JEITA

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Surface mount technology - Environmental and endurance test methods for solder joint of surface mount device Part 103: Torque shear strength test

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Standards of Japan Electronics and Information Technology Industries Association

Surface mount technology - Environmental and endurance test methods for solder joint of surface mount device Part 103: Torque shear strength test

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 torque shear 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**.

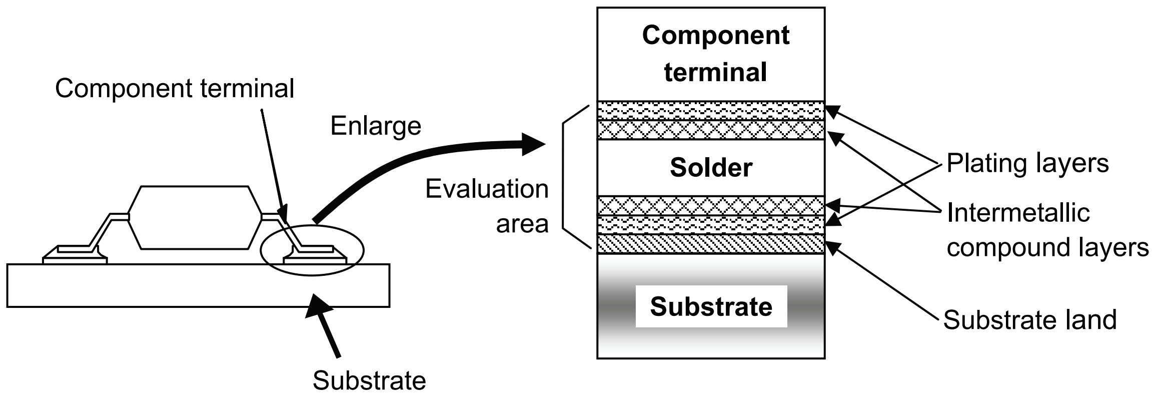


Figure 1 – Area under evaluation in the shear strength test

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**: 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

torque shear strength

maximum force applied to a component using a jig when a rotation moment is applied to both ends of the component in parallel to the surface of the board at the center of the component as the rotation center to break the joint of SMD mounted on aboard.

3.2

displacement rate

rotation speed of moving the jig, which is used to break the joint.

Note radial rotation speed of the jig used in this standard (rad/s or deg/s).

4 Test equipment and materials

4.1 Torque shear strength test equipment

Unless otherwise specified, the torque shear strength test equipment with the following features shall be used for the torque shear test.

The equipment shall have the mechanism to fasten the PWB on a base, shall be able to apply the shear force larger than the joint force between the lead of a SMD and land on the board, and shall be able to measure the torque shear strength of pushing by the side of the SMD. It is desirable that the distance between the bottom of the pushing jig and the board can be precisely controlled. The accuracy of the measurement of the torque shear force shall be better than ±1 % of the measured value. It is also desired that the displacement rate is within ±1 % of the predetermined value.

4.2 Jig for torque shear force application

Unless otherwise specified, the torque shear strength test jig shall have the following properties.

The jig shall have the machined rotating section as illustrated in **Figure A-2** and **Figure A-3** adjusted to the shape of the component to be tested in the evaluation of torque shear strength of the component. The center of the machined section is the center of the jig. The material for the jig is such as carbon steel (SK steel).

4.3 Optical microscope

The microscope shall be able to observe an object with a magnification approximately of 50X to 250X. It shall also be equipped with a lamp that can give an illumination level of approximately 2 000 lx to the object.

4.4 Scanning electron microscope (SEM)

The scanning electron microscope shall be able to generate a focused electron beam probe of 3 nm to 10 nm using an electric lens system and can scan over a specimen held in a vacuum chamber. The SEM shall detect secondary electrons or reflected electrons and display an enlarged image of the detected signal on a CRT or another display device.

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 Test substrate

Unless otherwise prescribed by the relevant specification, the test substrate shall be meet the following specifications.

a) Substrate material

The material of a testing substrate shall be glass fabric copper-clad laminated single or double sided substrate as specified in **JIS C 6484**.

b) Substrate thickness

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

c) Size of the substrate

The size shall be such that the board can be fastened to the test equipment. The size of the substrate depends on the size and shape of a surface mount device soldered on the substrate. The substrate shall be able to be fastened to the torque shearing test equipment.

d) Shape of the lands

The shape and size of a land shall comply with **JEITA ET-7501/10X**.

e) Thickness of the copper lands on test substrate

The thickness of lands shall be selected from the specification given in **JIS C 6484**.

Note The thickness of copper foil of the substrate for surface mounting is usually 35 μm to 45 μm including plating.

f) Anti-rust treatment

Preflux is coated over copper lands to prevent rusting of the land surface.

4.7 Solder

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

4.8 Solder paste

Unless otherwise specified, the solder paste used in this test shall comply with **IEC 61190-1-2**. The solder alloy specified in **4.7** shall be used for the solder paste.

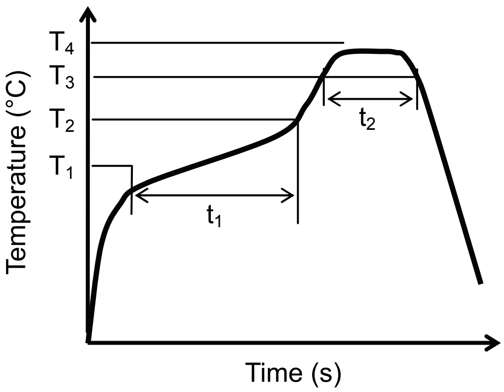
5 Mounting method for reflow soldering

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.



T_1: Minimum preheat temperature	150 °C
T_2: Maximum preheat temperature	180 °C
T_3: Soldering temperature	220 °C
T_4: Peak temperature	See **Table 1**
T_5: Preheat time	90 s ± 30 s
T_6: Soldering time	20 s ~ 60 s

Figure 2 – An example of reflow temperature profile

Table 1 – T_4 (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

a) Rapid change of temperature; test Na, specified in **JIS C 0025**.

b) The lower temperature is -40 °C and the higher temperature is +125 °C.

c) The exposure time to both higher and lower temperatures is 30 min.

d) The number of temperature cycles is 0 (start of the test), 500 and 1 000.

6.2 Torque shear strength test

The test shall be performed according to the test procedure described in **Annex A**.

Use the jig specified in **4.2.1**.

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 tested specimen is not to be used for further tests in the test sequence.

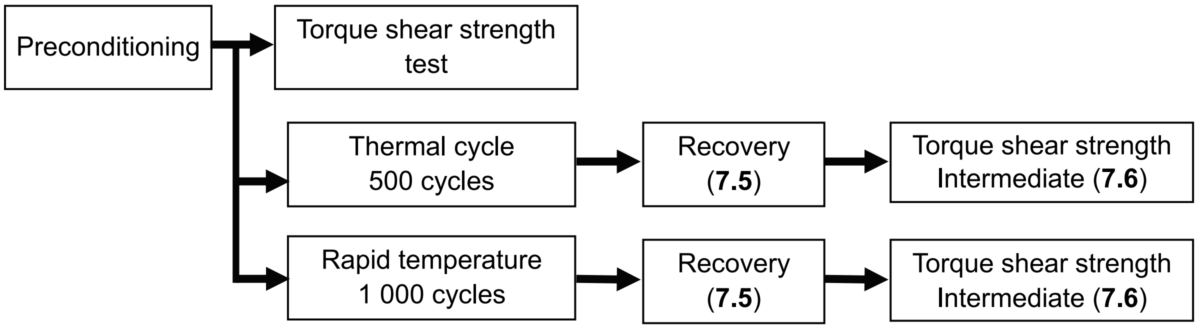


Figure 3 – Test procedure

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. The value of the force needed to break the joint and the failure mode (see **Figures 4** to **6**) shall be recorded. Observe the soldered joint using the optical microscope specified in **4.3**. Observe the broken joint precisely if there is any doubt to the result of the torque shear strength test using a scanning electron microscope as specified in **4.4**.

7.7 Items for evaluation

The items for evaluation are stated below in addition listed in the product specification.

Check the change of torque shear strength before and after the designated rapid change of temperature.

Record the break and failure mode of both the lead of the component mounted and the soldered joint after the torque shear strength test. The failure mode are shown in **Figures 4**, **5** and **6**.

8 Items to be included in the test report

When a test report is required, agreement shall be made between the reporting party and the recipient on the selection of reporting items from the following.

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) Torque shear strength test equipment (**4.1**)
b) Jig (**4.2**)
c) Test substrate (**4.6**)
d) Solder (**4.7**)
e) Solder paste (**4.8**)
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

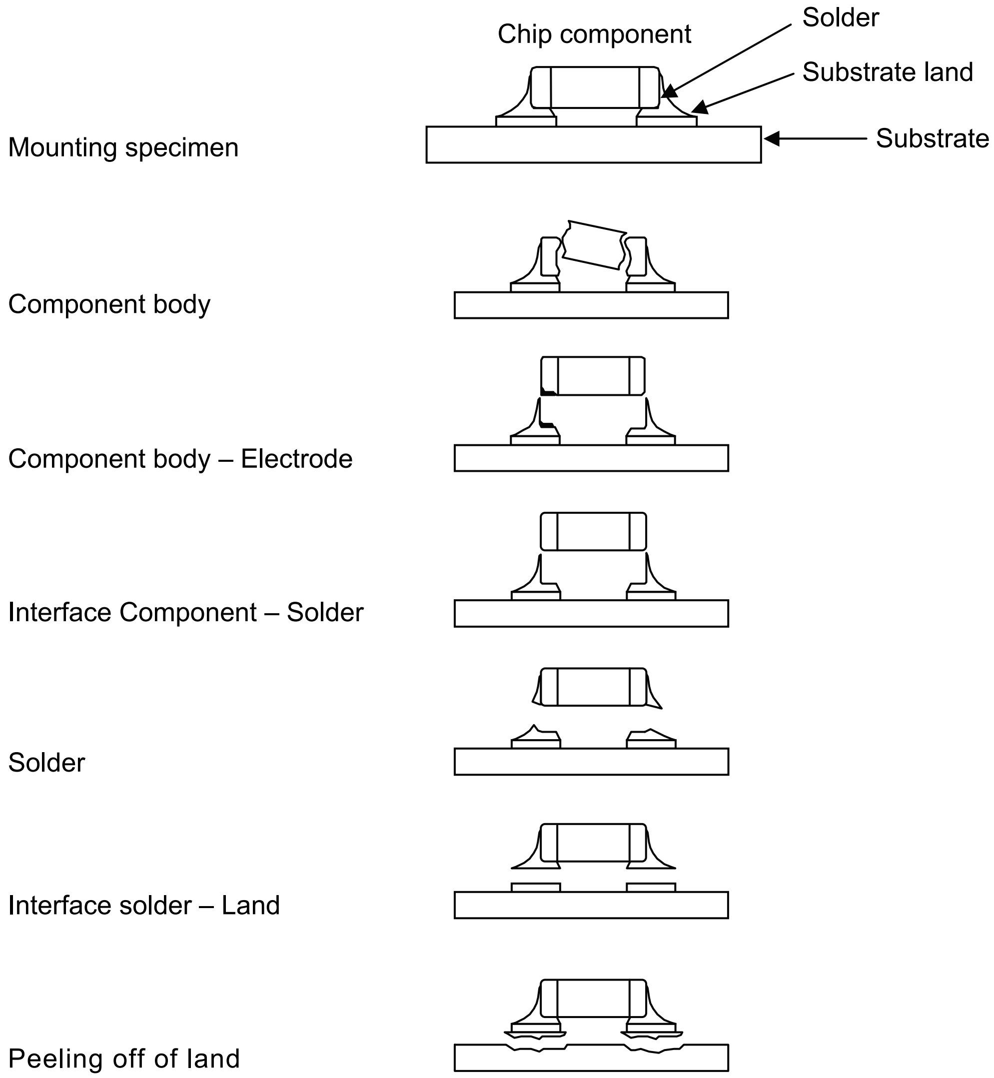


Figure 4 – Failure modes in torque shear strength test
(5-faced electrodes)

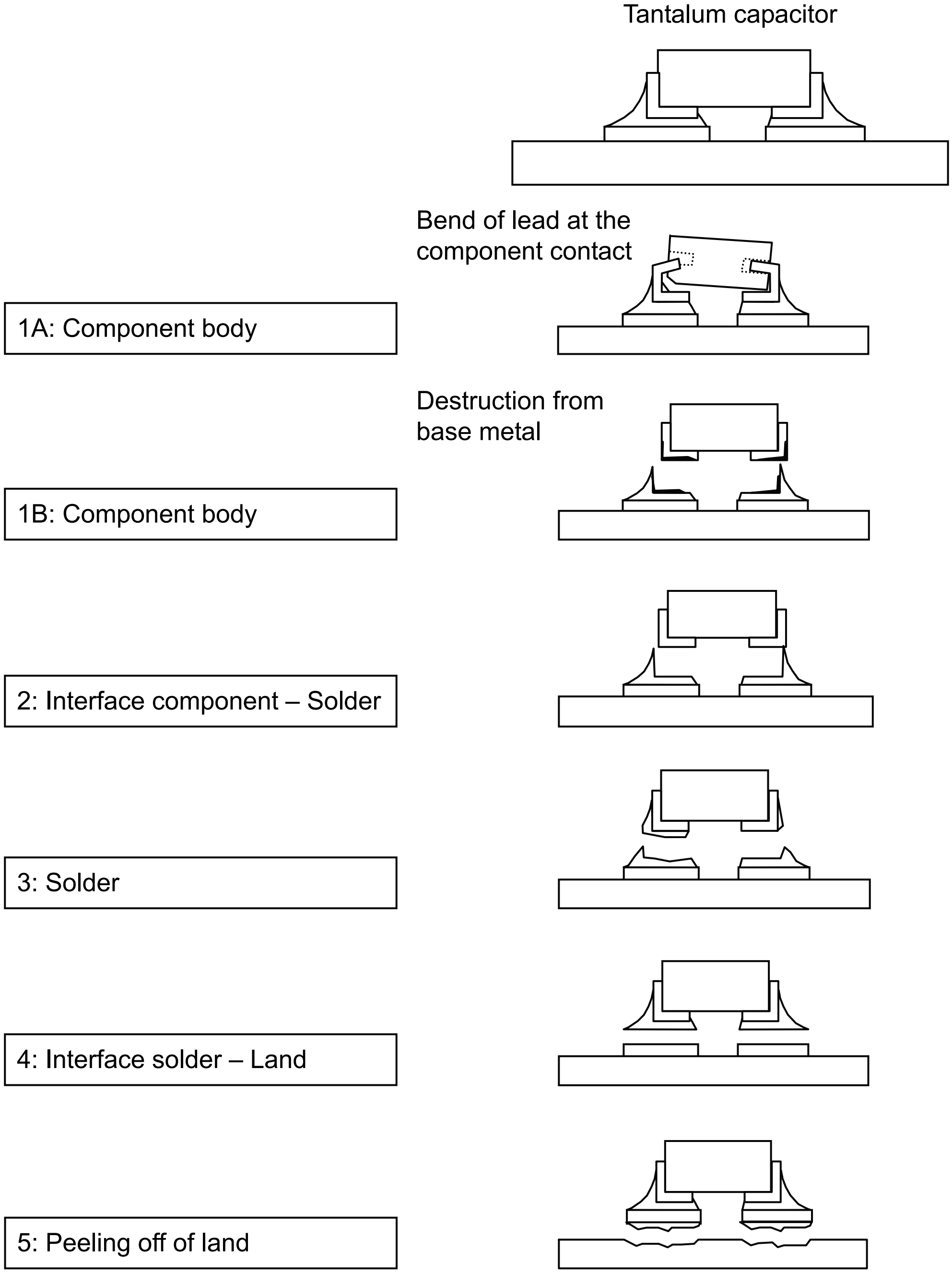


Figure 5 – Failure modes in torque shear strength test

(Two electrodes type)

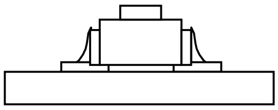
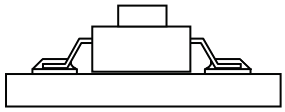
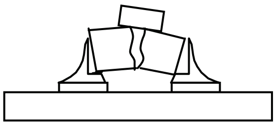
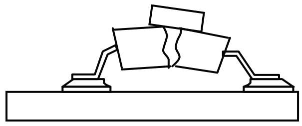
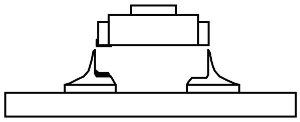
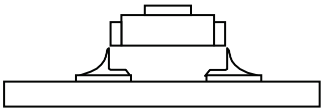
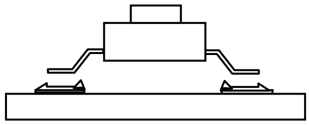
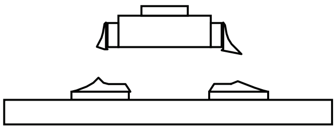
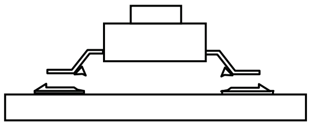
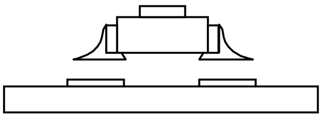
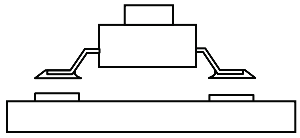
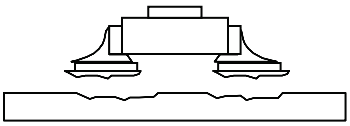
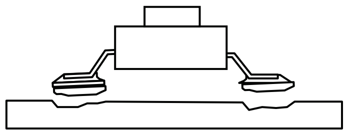
Code	Failure mode	Example (Switch)	
	Mounted specimen	Switch 	Switch (lead terminal) 
1A	Component body		
1B	Component body – Electrode		
2	Interface component – Solder		
3	Solder		
4	Interface solder – Land		
5	Peeling off of land		

Figure 6 – Failure modes in torque shear strength test
(Switches)

Annex A
(normative)
Torque shear strength test - Details

A.1 Object

Annex specifies details of the shear strength test given in **6.2**.

A.2 Test method

The test shall be made using the torque shear strength test equipment specified in **4.1** of the main text of this document and the torque shear jig specified in **4.2.1** in accordance to the following test method.

A.2.1 Preconditioning

Pre-conditioning is specified in **7.2**.

A.2.2 Fixing of the test board

The test board with SMDs mounted shall be fastened to the specimen holding jig using bolts. The test board shall be fastened to the holding jig at the four corners of the board, or by inserting it into the jig at the shorter edges of the board as shown in **Figure A-1**. The test board shall not bend when the shear force is applied to the component. At the application of a torque shear force, a rotation moment is induced to the test board.

A.2.3 Applying of Torque shear force

The test equipment shall be able to adjust the rotation speed in applying torque and should have a scheme that the rotation axis is held vertical to the test board.

A.2.3.1 Displacement rate

Derive the approximate maximum torque before a torque shear strength test by means of a preliminary test using an initial specimen. Choose the displacement rate of the torque shearing jig in a torque shear strength test from the obtained approximate torque in the preliminary tests as to the maximum torque is attained in several tens of seconds to several minutes.

Note The displacement rate is not specified in this standard but it is desirable to select a displacement rate in the range of 0.00698 rad/s to 0.0175 rad/s (0.4 deg/s to 1.0 deg/s) when the test equipment is capable of adjusting the displacement rate.

In the case the displacement rate is not adjustable, rotate the rotation jig as to the torque reaches to the maximum torque in several tens of seconds to several minutes.

A.2.3.2 Position adjustment of torque shear strength test jig

The torque shear strength test jig covers vertically over the test board and then the jig is rotated slowly for torque shear force (see **Figure A-2**). The rotation axis in applying the torque shall be adjusted to the center of the component mounted on the board. It is advisable to use a holding jig to suppress the deviation/vibration of rotation axis is plausible.

A.2.3.3 Torque shear strength test failure

The torque shear strength test jig is placed vertically over the component and slowly rotated. Care should be made that the torque meter is kept perpendicular to the board. The rotating speed shall be 0.00698 rad/s to 0.0175 rad/s (0.4 deg/s to 1.0 deg/s) when it is adjustable. When the speed is not adjustable, rotate the jig very slowly until the soldered joint breaks.

A.2.4 Torque shear strength test to a connector

It is recommended that the test equipment can adjust the rotation speed and has a scheme to keep the rotation axis perpendicular to the test board.

A.2.4.1 Torque shear strength test jig for a connector

Prepare a torque shear strength test jig as illustrated in **Figure A-3** for the torque shear strength test of a connector adjustable to the soldered joints of the connector and its shape to assist mechanical strength of the connector. It is desirable that this covering jig should in close fitting to the connector with minimum clearance to improve measurement accuracy in the test. The depth, H, of this covering jig should approximately equal to the height of the connector. Place the covering jig on the connector mounted on a test board.

A.2.4.2 Torque shear displacement rate to a connector

A preliminary test shall be made to find an approximate maximum torque shear using an initial specimen. Select the proper displacement rate from the preliminary shearing test of a specimen to find the rotation speed for the displacement rate that the maximum torque is attained at a time of several tens of seconds to several minutes for joint failure.

Note The displacement rate is not specified in this standard but it is recommended to select a displacement rate in the range of 0.00698 rad/s to 0.0175 rad/s (0.4 deg/s to 1.0 deg/s) for the test equipment which can adjust the speed and also radial speed (rotation rate).

In the case the displacement rate is not adjustable, rotate the rotation jig as to the torque reaches to the maximum torque in several tens of seconds to several minutes.

A.2.4.3 Position adjustment of torque shear strength test jig for a connector

The torque shear strength test jig covers vertically over the test board and then the jig is rotated slowly for torque shear force (see **Figure A-3**). The rotation axis in applying the torque shall be adjusted to the center of the component mounted on the board. It is advisable to use a holding jig to suppress the deviation/vibration of rotation axis.

A.2.4.4 Torque shear strength test failure of a connector

The torque strength test shear jig covers vertically over the test board and then the jig is rotated slowly for torque shear force. Care shall be made to keep the torque meter to be in the vertical position against the board. The rotation displacement rate shall be in the range of 0.00698 rad/s to 0.0175 rad/s (0.4 deg/s to 1.0 deg/s) for the test equipment which can adjust the rotation displacement rate. When the equipment is not capable of setting the rotation displacement rate, rotate the torque shear strength test jig very slowly around the connector keeping the rotation axis to perpendicular to the board until the soldered connection breaks.

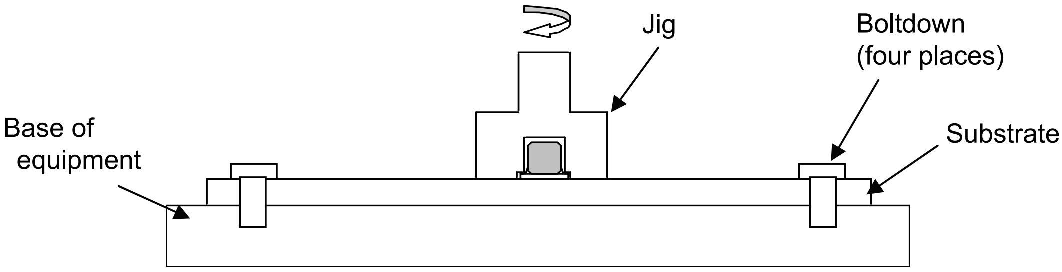


Figure A-1 – Fixing of substrate for torque shear strength test

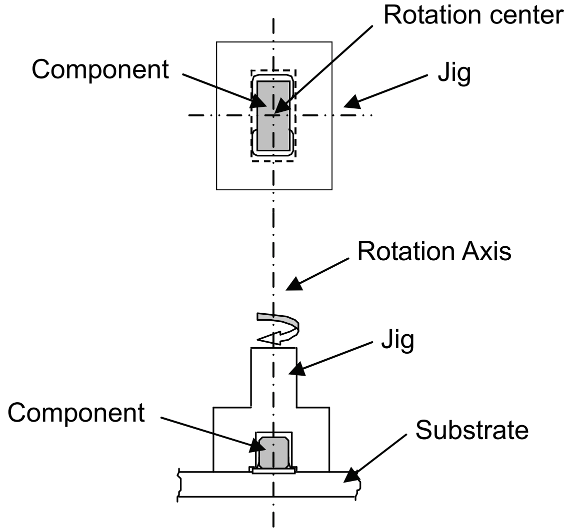


Figure A-2 – Torque shear strength test jig and position adjustment

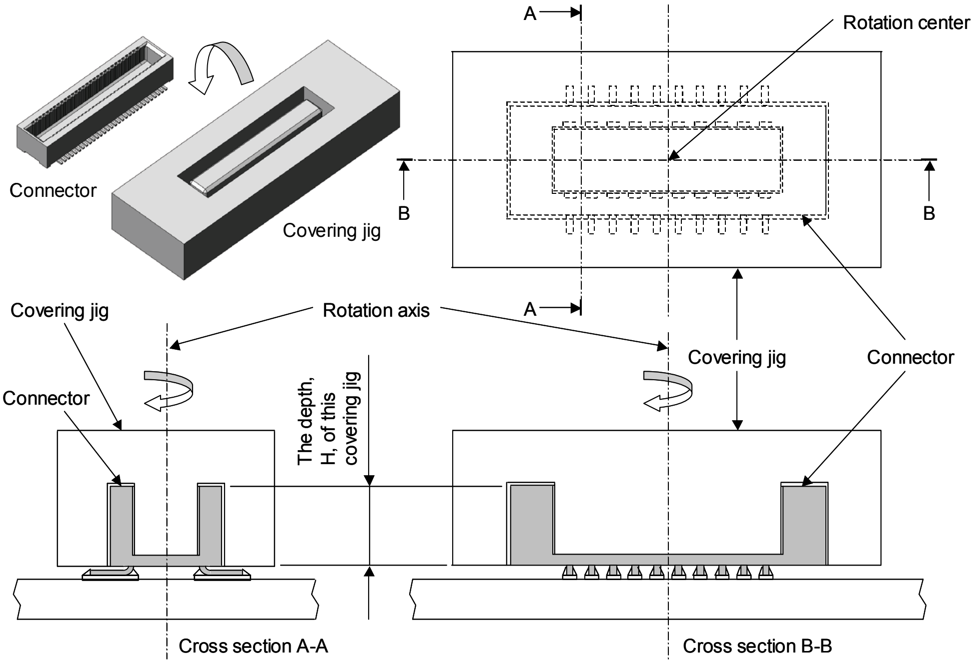


Figure A-3 – Torque shear strength test to a connector

Surface mount technology - Environmental and endurance test methods for solder joint of surface mount device Part 103: Torque shear strength test Additional information

Introduction

The information given here describes items of interest related to the descriptions made in this standard and in the Annex and does not consist of a part of the standard.

1 The purpose and history of establishing this standard

The manufacturing technology of electric and electronic equipment has been shifting from the use of lead-tin solder to lead-free solders especially on the consideration of environmental friendly society. It was noted that one of the factors hindering wide use of lead-free solder was the lack of proper test methods to evaluate the durability of soldered joints being made using lead-free solders. A three-year NEDO project started in 2001 to study test methods which was switched to a METI (Ministry of Economy, Trade and Industry) in the second year of the project, 2002. The Sub-committee of the Durability Test Methods of Soldered Joints in the Standardization Committee of New Assembly technology in **JEITA** (Japan Electronics and Information Technology Industries Association) was organized consisting of experts from the industry and academia to develop this test method based on the discussed made in the Committee and its project groups.

2 Description of Clauses

2.1 Title of this document

This document is a standard in the area of the test methods of surface mounting technology to confirm the durability of soldered joint between the land pattern and lead terminal. There are two shear strength tests, one for the shear strength test by pushing specimen from the side and the other for torque shear strength test. This document is for the torque shear strength test. The title of this document is selected as “Surface mount technology - Environmental and endurance test methods for solder joint of surface mount device - Part 103: Torque shear strength test”.

2.2 Introduction

It is stated that we did not have a document providing the necessary standards of evaluating durability of soldered joint, the reason to develop this standard.

2.3 Scope (See **clause 1** of the main text)

This standard specifies the test method for durability of the soldered joints of leaded electrodes to a board using lead-free solder. The durability of board and components themselves is not the target of this test standard. The rated temperature of SMDs is not considered in this standard.

The regions to be evaluated by this test method are the interface of soldered joint between leads and electrodes of SMDs, solder itself, and the interface between solder and the board.

2.4 Normative references (See **clause 2** of the main text)

IEC 61190-1-2 is added to the list of normative references as explained **2.6** of this information. The **JIS** numbers of environmental tests documents have been changed from the old numbers to the new five-digit **JIS** numbers.

e.g. **JIS C 0010 → JIS C 60068-1**

The reference documents referred to this standard are listed.

2.5 Definitions (See **clause 3** of the main text)

The definitions of those terms specifically used in this standard are listed.

2.6 Test equipment and materials (See **clause 4** of the main text)

The key materials in this clause are the test board, solder and flux.

It is known that the material, thickness and land design of the board affect considerably to the interface of a soldered joint. It is recommended to use the test board specified in **4.6** of the main text when various factors for the board are required to be the same but not specified in a product specification.

The solder specified in **4.7** is chosen for the test if it is not specified in a product specification, however, it is allowed to use the solder actually used in a production line. The solidus and liquidus temperatures of the solder may be quite different from those of the solder specified in **4.7**. Care should be made as the temperature profile shown in **5.1** of the main text may not be appropriate for an actual soldering process.

The standard flux to be used in solder paste was carefully reviewed in the committee. Discussion was made if the flux used for flow soldering might be specified as to the mixture of 25 g of colophony (rosin) specified in **JIS C 0050**, and 75 g of 2-propil alcohol specified in **JIS K 8839** or ethyl alcohol specified in **JIS K 1501**.

We tried to add a statement that “flux with added di-ethyl ammonium chloride (reagent class) of chlorine content of (shown as free chlorine to the content of colophony) up to 0.5 mass % may be used when failure of soldering occurs in flow soldering due to improper selection of flux in soldering components on board”. It was noted that reflow soldering was the main technique for assembly and the solder paste itself should be specified in this document. The above statement of the flux was not included in the text.

The solder paste originally proposed was the paste specified in **JIS C 0054** (draft) being composed of:

a) Solder powder

The size of the powder is as specified in Symbol 3 in **IEC 62290-1-3**, **Table 2**, or equivalent and the shape of the powder grain is sphere.

b) Composition of flux

In mass ratio, polymerized rosin 30 %, modified rosin 30 %, di-ethylen-glycohol-mono-butyl-ether 34.7 %, 1-3-diphenyl-guanyzin-bromhydrite salt 0.9 %, adipin acid 0.5 %, and water added caster oil 4 %.

c) Composition of solder paste

The composition of solder paste is, by mass ratio, solder powder 88 % and flux 12 %. The viscosity of the solder paste is 180 Pa s ± 50 Pa s.

However, this solder paste was not adopted in this standard based on the comment that this solder paste was not appropriate for the use in production lines. The wish from assembly manufacturers of proposing a guidance to the selection of solder was not realized as solder manufacturers were reluctant to disclose compositions of solders, and by the comment that it was not possible to clarify details of solder paste as paste was still in a development stage. Temperature profile of reflow soldering cannot be specified unless solder paste was specified. The solder paste used in this test was finally decided as the one specified in, **IEC61190-1-2**, after serious review of available information.

2.7 Mounting of component on board and preparation of specimen (See **clause 5** of the main text)

The temperature profile of the furnace considerably affects strength of the interface of a soldered joint. It was considered to include both CAP type and HAT type profiles (see **Figures Addition/Info 1a** and **Addition/Info 1b**) used in heat resistance evaluation of SMDs. The conclusion was that It was useless to include both profiles in the torque shear strength test. Only the HAT type temperature profile is shown in this document. The peak temperature was specified depending on the thickness and/or volume of component mounted on board and given in **Table 1** of this document.

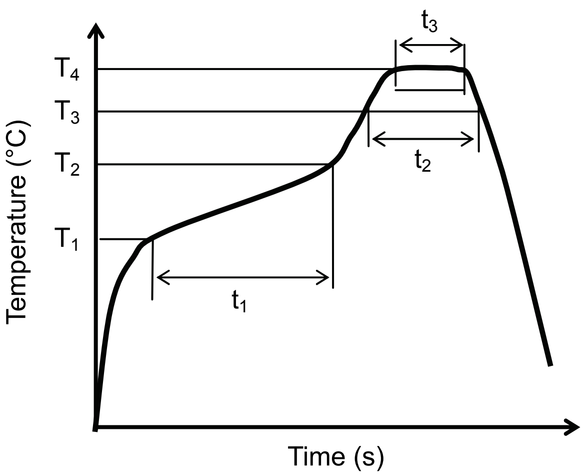


Figure Addition/Info 1a – Hat type profile

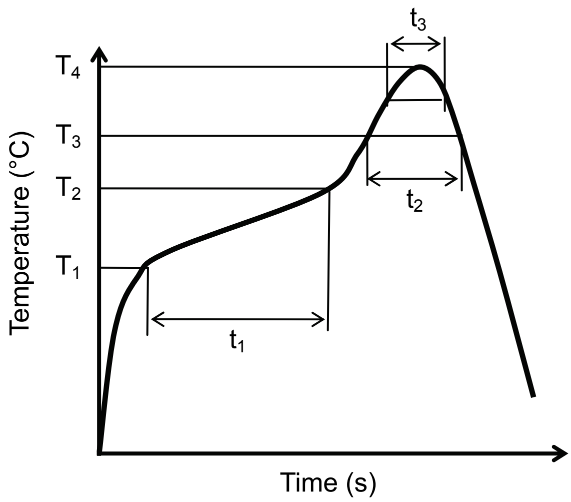


Figure Addition/Info 1b – Cap type profile

T_1: Minimum temperature of preheating
T_2: Maximum temperature of preheating
T_3: Soldering temperature
T_4: Peak temperature

t_1: Preheating time
t_2: Soldering time
t_3: Time to maintain the peak temperature

Figure Addition/Info 1 – Temperature profiles for reflow soldering

2.8 Test condition (See **clause 6** of the main text)

There was a comment that the rapid temperature change test should be made over a temperature range of the rated temperature range of SMDs, however, the temperature range selected in this durability test is beyond the rated temperature range as the test needs to use a temperature where the soldered joint can degrade to a measurable degree.

A maintaining time of 10 min at the high and low temperatures in the rapid temperature change test was considered first but we adopted 30 min as the sum of a temperature stabilizing time of 15 min and a stress relaxation time of 15 min based on the consideration of taking into account of the specific heat of the component and also that of the board.

2.9 Test procedure (See **clause 7** of the main text)

The torque shear strength test to be made before and after the rapid temperature change cycles as shown in the flow chart of the test procedure is a destructive test. The comparison of the results of the tests before and after a rapid temperature change as **clause 7** of the main test is not for the comparison of the results of the same specimen but comparison of the of different groups of specimens.

The ultrasonic cleaning of specimens was originally specified to use 2-propanol as the cleaning fluid. The cleaning equipment was the equipment of the following specification:

a) Frequency
25 kHz ± 4 kHz, or 40 kHz +8/-4 kHz

b) Oscillator Output
10 W/l to 30 w/l

c) Cleaning liquid
2-propanol specified in **JIS K 8839**.

We had a comment from the German National Committee to this document when the document was proposed to **IEC** as an **IEC** standard that the description of the cleaning specification should be deleted from the draft. Existing standards for similar tests do not have a specification of cleaning of this kind. The specification of the cleaning procedure was thus deleted from the **IEC** proposal. In the same time, the description is deleted from the present document.

Cleaning of remaining flux as a pretreatment to the test was originally included in the Annex of the first draft of this document but it is deleted from the present edition. Some people consider that the durability of a soldered joint is the durability of the soldered joints with including the remaining flux. Non-cleaning type solder paste has been rather widely used in production where cleaning after soldering is not required. A line was added in the document, instead, that the cleaning procedure can be included in the product specification if necessary.

2.10 Items to be included in the test report (See **clause 8** of the main text)

It is specified in this standard to include the factors and conditions which are preferred to be included in a report of a test.

2.11 Items to be stated in the product specification (See **clause 9** of the main text)

The items to be specified in a product specification are described in this clause. These items are specified in this document with a statement that either “not specified in the product specification” or “as specified in the product specification”. Many of them are factors and test conditions which may affect the test result and may duplicate with the items included in the test report.

2.12 Related standards (See **clause 10** of the main text)

JIS Z 3198-7:2003, “Test methods for lead-free solders - Part 7: Shear strength test for soldered joints of chip components”, is included in this clause as a related reference as it is an available and useful document for evaluation of lead-free solders in Japan though not referred in the present standard.

2.13 Annex A - Torque shear strength test (normative) (**Annex A** of the main text)

Details of the torque shear strength test stated in **6.2** of the main text are described. This test is a newly prepared test effective especially for small SMDs and connectors, but not proposed to **IEC** as there are still not test equipment generally available in the market. A torque meter available in the market is used in a verification test of this method.

There was a serious discussion first on the displacement rate of the jig. Sufficient time is necessary to apply torque shear to a specimen by rotating a torque shear jig to damage a soldered joint as in the case of the shear strength test. The rotation displacement rate was selected in the range of 0.00698 rad/s to 0.0175 rad/s (0.4 deg/s to 1.0 deg/s) for the test equipment which can adjust the rotation displacement rate.

Torque shear is applied to a specimen by twisting the jig. It was pointed out by an expert that the jig should not declined from the perpendicular position against the test board. The jig should be machined to fit to the shape of the specimen to be tested and tolerance in machining should be checked.

2.14 Annex A - Torque shear strength test to a connector (**Annex A** of the main text)

When the torque shear strength test is made to a connector by twisting a torque shear jig to a connector, the connector itself may be damaged before failure at the soldered joint appears especially the strength of the composing resin of the connector is not enough.

This is the reason to use a covering jig just fitting to the connector to accommodate mechanical strength to the connector as illustrated in **Figure Additional/Info 2**. This covering jig is fitted to the connector and the torque shear force is applied to the connector together with the jig to induce mechanical damages to the joints.

The design of a covering jig for a typical connector whose solder joint parts are concave to the surface is as follows.

The concave portion of a connector and the convex portion of the covering jig are fitted together to adjust the position of the connector and the cover against the board as illustrated in **Figure Additional/Info 2**. The depth of the cover, H, should be equivalent to the height of the connector.

The clearance of the four walls of the concave of the connector and the four convex walls of the cover should be C = $0^{+0.05}$ mm considering the dimensional precision of both of them. Measurement accuracy of repeated tests increases for smaller C.

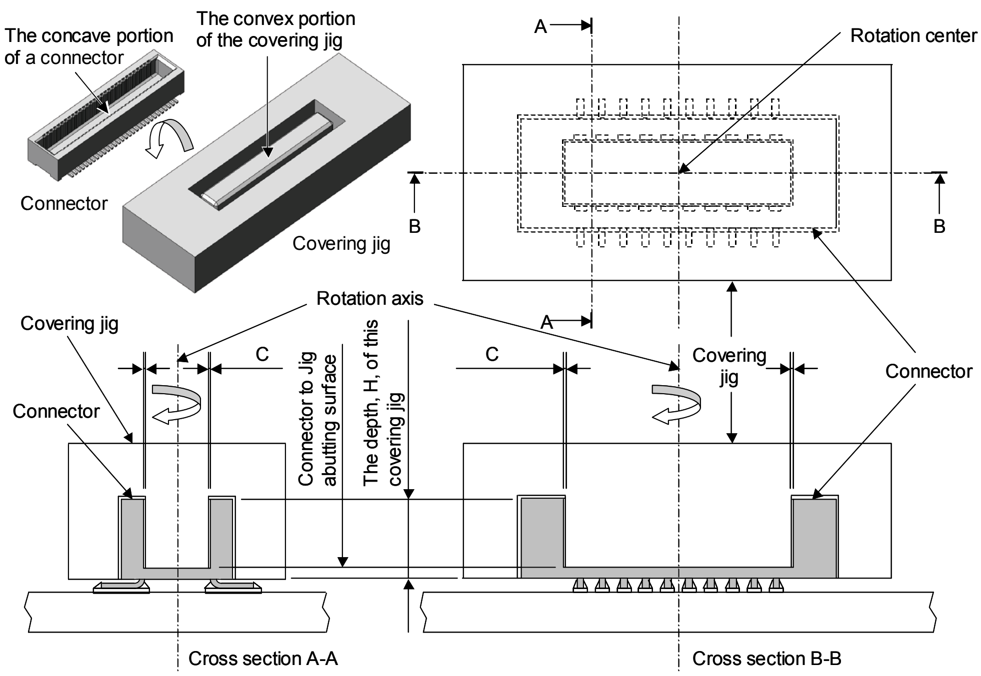


Figure Additional/Info 2 – Connector and covering jig

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