



Standard of Japan Electronic and Information Technology Industries Association

JEITA ET-7409/104

**Surface mount technology -
Environmental and endurance test methods
for solder joint of surface mount device
Part 104: Monotonic bending strength test**

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Introduction

The mechanical properties of the joint between a terminal to a land on a printed wiring board using lead free solder are not the same for the joint using tin-lead solder due to the difference in composing elements of the solders. Thus it becomes important to test the mechanical properties of solder joints, using different solder alloys.

1 Scope

The method is designed to test and evaluate the endurance of the solder joint between component terminals and lands on a substrate, by means of a monotonic bending type mechanical stress.

This test is applicable to evaluate the effects of repeated temperature change on the strength of the solder joints between terminals and lands on a substrate.

In this test method, the test specimens are mounted on a substrate by reflow soldering. The durability of the solder joint is evaluated by exposing the electronic components to a rapid change of temperature and applying a shear stress to the solder joint.

The exposure temperatures in this test may exceed the rated temperature range of the specific electronic component.

This test is not a test to measure the strength of the electronic components. The test method to evaluate the robustness of the joint to a board is described in the following standard.

JIS C 60068-2-21:2002, Environmental testing - Part 2-21: Tests - Test U: Robustness of termination and integral mounting devices

Note IEC 60068-2-21:1999, Environmental testing - Part 2-21: Tests - Test U: Robustness of termination and integral mounting devices (MOD)

The area of a joint to be evaluated is illustrated in **Figure 1**.



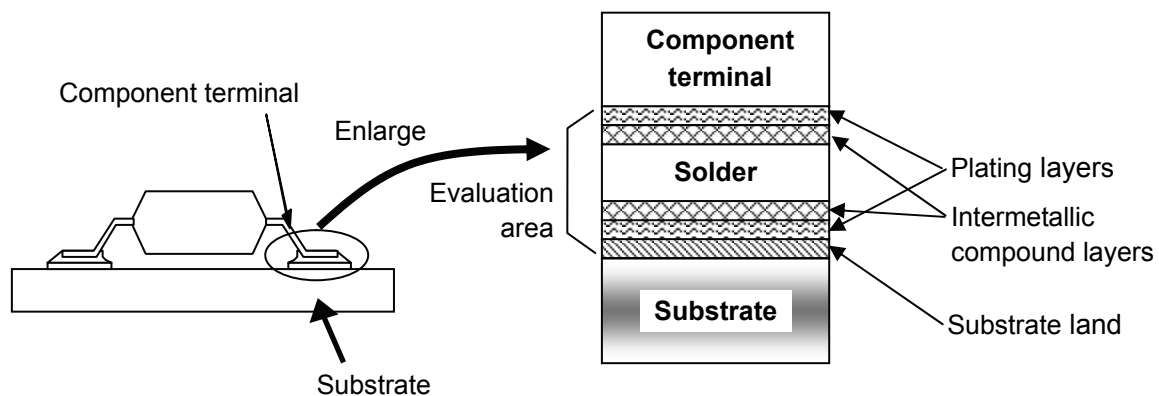


Figure 1 – Area under evaluation in the shear strength test

The shear strength test is applicable to most leadless surface mounting devices, except multi-leadless components (QFN, LGA etc.) and gull-wing lead components to which a pull strength test is applicable. This torque shear strength test is applicable to those components to which the shear strength test is not applicable or as the product specification specifies the use of the torque shear strength. This test is applicable to those components whose length is long compared to the width, such as connectors.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated reference, only the edition cited applies. For undated reference, the latest edition of the referenced document (including any amendment) applies.

JEITA ET-7501/10X series standards, Land pattern design for surface mount devices (SMDs): Sectional requirements

Note All the items referred in **JEITA ET-7501/10X** are equivalent to the items described **IEC 61188-5-X**, Printed boards and printed board assemblies - Design and use - Part 5-X.

JIS C 60068-1:1993, Environmental testing - Electricity and electronics Part 1: General and guidance

Note All the clauses referred to **IEC 60068-1:1988**, Environmental testing Part 1: General and guidance, and Amendment 1 are equivalent to the clause in this **JIS** document. **JIS C 60068-1:1993** is identical to **IEC 60068-1:1988**.

JIS C 0025:1988, Environmental testing (Electricity and electronics) - Part 2: Test N: Change of Temperature

Note All the clauses referred to **IEC 60068-2-14:1986**, Environmental testing - Part 2: Test N: Change of Temperature and Amendment 1:1986 and **IEC 60068-2-33:1971**, Environmental testing - Part 2: Tests. Guidance on change of temperature tests are equivalent to the clause in this **JIS** document.

JIS C 5603:1993, Terms and definitions for printed circuits

Note All the items referred to **IEC 60194-3ed** are equivalent to this document. **IEC 60194-4ed:1999** and **IEC 60194-5ed:2006** are published, however, the corresponding **JIS** document is not prepared yet.



JIS C 6484:2005, Copper-clad laminates for printed wiring boards - Epoxide woven E-glass laminated sheet of defined flammability

Note All the clauses referred to **IEC 61249-2-7:2002**, Materials for printed boards and other interconnecting structure - Part 2-7: Reinforced base materials clad and unclad - Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad and **IEC 61249-2-8:2003**, Materials for printed boards and other interconnecting structure - Part 2-8: Reinforced base materials clad and unclad - Modified brominated Epoxide woven fiberglass reinforced laminated sheets of defined flammability (vertical burning test), copper-clad are equivalent to the clause in this **JIS** document.

IEC 61190-1-2:2007, Attachment materials for electronic assembly - Part 1-2 Requirements for solder pastes for high-quality interconnections in electronics assembly

3 Terms and definitions

For the purposes of this document, the terms and definitions in **JIS C 60068-1** and **JIS C 5603**, as well as the following, apply.

3.1

monotonic bending strength

the strength of solder joints expressed in the maximum bending depth when the substrate on which a specimen is mounted is bended in convex until the solder joints break.

3.2

displacement rate

the moving velocity of the indenter of the bending jig.

4 Test equipment and materials

4.1 Test equipment for monotonic bending strength test

The equipment for monotonic bending test consists of a tension-compression testing machine, a substrate bending jig, a resistance measurement instrument and a recorder. Details of the test equipment are described in the **Annex 2**.

4.2 Test substrate

Unless otherwise prescribed by the product specifications, the test substrate shall meet the following conditions.

a) Material

The material shall be epoxide woven glass fabric copper-clad sheet laminated to single or double sided as specified in **JIS C 6484**.

b) Board thickness

The thickness of a test board shall be 1.6 mm $\pm$ 0.2 mm including the thickness of copper foil, or another thickness specified in **JIS C 6484**.

c) Size

The length of the long side of a test substrate shall be 130 mm and the length of the short side shall be from 30 to 60 mm, adjusted to the size of the testing component to be mounted on the substrate. The substrate shall be able to be fastened to the monotonic bending test equipment.



d) Land geometry

The shape and size of the lands used in the testing board shall comply with **JEITA ET-7501/10X series standards** or other relevant standards.

e) Thickness of the copper lands

The thickness of lands shall be selected from the specification given in **JIS C 6484**. It is desirable that the land should not be made at the both ends of the board, the ends where the board is fastened to the base of the testing machine.

Note The thickness of copper foil of the board for surface mounting is usually from 35 μm to 45 μm .

f) Anti-rust treatment

Pre-flux is coated over copper lands to prevent oxidation.

4.3 Solder

Unless otherwise prescribed by the product specification, the composition of the solder to be used shall be Sn96.5Ag3.0Cu0.5.

4.4 Solder paste

Unless otherwise specified, the solder paste used in this test shall comply with **IEC 61190-1-2**. The solder alloy specified in **4.3** shall be used for the solder paste.

4.5 Reflow soldering oven

The reflow soldering oven shall be able to realize the temperature profile given in **Figure 2** in **5.1**.

4.6 Surface mount component for testing

Unless otherwise prescribed by the product specification, the SMD to be tested shall have the structure that enable the measurement of electrical resistance, for example the daisy chain.

Note In connecting daisy chain, care should be given prevent braking of wiring pattern, such as by drawing the wiring pattern forth from a shorter direction, not from a longer direction of the board.

5 Mounting method for reflow soldering

Unless otherwise specified, the following steps shall be taken.

- a) Apply the solder paste specified in **4.8** to the lands of a test substrate as specified in **4.6 d)**, using a metal mask with openings of the same size, shape and configuration as the lands on the substrate, made of stainless steel with a thickness of 100 μm to 150 μm .
- b) Mount the test specimen on the test substrate with solder paste applied.
- c) Use the reflow soldering equipment specified in **4.5** to solder the terminals under the conditions given below. A typical temperature profile of reflow soldering is given in **Figure 2**. The temperature is measured at the land.



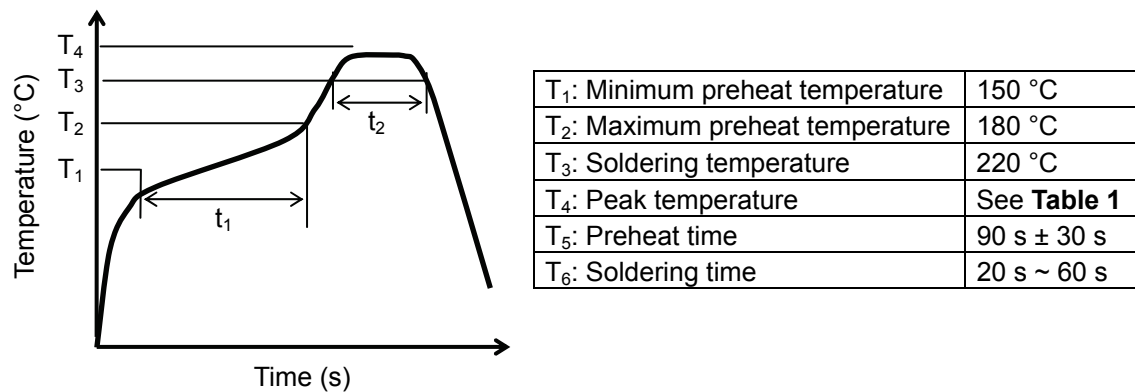


Figure 2 – An example of reflow temperature profile

Table 1 – T₄ (land temperature)

Component	T ₄
thickness < 2.5 mm volume < 350 mm ³	240 °C ± 5 °C
thickness < 2.5 mm volume ≥ 350 mm ³	230 °C ± 5 °C
thickness ≥ 2.5 mm	230 °C ± 5 °C

6 Test conditions

Unless otherwise specified, the following test conditions apply.

6.1 Rapid change of temperature test

- Rapid change of temperature; test Na, specified in **JIS C 0025**.
- The lower temperature is -40 °C and the higher temperature is +125 °C.
- The exposure time to both higher and lower temperatures is 30 min.
- The number of temperature cycles is 0 (start of the test), 500 and 1 000.

6.2 Monotonic bending strength test

The test shall be made using the monotonic bending strength test equipment as described in **4.1**. Details of the test method are described in **Annex**.

7 Test

7.1 Test procedure

Unless otherwise specified, the sequence of tests shall comply with **Figure 3**.

Note This test is a destructive test. The monotonic bending strength test shall not be made before the rapid temperature change test to the specimens to be measured at an intermediate point and at an end of the rapid temperature change test.



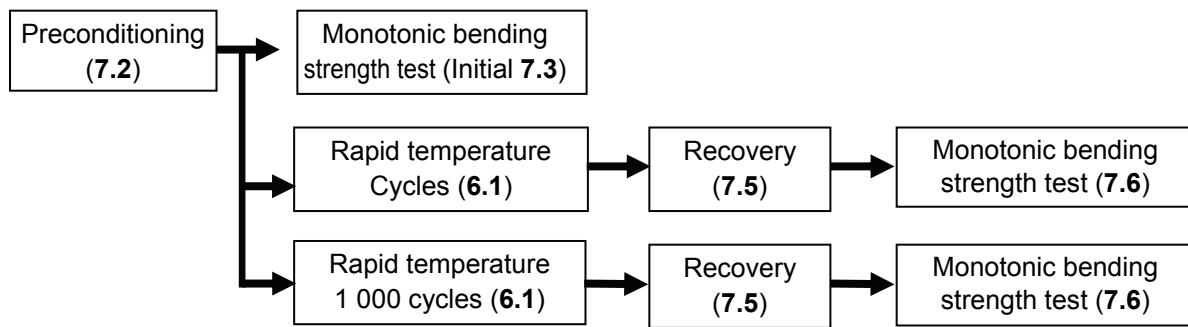


Figure 3 – Test procedure

7.2 Preconditioning

Flux elimination should be specified in the product specification. Unless otherwise specified, leave the specimen for more than four (4) hours at the standard atmospheric conditions for measurements and tests (specified in **JIS C 60068-1, 5.13**).

7.3 Initial shear strength

Unless otherwise specified, after preconditioning as specified in **7.2**, the shear strength test as specified in **6.2** shall be performed. The value of the force needed to break the joint and the failure mode (see **Figures 4 to 6**) shall be recorded.

7.4 Rapid change of temperature

Perform the test as specified in **6.1**.

7.5 Recovery

After finishing the specified temperature cycles, leave the specimen for more than four (4) hours at the standard atmospheric conditions for measurements and tests (specified in **JIS C 60068-1, 5.13**).

7.6 Intermediate/final shear strength

Unless otherwise specified, the shear strength test as specified in **6.2** shall be performed. Record the result of the strength test.

8 Items to be included in the test report

The items shall be selected from the following list as agreed between user and supplier and recorded in the test report of this monotonic bending strength test.

- a) Date of test
- b) Name of the test organization
- c) Name of the electronic component, type, size, dimensions
- d) Material of the component terminals, and surface finish
- e) Material of the test substrate, size, structure of layers
- f) Geometry of substrate lands and surface finish
- g) Types of solder alloy and solder paste used for reflow soldering
- h) Temperature profile of reflow soldering and the atmosphere (oxygen content, if soldered in nitrogen atmosphere)



- i) Test condition of rapid temperature change test and number of cycles
- j) Type of torque shear strength test equipment
- k) Details of setting of the substrate (illustration(s) recommended)
- l) Displacement rate of the torque shear
- m) Displacement position adjustment of torque shear jig to substrate
- n) Details of the torque jig
- o) The torque shear strength value to break the solder joint
- p) The failure mode in torque shear strength test

9 Items to be stated in the product specification

Product specification shall be specified following items.

- a) Monotonic bending strength test (4.1)
- b) Jig (4.2)
- c) Test substrate (4.2)
- d) Solder (4.3)
- e) Solder paste (4.4)
- f) Mounting method (5)
- g) Test condition (6)
- h) Rapid change of temperature (7.4)
- i) Preconditioning (7.2)
- j) Initial shear strength (7.3)
- k) Recovery (7.5)
- l) Items for evaluation (7.7)

10 Related standards

JEITA ET-7409, Surface mount technology - Environmental and endurance test methods for solder joint of surface mount device or lead terminal type device: Selection of the test methods

JIS C 60068-2-21:2002, Environmental Testing-Test U: Robustness of terminations and integral mounting devices

JIS Z 3198-7:2003, Test methods for lead-free solders - Part 7: Shear test of soldered joints of chip component



Annex A (normative) Monotonic bending strength test - Details

A.1 Scope

Annex specifies details of the monotonic bending strength test given in 6.2.

A.2 Monotonic bending strength test equipment

Unless otherwise specified in the product specification, the monotonic bending strength test equipment shall be as follows.

A.2.1 Testing machine

The testing machine shall be as follows,

- a) The machine shall be able to push the indenter at a specified speed to the specified displacement (maximum of 20 mm). The precision of the displacement measurement should be ± 1 % of the indication on the test machine (setting value).
- b) The machine should be able to measure the force applied to the indenter and the displacement with time passage.

A.2.2 Substrate bending jig

The substrate bending jig should be able to support the specimen with the face down of the component side of the printed circuit board, push the center of the substrate down with the indenter. Unless otherwise specified by the product specifications, the jig shall be as follows.

Note The structure of the substrate bending jig shall be as **Figure A-1**.

a) Material

The material of the jig shall be steel.

Note It is recommended to use high strength steel to prevent deformation due to cyclically testing.

b) Indenter

The radius of the indenter shall be $5 \text{ mm} \pm 0.2 \text{ mm}$.

c) Supporting jig

The radius of the supporting jig shall be $2.5 \text{ mm} \pm 0.2 \text{ mm}$.

d) Distance between supporting jigs

The distance shall be $90 \text{ mm} \pm 1 \text{ mm}$.

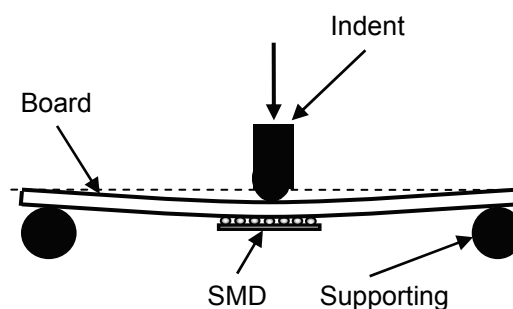


Figure A-1 – An example of board bending jig

A.2.3 Electrical resistance measuring instrument

The electrical resistance measuring instrument should have the mechanism to verify electrical continuity and discontinuity on the test substrate and to be able to judge as interruption when resistance value exceed $1 \times 10^3 \Omega$. In order to detect electrical discontinuity of least quantity, a desirable instrument is the one that can detect momentary continuity interruption of 10 to 100 μs .

A.2.4 Recorder

The recorder should record displacement and force with time passage during the test.

A.3 Test procedure

Unless otherwise specified by the product specifications, the test procedure shall be as follows.

a) The test substrate shall be fixed to the substrate bending jig as follows.

- 1) First, solder lead-wire to terminals (daisy chain) used for monitoring electrical resistance on the substrate, and then connect the wire to a momentary interruption detector.
- 2) Confirm that the centers of supporting jigs are at the same distance from the center of the indenter (45 mm $\pm$ 0.5 mm).
- 3) The test substrate is set on the testing machine with the face down of the surface mount component side. Adjust the position such that the indenter will push at the center of the substrate.
- 4) Make sure that the indenter is at the center position by having it in contact with the substrate.

Note Keep pushing the substrate until a force of 1 N $\pm$ 0.1 N is apply to confirm that the indenter is actually in connect with the substrate.

- b) Depress the indenter to the substrate until the electrical discontinuity will be detected. Record the applied force, displacement and the electrical resistance of the Daisy chain.
- c) A solder joint is considered failure when the circuit is confirmed as “open”. Record the monotonic bending strength at this moment.

Note Unless otherwise specified by the product specification, the maximum displacement shall be 20 mm. The test shall be terminated when the conduction failure is not observed with this displacement.

- d) Observe the joint failure when necessary. Check and record the failure mode.

A.4 Displacement rate

Unless otherwise specified by the product specification, the displacement rate shall be selected in the range of 0.0083 mm/s to 0.1 mm/s (0.5 mm/min ~ 6 mm/min).

Note The proper displacement rate is to induce solder joint failure in several tens of seconds to several minutes.



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