IEC 62137-1-5

Edition 1.0 2009-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Surface mounting technology – Environmental and endurance test methods for surface mount solder joints – Part 1-5: Mechanical shear fatigue test

Technologie du montage en surface – Méthodes d'essais d'environnement et d'endurance des joints brasés montés en surface – Partie 1-5: Essai de fatigue par cisaillement mécanique

IEC 62137-1-5:2009

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INTERNATIONAL
ELECTROTECHNICAL
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COMMISSION
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PRICE CODE
CODE PRIX **S**

ICS 31.190

ISBN 978-2-88910-628-8

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SURFACE MOUNTING TECHNOLOGY – ENVIRONMENTAL AND ENDURANCE TEST METHODS FOR SURFACE MOUNT SOLDER JOINTS –

Part 1-5: Mechanical shear fatigue test

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International Standard IEC 62137-1-5 has been prepared by IEC technical committee 91: Electronics assembly technology.

The text of this standard is based on the following documents:

FDIS	Report on voting
91/826/FDIS	91/841/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
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INTRODUCTION

The mechanical properties of lead-free solder joints between leads and lands on a printed wiring board are not the same with tin-lead-containing solder joints, due to their solder compositions. Thus, it becomes important to test the mechanical properties of solder joints of different alloys.

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SURFACE MOUNTING TECHNOLOGY – ENVIRONMENTAL AND ENDURANCE TEST METHODS FOR SURFACE MOUNT SOLDER JOINTS –

Part 1-5: Mechanical shear fatigue test

1 Scope

The test method described in this part of IEC 62137 applies to area array packages, such as BGA. This test method is designed to evaluate the fatigue life of the solder joints between component leads and lands on a substrate as shown in Figure 1. A temperature cyclic approach is generally used to evaluate the reliability of solder joints. Another method is to mechanically cycle the solder joints to shorten the testing time rather than to produce the strains by changing temperatures. The methodology is the imposition of shear deformation on the solder joints by mechanical displacement instead of relative displacement generated by CTE (coefficient of thermal expansion) mismatch, as shown in Figure 2. In place of the temperature cycle test, the mechanical shear fatigue predicts the reliability of the solder joints under repeated temperature change conditions by mechanically cycling the solder joints. In this test method, the evaluation requires first to mount the surface mount component on the substrate by reflow soldering, then cyclic mechanical shear deformation is applied to the solder joints until fracture of the solder joints occurs. The properties of the solder joints (for example solder alloy, substrate, mounted device or design, etc.) are evaluated to assist in improving the strength of the solder joints.

NOTE This test, however, does not measure the strength of the electronic components. The test method to evaluate the robustness of the joint to a board is described in IEC 60068-2-21.

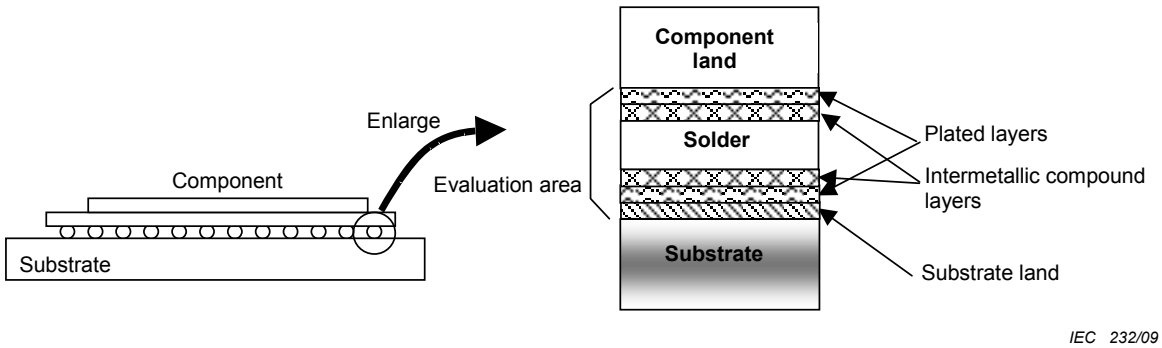

Figure 1 – Image drawing on evaluation area of joint strength

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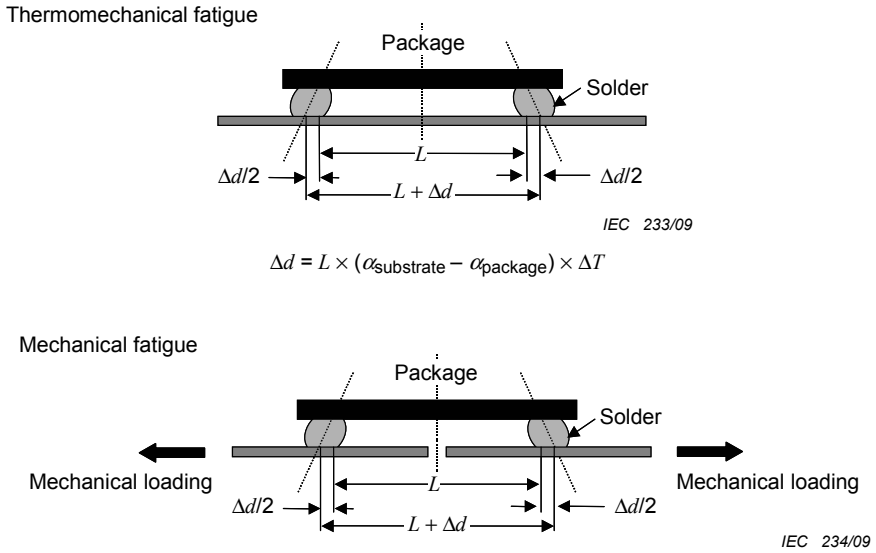

Key

Δd Relative displacement

ΔT Temperature range

α Coefficient of thermal expansion

Figure 2 – Schematic illustrations of thermomechanical and mechanical fatigue for solder joints

2 Normative references

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

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 61188-5 (all parts), *Printed boards and printed board assemblies – Design and use*

IEC 60194, *Printed board design, manufacture and assembly – Terms and definitions*

IEC 61190-1-2:2007, *Attachment materials for electronic assembly – Part 1-2: Requirements for soldering pastes for high-quality interconnects in electronics assembly*

IEC 61190-1-3, *Attachment materials for electronic assembly – Part 1-3: Requirements for electronic grade solder alloys and fluxed and non-fluxed solid solders for electronic soldering applications*

IEC 61249-2-7:2002, *Materials for printed boards and other interconnecting structures – Part 2-7: Reinforced base materials clad and unclad – Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad*

IEC 61760-1, *Surface mounting technology – Part 1: Standard method for the specification of surface mounting components (SMDs)*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-1, in IEC 60194, as well as the following apply.

3.1
mechanical shear fatigue life
number of cycles to attain the joint fracture between surface mount component terminals mounted on the printed board and the copper land of the substrate after application of cyclic mechanical shear deformation

3.2
ramp rate
moving velocities of the fixing jig attached to the actuator of the mechanical testing machine

3.3
displacement range
distance between the maximum and the minimum test position caused by pushing and pulling the actuator back, which means relative displacement in shear direction between the surface mount component and the substrate

3.4
maximum and minimum forces
reaction forces at the maximum and minimum test positions caused by shear deformation of the solder joint at each cycle

4 Test equipment and materials

4.1 Test equipment for mechanical shear fatigue testing

The equipment for mechanical shear testing consists of a tension-compression testing machine, sample fixing jigs, a resistance-measuring instrument and a recorder. The specifications shall be in compliance with those of the mechanical test equipment prescribed in Annex A.

4.2 Test substrate

Unless otherwise stated in the relevant product specifications, the test substrate shall satisfy the following conditions.

a) Material: Epoxide woven glass fabric copper-clad laminated sheet, general purpose grade (IEC 61249-2-7:2002), with foil bonded to one side and a nominal thickness of the sheet, including the metal foil, of 1,6 mm with a tolerance of ±0,20 mm. The copper foil shall have a thickness of 0,035 mm ± 0,010 mm.

b) Size: 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 mechanical shear fatigue test equipment.

c) Land geometry: The shape and size of a land shall comply with IEC 61188-5 (all parts) or the pad geometry recommended by the respective component supplier.

d) Surface protection: The solderable areas of the substrate (lands) shall be protected against oxidization by suitable means, for example by an organic surface protection layer (OSP), or other finishes. This protective layer shall not have an adverse effect on the solderability of the lands under the soldering conditions of the reflow soldering equipment.

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4.3 Solder alloy

Unless otherwise specified, the solder alloy shall consist of a ternary composition of Sn, Ag and Cu with 3,0 wt. % to 4,0 wt. % Ag and 0,5 wt. % to 1,0 wt. % Cu with Sn for balancing, for example Sn96,5Ag3,0Cu0,5. The solder alloy shall be in accordance with IEC 61190-1-3.

4.4 Solder paste

Unless otherwise stated in the relevant product specifications, solder paste should be chosen from IEC 61190-1-2. However, the solder to be used shall be the one that is specified in 4.3 above.

4.5 Reflow soldering equipment

Unless otherwise stated in the relevant product specifications, reflow-soldering equipment should be the one that can realize the temperature profile as shown in Figure 3.

5 Mounting

Unless otherwise stated in the relevant product specifications, the surface mount component shall be mounted on the substrate in the following sequence.

The following steps shall be taken.

a) Apply the solder paste specified in 4.4 to the lands of a test substrate as specified in 4.2, using a stainless steel mask that has openings of the same size, shape and configuration as the lands as specified in item c) of 4.2 with a thickness of 100 µm to 150 µm.

b) Mount the test specimen on the test substrate with the printed solder paste.

c) Perform soldering using the reflow soldering equipment specified in 4.5 and the solder paste specified in 4.4 with the following conditions. Typical temperature profile of reflow soldering is given in Figure 3 and as proposed in IEC 61760-1. The temperature shall be measured at the land.

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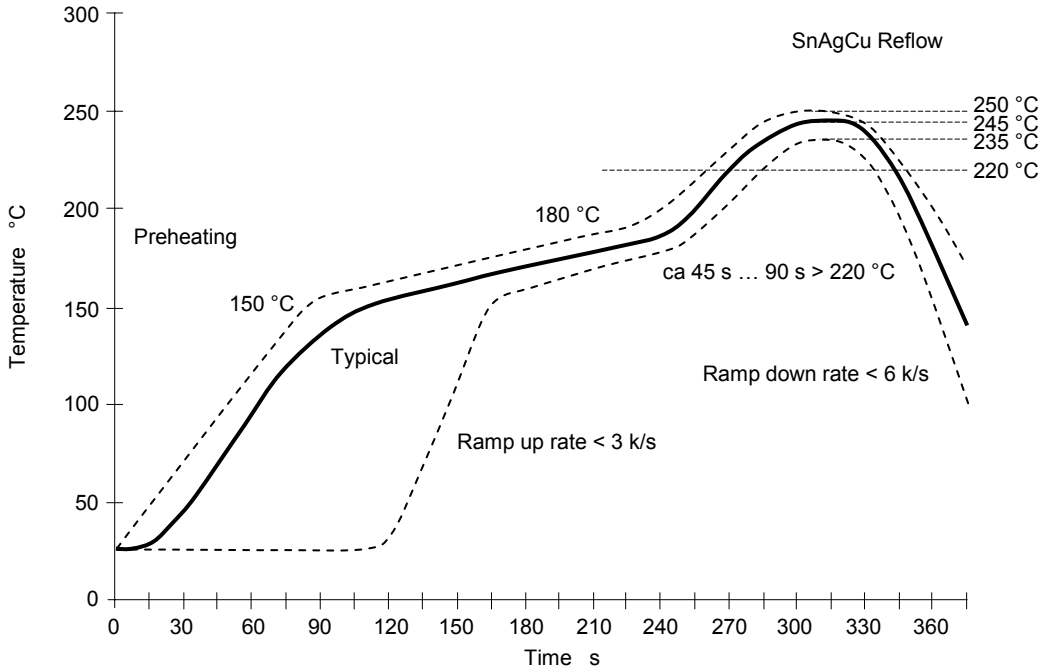

Continous line: typical process (terminal temperaure)

Dotted line: process limits. Bottom process limit (terminal temperature). Upper process limit (top surface temperature)

IEC 1176/07

Figure 3 – A typical temperature profile taken by reflow soldering equipment

6 Test conditions

6.1 Pre-treatment

Unless otherwise stated in the relevant product specifications, leave the specimen under standard atmospheric conditions (specified in IEC 60068-1) for 4 h or more.

6.2 Test procedures

Unless otherwise stated in the relevant product specifications, the following procedures should be followed. The detail of the mechanical shear fatigue test procedures is prescribed in Annex B.

a) Fix the test sample to the fixing jig.

b) Ramp rate, allowable displacement range and test temperature shall be set.

c) Continue the mechanical shear fatigue tests at each level in the selected displacement range until the maximum force decreases to a certain value or the electrical resistance-measuring instrument can detect electric continuity interruption. Make a record of the number of cycles at fatigue life.

d) Make analytical observations of the fractured parts, as needed, verify the fracture mode and record it.

6.3 Judging criteria

When the maximum force decreases to a certain value, for example a 20 % drop from the initial value, or a momentary interruption detector detects that electrical continuity interruption has occurred in the specimen, it shall be judged as fatigue life.

The result obtained by the methods described in Annex A and Annex B shows the average measures for all the joints of the component mounted on the test specimen, including the

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influences of the component and substrate with respect to fatigue life. Annex C describes the test procedure for evaluating the mechanical shear fatigue life of a single solder joint which is effective for eliminating the effects of the component and substrate on the fatigue life.

7 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) test date;
b) location of the test organization;
c) name of the electronic component, type, size, body dimensions and lead pitch;
d) base materials of lead on electronic components; and with or without plating, and materials of plating;
e) materials of the test substrate, dimensions and layer structure;
f) measurements of the land on the substrate and materials for the surface treatment;
g) type of solder and type of solder paste;
h) temperature profile of reflow soldering and soldering ambience (for the case of a nitrogen ambient atmosphere, oxygen concentration should apply);
i) model of the tensile and compression machine;
j) details of the substrate bending jig (drawing is preferable);
k) specifications of the electrical resistance-measuring instrument;
l) specifications of the recorder;
m) displacement rate;
n) displacement range and the number of cycles to fracture initiation;
o) fracture mode (photos, etc.).

8 Items to be given in the product specification

The following items shall be included:

a) test substrate (4.2);
b) solder alloy (4.3);
c) solder paste (4.4);
d) reflow soldering equipment (4.5);
e) mounting (Clause 5);
f) pre-treatment (6.1);
g) test procedures (6.2).

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Annex A
(normative)

Mechanical shear fatigue test equipment

A.1 Application

This annex applies to the test equipment for mechanical shear fatigue specified in 4.1 and specifies the requirements.

A.2 Mechanical shear test equipment

A.2.1 Tension-compression testing machine

Unless otherwise stated in the relevant product specifications, the mechanical shear fatigue test machine shall satisfy the following requirements.

a) This machine needs the capability of actuating the sample fixing jigs to the prescribed displacement range (±0,001 mm to ±0,1 mm) with the use of triangular waves at the prescribed speed (0,001 mm/s to 0,01 mm/s).

NOTE 1 In order to control displacement within a fine range, a linear DC motor or a piezo actuator is recommended for the actuator of the machine.

NOTE 2 As the test is effective with sine and trapezoid waves instead of triangular waves, the test machine should also be able to function with sine and trapezoid waves.

b) This test machine also needs the capability of measuring the prescribed displacement in the neighborhood of the sample by using a displacement sensor attached to the sample fixing jigs (not using displacement sensor in the actuator), and the capability of controlling the actuator by using the displacement (feedback control). An eddy current type, capacitance type or laser type displacement sensor is recommended.

c) The test machine should be able to measure and record elapsed cycle and time, as well as the reaction forces generated by shear deformation of the solder joint in the course of the fatigue test using a load cell.

d) The load cell needs the capability of measuring the reduction of the reaction force caused by degradation of the solder joint (crack initiation and propagation).

e) The test machine should be able to control test temperature, if the test is performed with raised temperature.

A.2.2 Shear fatigue jig

A.2.2.1 General

The shear fatigue jigs should be able to fix the sample and to impose shear deformation on the solder joints by mechanical displacement between the component and substrate. There are two types of load-applying methods for the shear fatigue test as shown in Figure A.1.

Unless otherwise stated in the relevant product specifications, these jigs shall meet the following conditions.

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