.2 Semi-flexible leads. Semi-flexible leads are those leads with a section modulus (in the least rigid direction) greater than that of a rectangular lead with a cross section of 0.15 x 0.51 mm (0.006 x 0.020 inch) which are intended to be bent during insertion or other application. Round leads greater than 0.51 mm (.020 inch) diameter shall be considered semi-flexible except as noted in 3.5. 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. Dual-in-line package leads are leads with more than one section modulus, with 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). Pin grid array packages shall have the 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. At the completion of the initial bend, the leads shall be returned to their approximate original position.

3.5 Procedure for rigid leads or terminals. A lead or terminal shall be considered rigid if it is not intended to be flexed in mounting, and not covered in 3.3 or 3.4. Devices with terminals complying with this description shall be subjected to a normal mounting operation and removal, unless otherwise specified. When the normal mounting/removal operation is destructive to the terminals (e.g., terminal weld, wire wrap), the initial conditioning need not be performed.

3.6 Failure criteria. When examined using magnification between 10X and 20X after removal of the stress, any evidence of breakage, loosening, or relative motion between the terminal lead and the device body shall be considered a device failure. When specified, post-test measurements (see 4) shall be made after visual examination. When the above procedures are used as initial conditioning in conjunction with other tests, these measurements may be conducted at the conclusion of that test or sequence of tests.

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)

TEST CONDITION B_2 - LEAD FATIGUE

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

3.1 Procedure for dual-in-line packages. The leads to be tested shall be subjected to three cycles of test condition B_1 and shall be subjected to a force sufficient to bend the leads as specified in 3.4 of condition B_1.

3.2 Procedure for flat packages and can packages. A force of 0.229 ±0.014 kg (8 ±0.5 ounces), unless otherwise specified, shall be applied to each lead to be tested for three 90° ±5° arcs of the case. For leads with a preplated or prefinished section modulus equal to or less than that of a rectangular lead with a cross section of 0.16 x 0.51 mm (0.006 x 0.020 inches) or round leads with a cross section of 0.51 mm (0.020 inch) in diameter, the force shall be 0.085 ±0.009 kg (3 ±0.3 ounces). Section modulus is defined as $bc^2/6$ for rectangular leads, and 0.098 $(\phi b_1)^3$ for round leads (see MIL-STD-1835). 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. A bending cycle shall be completed in from 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.

3.2.1 Optional procedure for fine pitch/small leads. 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 3.2 shall apply: Weight = (area in square inches) x 2.1 % x (K psi) x 453.6 grams/lb. Where K is based on the ultimate tensile strength (UTS) for a particular material. Typical value for kovar and alloy 42 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.

NOTE: A lead pitch of less than or equal to 25 mils is considered fine pitch.

Material	UTS in psi
Kovar	75000
Alloy 42	71000

3.3 Failure criteria. A broken lead on a device shall be considered a failure. When examined using magnification between 10X and 20X after removal of the stress, any device which exhibits any evidence of breakage, loosening, or relative motion between the terminal lead and the device body shall be considered a device 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).

TEST CONDITION C_1 - 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 evidence of breakage, loosening, or relative motion between the terminal (lead) and the device body 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 ±0.145 kg-mm (2.0 ±0.2 ounce-inch) (see 3.2).

d. See general summary above.

TEST CONDITION C_2 - 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 ANSI/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 3.1).

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.

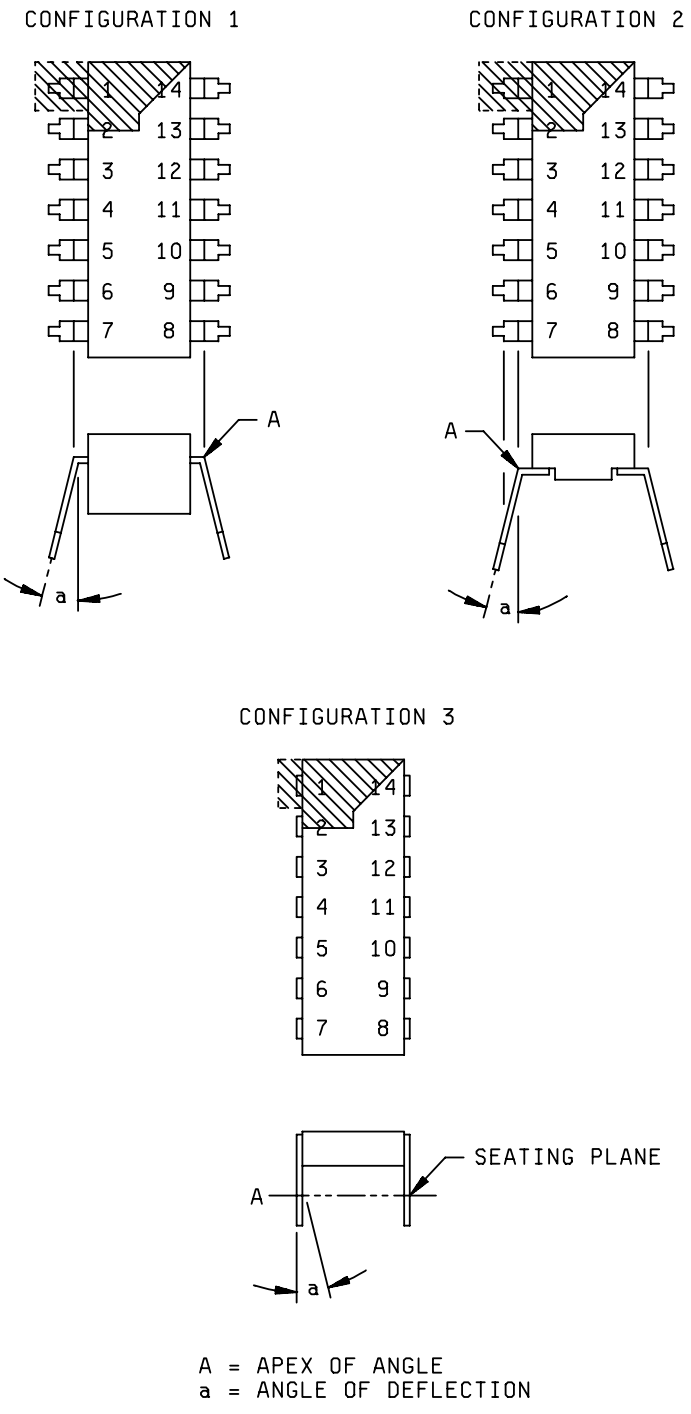
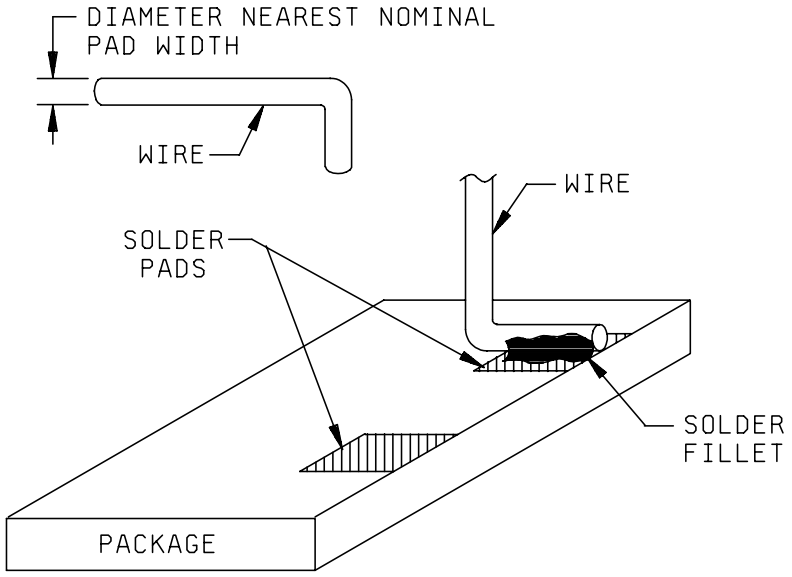


FIGURE 2004-1 Angle of bend for dual-in-line package configurations.



MATERIALS

Flux: Flux type symbol “A” or “B” (flux type “L0” or “L1”) in accordance with ANSI/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 ANSI/J-STD-006 (previously designated as Sn 60 or Sn 63 in accordance with QQ-S-571).

Wire: Soft annealed solid copper.

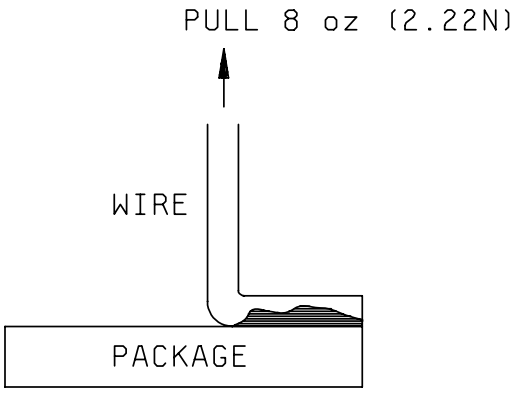


FIGURE 2004-2 Solder pad adhesion.