Standard of Japan Electronic and Information Technology Industries Association

JEITA ET-7409/201

Surface mount technology - Environmental and endurance test methods for solder joint of lead terminal type device Part 201: Pull strength test

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Standards of Japan Electronics and Information Technology Industries Association

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Introduction

The solders used in production are being switched from tin-lead eutectic solder to lead-free solders in many production lines from the recent request to reduce burdens to the environment. Use of the new solder in production of electronic equipment requires standards to evaluate reliability of produced equipment. Among the needed standards, we did not have a pull strength test for components having lead terminal type devices. This document provides the necessary information of the pull strength test for lead terminal devices.

1 Scope

This standard specifies the pull strength test of the soldered joint of the lead terminal type devices being made using lead-free solder to evaluate the durability of the joint. This standard is also applicable to such a device whose leads can be separated from the device itself without any force applied to the joint. A lead-frame or the lead material (wire) itself may be used for a test of a device whose leads cannot be separated from the device.

This test can evaluate the durability of a soldered joint of a lead and a land on a substrate from the time dependence of the pull strength of a reflow soldered joint by pulling the lead at a constant speed to the break of the joint. Time dependent degradation of a joint is caused by the self heating of equipment and the environmental temperature changes in use in the field.

This test is basically a durability test for the soldered joints and is not a test for the evaluation of the pull strength of a device itself such as the bonding strength of lead to the device. The condition for the rapid temperature change may exceed the rated temperature range for guaranteed operation of the device as this test is a durability test of mechanical strength of a soldered joint but not for its electrical performance.

The structure of the joint for evaluation in this test is illustrated in **Figure 1**.

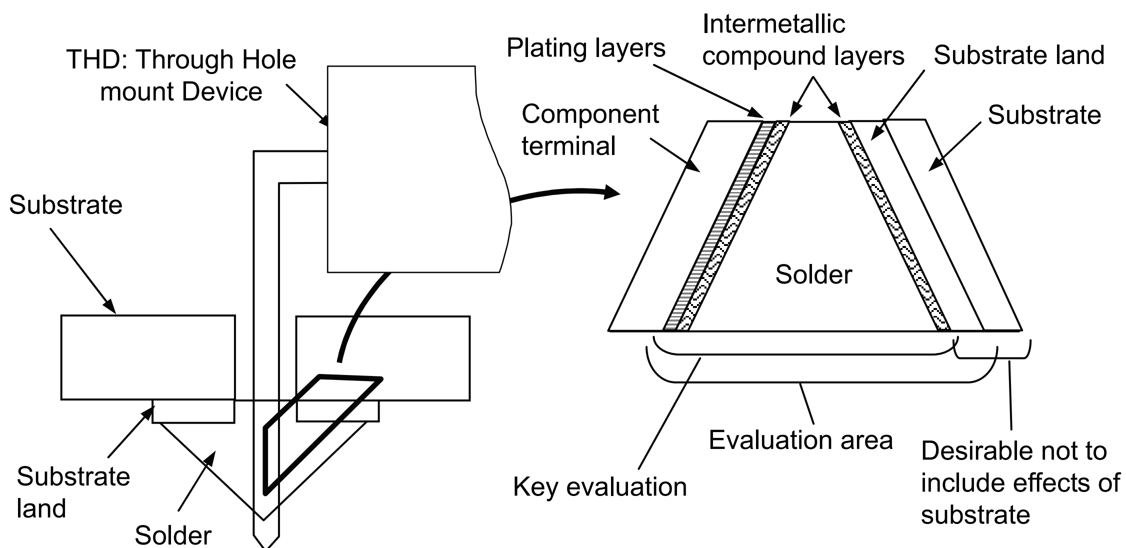

Figure 1 – Schematic illustration of the pull strength of a soldered joint

Note The reason why the test board is limited to a single-sided board is that the test using a double-sided board with through-holes results in break of the leads from a component before a soldered joint breaks. It is also important that minimal stress is to be applied to a soldered joint when a lead is cut-off from a component.

The mechanical strength test of the effect of self-heating of equipment and of environmental heat condition in use to a soldered joint of a lead and a land of a board is given in **JEITA ET-7409/202**, the creep strength test.

We have **JIS C 60068-2-21** for the tests for the connection strength of a lead to a component. This standard includes the following tests for lead strength but they are not the test for a soldered joint.

Test **Ua1** Tensile test
Test **Ua2** Thrust test
Test **Ub** Bending test
Test **Uc** Torsion test

2 Normative references

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

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 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.

IEC 61190-1-1:2002, Attachment materials for electronic assembly - Part 1-1 Requirements for soldering fluxes for high-quality interconnections in electronics assembly

3 Terms and definitions

The terms and definitions used in this document are given below.

3.1

flow soldering

a wave, drag or dip soldering process where the product is brought into contact with molten solder in to attach electronic components to the interconnecting surface of a board. It is often called also “wave soldering”.

3.2

through hole

the hole made on a board for mounting of components to a conductive pattern.

3.3

land

a portion of a conductive pattern usually used for the connection and/or attachment of components.

3.4

solder fillet

the form of solder after solidification, with a normally concave surface, at the intersection of the metal surfaces of a soldered connection.

3.5

pull strength

the maximum applied force to break the solder joint of a Through Hole mount device from the copper land of printed wiring board using a jig to pull the lead.

4 Test equipment and materials

4.1 Flow soldering bath

The bath for flow soldering is a bath that can realize the temperature condition stated in **5**. An example of the temperature profile for flow soldering is shown in **Figure 2**.

4.2 Rapid temperature change chamber

The rapid temperature change chamber shall be able to satisfy the test condition stated in **6.1** under the condition specified in **JIS C 0025**, **Na**.

4.3 Pull strength test equipment

The pull strength test equipment shall be capable of realizing the test condition stated in **6.2**.

4.4 Test board

Unless otherwise specified in the product specification, the testing board shall be of the following specifications.

a) Board material

The material of a testing board shall be epoxide woven E-glass copper–clad laminate of general purpose sheet laminated to single- or double sided board as specified in **JIS C 6484**.

b) Board thickness

The thickness of a test board 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 board

The size of a testing board shall be 140 mm × 45 mm.

Note This size of the board is for the board to be used in a test. The size of a board used in flow soldering process may be four times of this size but should be able to be divided into this size.

d) Thickness of the copper land

The thickness of the land of the board for shall be 35 μm to 45 μm including plating.

e) Diameter of a through hole

The diameter of a through hole is given in **Table 1**.

f) Diameter of a land

The diameter of a land is given in **Table 1**.

Table 1 – Nominal cross section of leads and diameters of through holes and lands

Nominal cross section(S), mm^2	Nominal diameter(d) of a round cross section type lead, mm	Through hole diameter, mm	Land diameter, mm
$S \leqq 0.10$	$d \leqq 0.35$	0.8	1.4
$0.10 < S \leqq 0.28$	$0.35 < d \leqq 0.6$	1.0	1.6
$0.28 < S \leqq 0.5$	$0.6 < d \leqq 0.8$	1.2	1.8
$0.5 < S \leqq 0.79$	$0.8 < d \leqq 1.0$	1.4	2.0
$0.79 < S \leqq 1.20$	$1.0 < d \leqq 1.25$	1.6	2.2

g) Solder resist

Solder resist is not applied.

h) Anti-rust treatment

Pre-flux is coated on copper land to prevent surface oxidation

4.5 Solder

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

4.6 Post flux for flow soldering

Unless otherwise specified in the product specification, the flux specified in **IEC 61190-1-1** shall be chosen.

5 Preparation for mounting of component on board

5.1 Mounting of a specimen to a test board

Mounting of a specimen to a test board shall be in the following.

a) Insert the leads of a specimen into through holes of a board as specified in **4.4** using adhesive.

b) Coat the post flux as specified in **4.6** on the board surface on which a component is mounted in either the form of foam or by spraying.

Unless otherwise specified in the product specification, solder a component to a board by using a flow soldering bath specified in **4.1** and solder specified in **4.5** with the following condition. The temperature of preheating is 100 °C to 120 °C, the temperature of the soldering bath is 250 °C ± 5 °C with a dipping time of 3 to 5 s. An example of the temperature profile for flow soldering is shown in **Figure 2**. The position to measure the temperature is the land immersed into the molten solder.

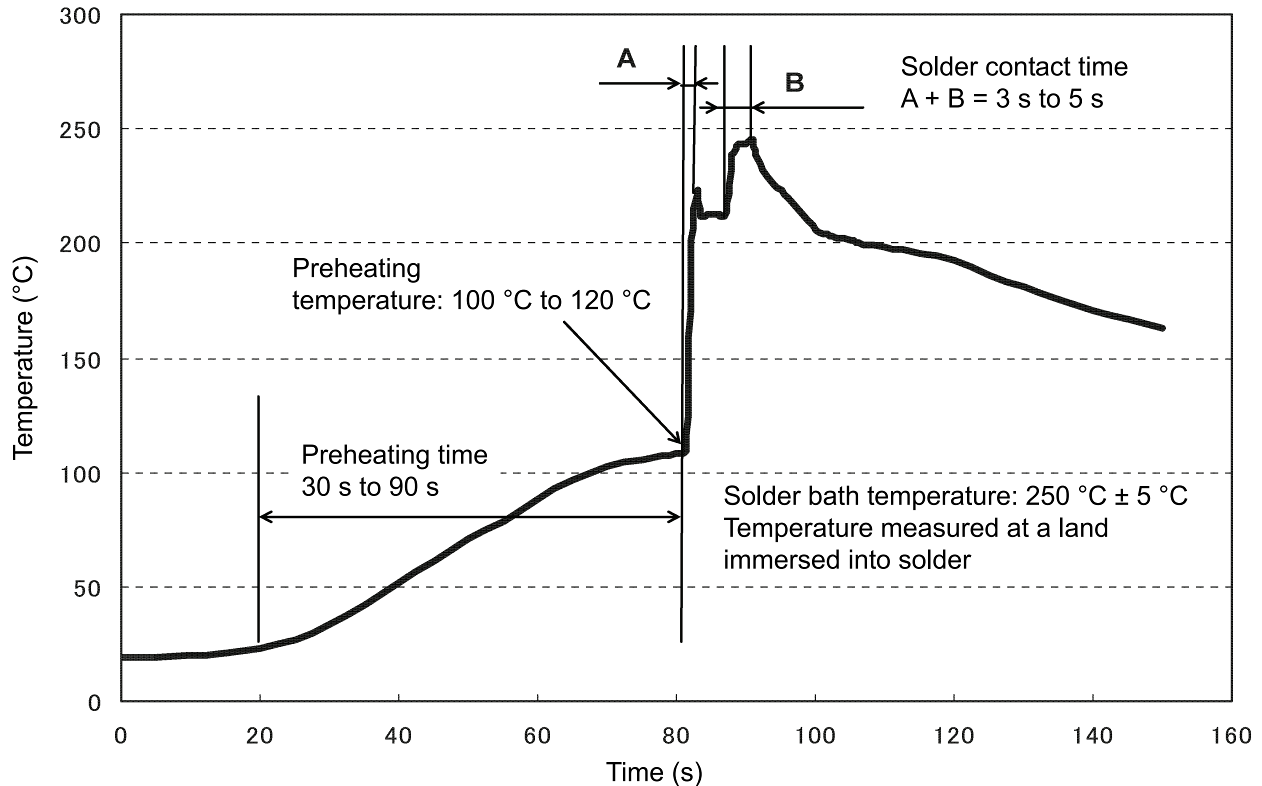

Figure 2 – Example of a flow soldering profile
(actual measurement for double wave soldering)

5.2 Preparation of specimen

The lead for the pull strength test is cut off from the Through Hole mount Device. Care shall be made not to apply any force to the soldered joint. In a case that the lead terminal to be tested cannot be fastened to the fastening jig, other methods of fixing the lead to the jig (e.g., welding) may be used. A fixing method shall be selected that there is no ambiguity in judgment of the joint failure is anticipated.

6 Test condition

6.1 Rapid temperature change test

Unless otherwise stated in the product specification, the test conditions are as stated below.

a) The test shall be the test **Na** as specified in **JIS C 0025**.

b) The low temperature of the test shall be -40 °C ± 2 °C and the high temperature to be +125 °C ± 2 °C.

c) The time to leave the specimen at each temperature shall be 30 min.

d) The numbers of temperature cycles of the test shall be 500 and 1 000 cycles,

6.2 Pull strength test

The test shall be made as stated in the **Annex** of this document.

7 Test

7.1 Test procedure

Unless otherwise stated in the product specification, the test procedure after mounting of devices on the test board shall be in accordance as illustrated in **Figure 3**.

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

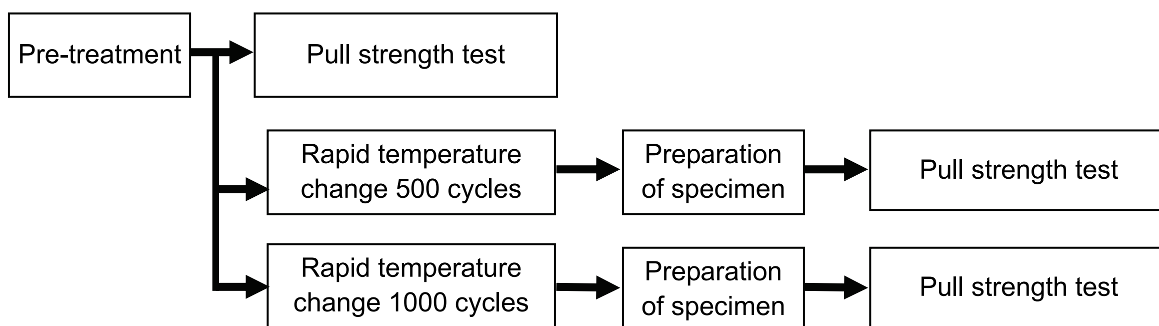

Figure 3 – Test procedure

7.2 Pre-treatment

Keep the board in the standard atmospheric environment to perform the measurement and the test as stated in **JIS C 60068-1**, **5.13** for more than 4 h.

7.3 Initial measurement

Pre-treat the test specimen as described in **5.2**. Perform the pull strength test as specified in **6.2** of this document after observation of the specimen as to no defect is observed to the specimen. Record the number of rapid temperature cycles at the break of the joint and the mode of failure as specified in the product specification.

7.4 Rapid temperature change test

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

7.5 Post-treatment

After the required cycles of specified rapid temperature change, the test specimen shall be kept in the standard atmospheric environment for more than 4 h for the measurement and the test as stated in **JIS C 60068-1**, **5.13**.

7.6 Intermediate and final measurements

Perform the pull strength test to the specimen as stated in **6.2** of this document. Record the number of temperature cycles to the break of the joint and the mode of failure.

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 pull strength test.

a) Date of the test
b) Name of the test laboratory, or venue of the test
c) Name, type, and dimensions of the device tested
d) Material, presence or not of metal plating, and the material of plating of the leads
e) Material, dimension and the structure of plating layer (surface treatment) of the board
f) Diameters of the land and the through hole on the test board
g) Diameter (or cross section) of the lead and electrolytic plating if any
h) Types of solder and flux used
i) Temperature profile in the case of reflow soldering
j) Condition of the rapid temperature change and the number of cycles
k) Type of pull strength test equipment used
l) Pulling speed of the pulling jig
m) Pull strength
n) The failure mode in pull strength test

9 Items to be stated in the product specification

a) Material, thickness and size of the test board, thickness of copper foil of the land, diameters of land and through hole and solder resist if used (**4.4**)

b) Solder (**4.5**)

c) Post flux for flow soldering (**4.6**)

d) Temperature profile in flow soldering (**5.1 b**)

e) Condition of rapid temperature change (severity, high and low temperatures, time kept at an environment, and number of cycles) (**6.1**)

f) Condition of pull strength test (test temperature and pull speed) (**6.2**)

g) Test procedure (**7.1**)

h) Pre-treatment (**7.2**)

i) Items to be recorded in the test report (**8**)

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 - Part 2-21: Tests - Test U: Robustness of termination and integral mounting devices (MOD).

Note All the items referred to **IEC 60068-2-21**:1999, Environmental testing - Part 2-21: Tests - Test U: Robustness of termination and integral mounting devices (MOD) are equivalent to **JIS C 60068-2-21**.

Annex A
(normative)
Pull strength test

A.1 Scope

This Annex specifies details of the pull strength test specified in **6.2** of this standard.

A.2 Test procedure

The test shall be made using the pull strength test equipment specified in **4.3** of the main text of this document in accordance to the following procedure.

a) The specimen shall be kept in the standard atmospheric environment as specified in **JIS C 60068-1**, **5.3** for more than 4 h before the test. The test shall be performed after the appearance inspection of the specimen.

b) The test board shall be fastened to the pull strength test equipment as illustrated schematically in **Figure A-1**.

Note When fastening the test board, the lead terminal to be tested shall be fixed at the center of the board fastening jig as to the lead is perpendicular to the lead fastening jig.

c) Fasten the lead terminal to the jig of the pull strength test equipment

Note 1 Care shall be made when the lead terminal is required to be cut-off from the component not to impose mechanical, thermal or chemical stress to the soldered joint of the lead and land.

Note 2 Record the way of fixing the test board and the relative position of the fastening jig and the lead terminal.

Note 3 Any possible care shall be made not to impose bend or twist force to the joint when the lead is fixing to the pulling jig of the equipment.

d) The pulling speed of the jig shall be selected from the following, 0.167 mm/s (1 mm/min), 0.333 mm/s (2 mm/min), 0.833 mm/s (5 mm/min) 1.67 mm/s (10 mm/min) or 3.33 mm/s (20 mm/min). The pulling speed is stated in the product specification of the component.

Note The pulling speed should be selected as to it takes several tens of seconds to several minutes to break the joint from the start of pulling.

e) Pull a lead of the component mounted at a speed selected as in **d)** until the joint is broken. Record the maximum force when the joint is broken.

Note When recording the change of the force, it is desirable to record also the change of displacement at several points near the joint.

f) Record the broken position of the joint and the failure mode.

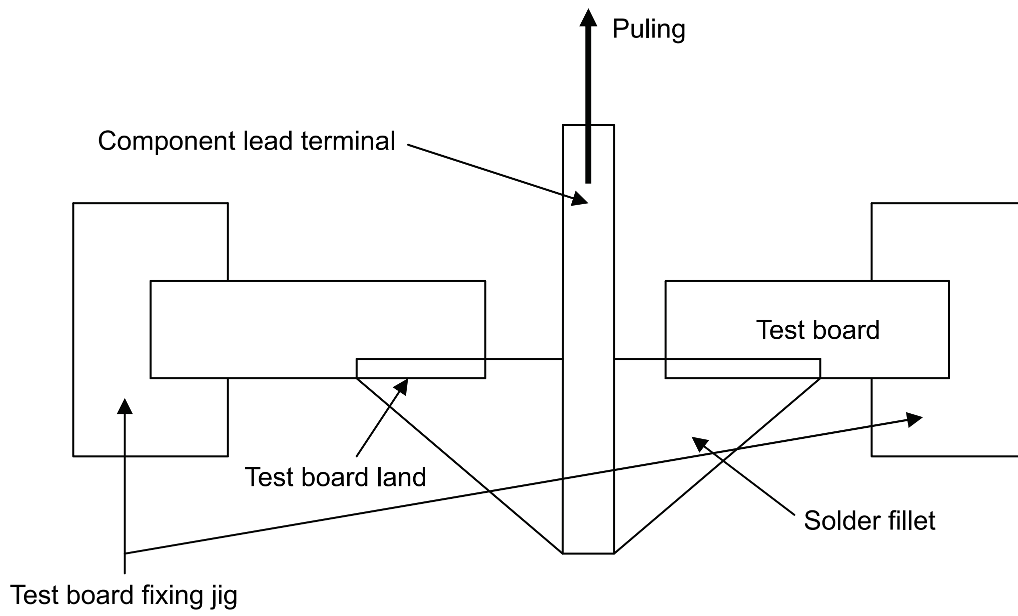

Figure A-1 – Illustration of the pull strength test

A.3 Members of the Standard Development Committee

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