* 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 B_1 provides for application of bending stresses to determine integrity of leads and seals. Test condition 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. 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 $bh^2/6$ (width x thickness $^2/6$) for rectangular leads, and 0.098 (ϕb1)3 or $.098D^3$ 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 A_1 – 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 B_1 - 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 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 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 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.

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)

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. 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.

Material	UTS in psi
Kovar	75000
Alloy 42	71000
Copper 101	43,500
Copper 110	31,900

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 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 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 ±0.145 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 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 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.

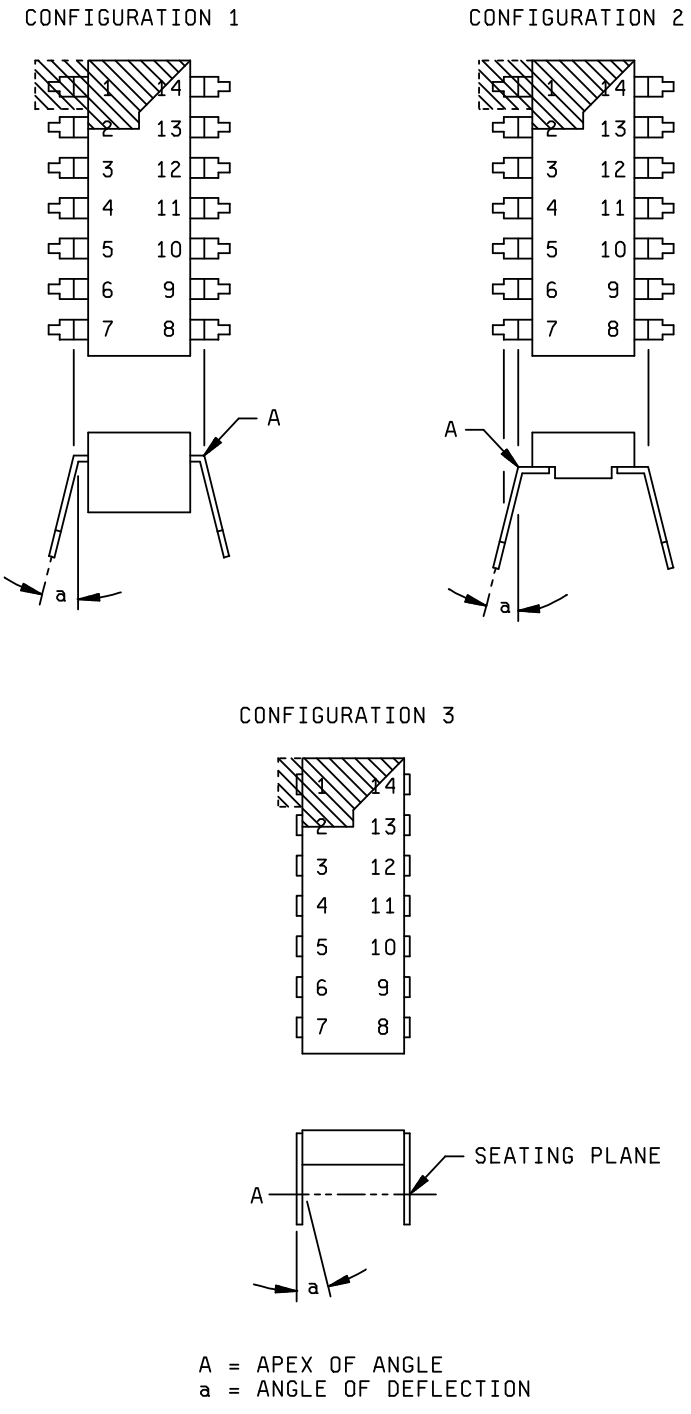
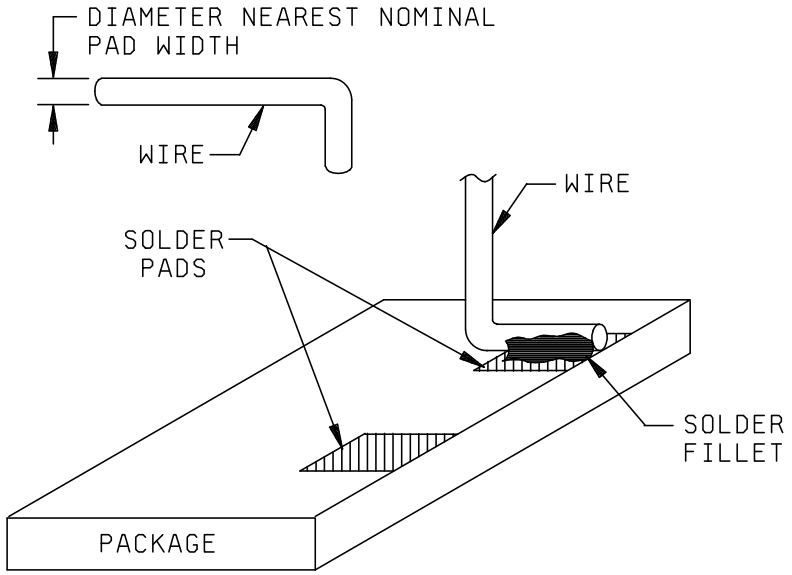


FIGURE 2004-1 Angle of bend for dual-in-line package configurations.



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.

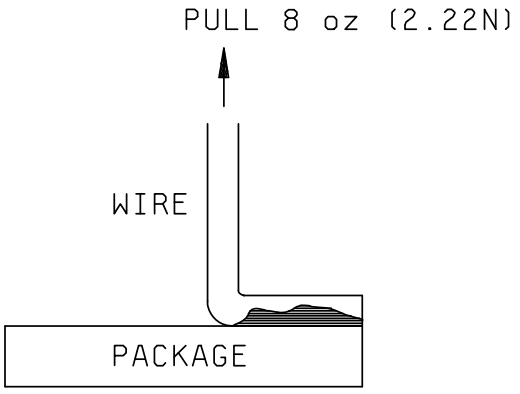


FIGURE 2004-2 Solder pad adhesion.

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