IEC JEITA

IEC/PAS 62137-3

Edition 1.0 2008-11

PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

withdrawn

Electronics assembly technology – Selection guidance of environmental and endurance test methods for solder joints

IEC/PAS 62137-3:2008(E)

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub
  The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.
- IEC Just Published: www.iec.ch/online_news/justpub
  Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.
- Electropedia: www.electropedia.org
  The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.
- Customer Service Centre: www.iec.ch/webstore/custserv
  If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC JEITA

IEC/PAS 62137-3

Edition 1.0 2008-11

PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

Electronics assembly technology – Selection guidance of environmental and endurance test methods for solder joints

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **X**

ICS 31.190

ISBN 978-2-88910-809-1

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

ELECTRONICS ASSEMBLY TECHNOLOGY – SELECTION GUIDANCE OF ENVIRONMENTAL AND ENDURANCE TEST METHODS FOR SOLDER JOINTS

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

A PAS is a technical specification not fulfilling the requirements for a standard but made available to the public.

IEC-PAS 62137-3 was submitted by the JEITA (Japan Electronics and Information Technology Industries Association) and has been processed by IEC technical committee 91: Electronics assembly technology.

The text of this PAS is based on the following documents	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document:
Draft PAS	**Report on voting**
91/784/DPAS	91/821/RVD

Following publication of this PAS, which is a pre-standard publication, the technical committee or subcommittee concerned will transform it into an International Standard.

This PAS shall remain valid for an initial maximum period of three years starting from the publication date. The validity may be extended for a single three-year period, following which it shall be revised to become another type of normative document or shall be withdrawn.

INTRODUCTION

Tin-Lead eutectic solder had been used for both internal and external joints of electric and electronic equipment for its characteristics and cost for long time. The recent request to reduce burdens to the environment, however, resulted in various types of lead-free solders being developed by many organizations. Now the solders used in production are being switched from tin-lead based solders to lead-free solders in many production lines. The study of the solder joints using lead-free solders has revealed that the reliability of the joints is not the same as that of joints prepared using tin-lead solder. The Japan Electronics & Information Technology Industries Association (JEITA) has been developing test methods to evaluate the performance of the joints based on analysis of various experiments made by member experts. It should be noted that any single test is not necessarily applicable to all the electronic components. There are appropriate tests suitable for the size and shape of a component and also for specific types of leads of components. This series of standards are thus prepared to provide the industry with the necessary evaluation methods to produce reliable products to the society.

ELECTRONICS ASSEMBLY TECHNOLOGY – SELECTION GUIDANCE OF ENVIRONMENTAL AND ENDURANCE TEST METHODS FOR SOLDER JOINTS

1 Scope

This guidance describes the selection of an appropriate test method for reliability test of solder joints for various shapes and types of surface mount devices (SMD) and leaded devices, including various types of solder material.

The regions of the joints to be tested are shown in **Figure 1**. The test methods given here are applicable to evaluate the strength of joints of a component mounted on printed wiring board but not to test the mechanical strength of components themselves.

The test conditions for accelerated tests (rapid temperature change and high temperature tests) may exceed the maximum allowable temperature range for a component.

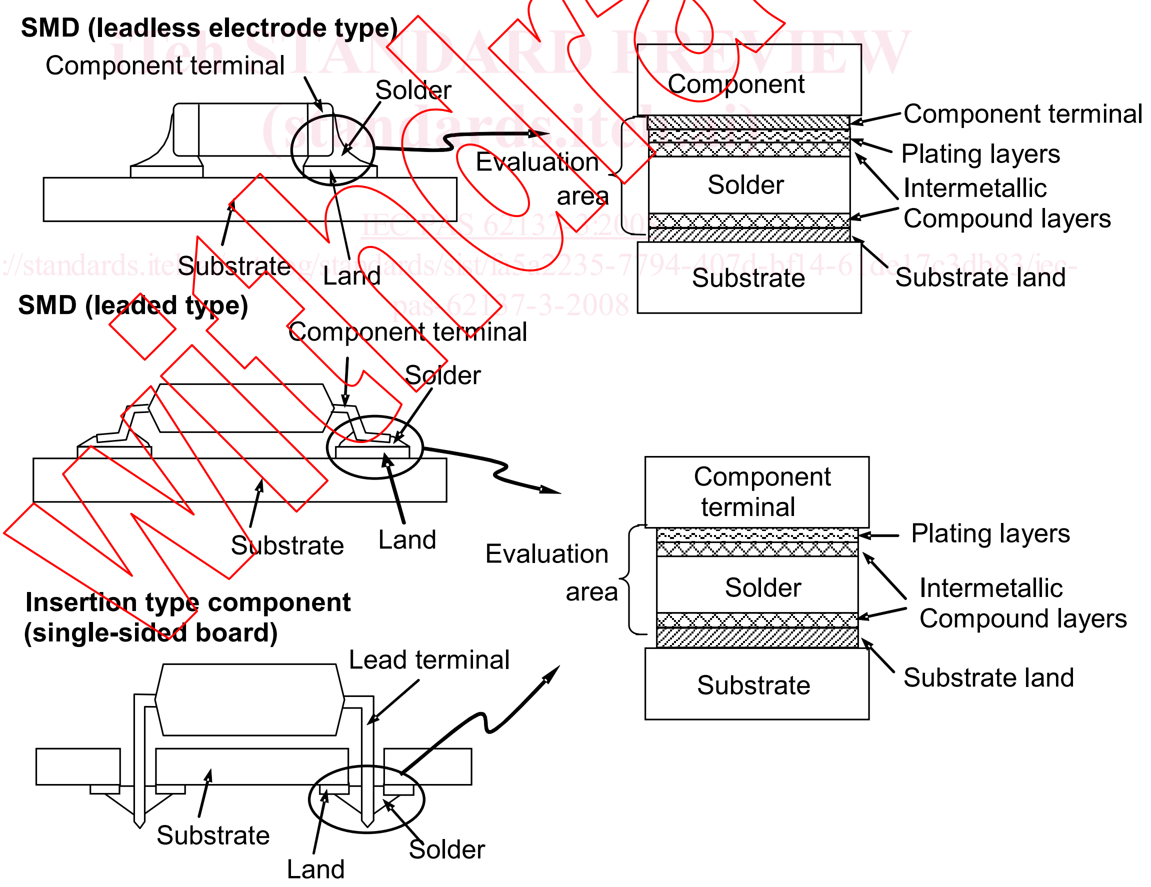


Figure 1 – The joint regions for the reliability tests

The lead-free solders have different properties from those of the conventional tin-lead eutectic solder. The reliability of soldered joints using lead-free solder may be reduced by the composition of the solder used, the shape of terminals and surface treatment.

The factors affecting the joint reliability using Sn96,5Ag3Cu,5 solder are shown in **Figure 2**. This solder has the properties of higher melting temperature and harder than the tin-lead eutectic solder and the solid is not easily deformed. Consequently, the stress induced to the joint becomes higher than the tin-lead eutectic solder.

These properties may induce break of a soldered joint by accelerated temperature changes, or mechanical stress.

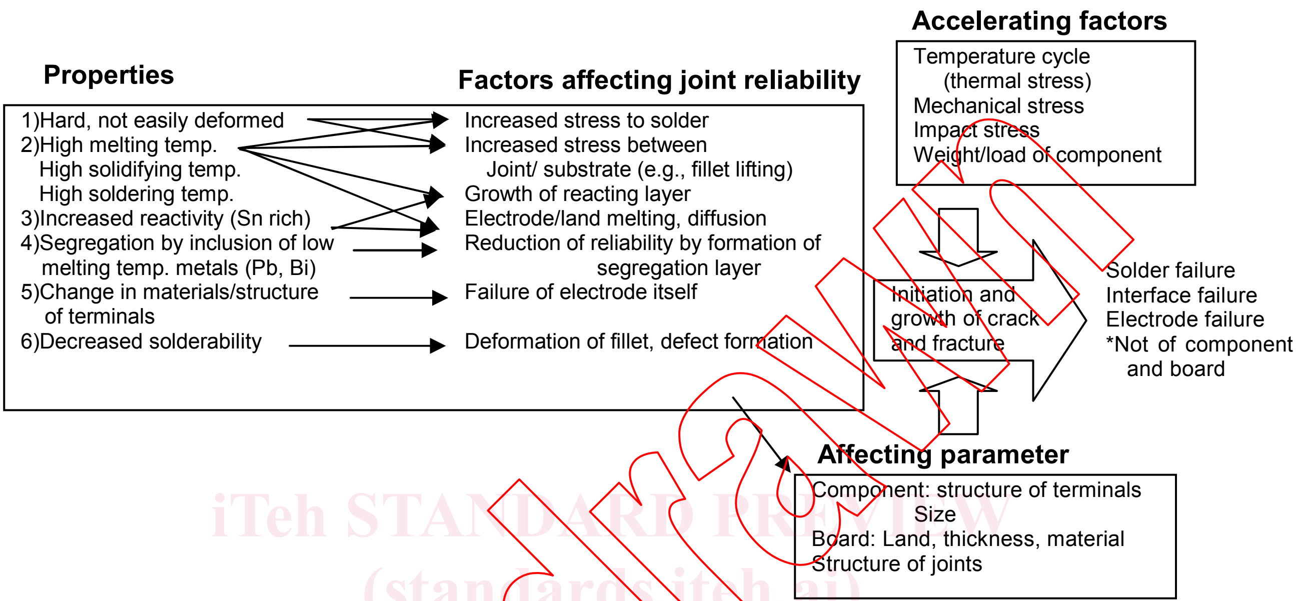


Figure 2 – Factors affecting the joint reliability made by lead-free solder

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.

IEC 60068-1:1988, *Environmental testing. Part 1: General and guidance,* Amendment 1:1992

IEC 60068-2-2:2007, *Basic environmental testing procedures Part 2:Tests, Test B: Dry heat*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Test N: Change of Temperature* Amendment 1:1986

IEC 60068-2-78:2001 *Environmental testing – Part:2-78: Tests – Test: Cab: Damp heat, steady state*

IEC 60194:2006, *Printed board design, manufacture and assembly – Terms and definitions*

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

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

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

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*

IEC 62137:2005, *Environmental and endurance testing – Test methods for surface-mount boards of area array type packages FBGA, BGA, FLGA, LGA, SON and QFN*

IEC 62137-1-1:2007, *Surface mounting technology – Environmental and endurance test methods for surface mount solder joint – Part 1-1: Pull strength test*

IEC 62137-1-2:2007, *Surface mounting technology – Environmental and endurance test methods for surface mount solder joint – Part1-2: Shear strength test*

IEC 62137-1-3(91/708/CDV), *Surface-mount technology – Environmental and endurance test methods for surface mount solder joint – Part 1-3: Cyclic drop test*

IEC 62137-1-4(91/746/CDV), *Surface mounting technology – Environmental and endurance test methods for surface mount solder joints – Part 1-4: Cyclic bending test*

IEC 62137-1-5(91/743/CDV), *Surface mounting technology – Environmental and endurance test methods for surface mount solder joints – Part 1-5: Mechanical shear fatigue test*

3 Terms and definitions

For the purposes of this document, the terms and definitions in **IEC 60194**, as well as the following, apply.

3.1
lead-free
the lead content in the objective portion of an electronic components or similar products is equal or less than 0,1 wt%

3.2
pull strength for SMD
applied force to break the joint of the lead of a gull-wing type SMD solder mounted and the copper land of printed wiring board using a jig to pull the lead

3.3
shear strength for SMD
applied force to break the all the joints of leads of an SMD and lands on the printed wiring board when a force is applied parallel to the side of the SMD

3.4
torque shear strength for SMD
applied force to break the soldered joints of leads of an SMD to the lands on printed wiring board when a rotating force is applied to the SMD at the both end with the centre of the moment at the center of the SMD with the rotation moment in parallel to the printed wiring board surface

3.5
monotonic bending strength for SMD
strength of soldered joints of SMD mounted on board when the board is bent convex toward to the mounted SMDs expressed by the maximum bending depth to the break of joints

3.6
cyclic bending strength for SMD
number of bending to the break of soldered joints of SMDs to the copper lands on board which is fixed to a jig when the board is bent convex toward to the mounted SMDs

3.7
mechanical shear fatigue strength for SMD
imposition of cyclic shear deformation on the solder joints by mechanical displacement instead of relative displacement generated by CTE (coefficient of thermal expansion) mismatch in thermal cycling testing

NOTE The mechanical shear fatigue tests continues until the maximum force decreases to a certain value, which corresponds to the appearance of an initial crack, or the electrical resistance-measuring instrument can detect electric continuity interruption, and the number of cycles is recorded as fatigue life

3.8
cyclic drop test for SMD
number of drops to the break of soldered joints of an SMD to the copper lands on a board which is fixed to a jig when the board is dropped from a specified height

3.9
cyclic steel ball drop strength for SMD
number of drops to the break of soldered joints of an SMD to the copper lands on a board when the steel ball is dropped from a specified height on a board

3.10
pull strength for lead terminal type device
maximum applied force to break the soldered joint of a lead of an SMD to a land on board when the lead is pulled using a jig

3.11
creep test for lead terminal type device
strength of a soldered joint expressed by the time to break the joint held in a thermostat when a continuous force is applied to a lead of an SMD soldered to a land

3.12
fillet lifting phenomenon
phenomenon a solder fillet of a lead of an SMD is fillet lifting from a land on a board, or of the land from the board (De-lamination)

3.13
daisy chain
all chain of connections solder joint are connected in series

NOTE Lands on both sides of a board and leads are solder- connected in a chain in the case of a lift off test

4 Procedure of selecting the applicable test method

4.1 Stress to solder joints in the field and test methods

The correlations between the test methods and the actual stress induced to components are shown in Figure 1. The printed wiring board and the shapes of terminals effective to correlate the test results to actual conditions of the component mounting in the filed are also shown as reference. The selection of a test method suitable for a specific shape of terminal is given in 4.2.

Table 1 – Correlations between test methods and actual stresses in the filed

Test method **(Applicable standard)**	**Accelerated stress application**	**Applicable board/ Components**	**Stress in the field and applicable products**
Conduction test [a), b)] **IEC 62137:Annex B**	Temperature cycling (rapid temperature change) [c)]	SMD	Repeated thermal stress caused by the difference in thermal expansion coefficients of component and board at the ON/OFF of equipment and/or temperature changes in the surrounding environment
Pull strength [a)] **IEC 62137-1-1**		SMD (Gull-wing)	
Shear strength [a)] **IEC 62137-1-2**		SMD	
Torque shear strength [a)] **Annex C**		SMD	
Monotonic bending test [a)] **Annex D**		SMD	
Cyclic bending strength test **IEC 62137-1-4**	Repeated board bending	SMD	Repeated mechanical stress applied to soldered joints and board as in the case of keying, especially for portable equipment
Mechanical shear fatigue test **IEC 62137-1-5**	Cyclic strain	SMD	Repeated thermal stress caused by the difference in thermal expansion coefficients of component and board at the ON/OFF of equipment and/or temperature changes in the surrounding environment
Cyclic drop test [d)] **IEC 62137-1-3**	Repeated board drop	SMD	Shock induced to soldered joints when equipment is erratically dropped while the equipment is in use
Cyclic steel ball drop strength test [d)] **Annex E**	Repeated ball drop	SMD	
Pull strength test **Annex F**	Temperature cycling (rapid temperature change) [c)]	Single-sided TH/Leaded insertion type	Repeated thermal stress caused by the difference in thermal expansion coefficients of component and board at the ON/OFF of equipment and/or temperature changes in the surrounding environment
Creep strength test **Annex G**	Loading + Temperature	Single-sided TH/Leaded insertion type	Degradation of soldered joint when a continuous force is applied
Observe of fillet lifting phenomenon **Annex H**	Evaluation method	Single-sided TH/Leaded insertion type	The external observation method of fillet lifting phenomenon that may occur when soldering an alloy and the terminal plating

NOTE 1

[a)] This is a test to evaluate degradation of joint strength with repeated thermal stress induced to the joint by means of rapid temperature change for an accelerated test. A proper test should be selected according to the features of the component under test such as the shape of its leads.

[b)] This is a test to check if there is a failure at a soldered joint by measuring changes of resistance of the joint without applying mechanical stress. This test method is not a new test method developed in this document but referred here as an alternative method as it is a useful test especially for BGA and LGA.

[c)] Each temperature test is applied in the case of the following alloys.

1) temperature cycling test (Rapid temperature change): Sn-Ag-Cu, Sn-Zn, Sn-Bi and Sn-In

2) High temperature / high humidity test: Sn-Zn

3) High temperature test: Sn-Bi

[d)] Applicable using Sn-Ag-Cu, Sn-Zn, Sn-Bi and Sn-In alloy

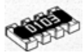
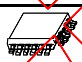
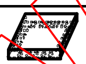
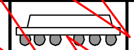
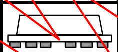
NOTE 2 The vibration test is a test of a durability against the vibration a product may receive while in transportation or in the service in the field. It was not proved that a vibration test, including the most severe random acceleration test, could evaluate degradation of soldered joints. The vibration test is, therefore, not included in this document.

4.2 Selection of test methods based on the shapes and terminals of electronic components

4.2.1 Surface Mount Devices

The recommended test methods suitable for specific shapes and terminals of devices are listed in **Table 2**.

Table 2 – Recommended test methods suitable for specific shapes and terminals of SMDs

	Types and terminals of device				Rapid temperature change test					Cyclic bending test	Cyclic drop test	Mechanical shear fatigue test
	Terminals		Number of terminals	Examples	Pull test	Shear strength test	Torque shear test	Resistance measurement	Monotonic bending limit			
General electronics components	Electrodes on 2 sides (bent leads)		2	Tantalum capacitor, inductor	-	A,B	-	-	-	-	C	-
	Electrodes on 3 sides		2	Rectangular chip resistor/film capacitor	-	A,B	-	-	-	-	C	-
	Electrodes on 5 sides (including cap)		2	Laminated capacitor, thermistor,	-	A,B	-	-	-	-	C	-
	Multi terminals (terminals on sides)		4 or more	Resistor array, capacitor array	-	A,B	-	-	-	C	C	-
	Gull wing – 1		4 or more	Transformer	A,B	C	-	-	C	-	C	-
	Gull wing – 2		Up to 6	Switch	-	B	A,B	-	-	-	C	-
	Gull wing – 3		4 or more	Connector	-	A,B	A,B	-	C	-	C	-
	Electrodes on bottom		2	Inductor, tantalum capacitor	-	A,B	B	-	-	-	C	-
	Round electrode (including cap)		2	MELF capacitor/resistor/fuse	-	A,B	B	-	-	-	C	-
Semiconductor devices	Leads on two sides (bent lead)		2	Diode	-	A,B	C	-	-	-	C	-
	Gull wing leads		3 to 6	Small transistor	C	B	C	-	-	-	C	-
	Gull wing leads		6 or more	QFP, SOP	A,B	-	-	C	C	C	B	B
	Non-lead		6 or more	QFN, SON	-	-	-	A,B	C	B	B	B
	Ball electrodes on bottom		Multiple	BGA, FBGA	-	-	-	A,B	C	B	B	B
	Electrodes on bottom without ball		Multiple	LGA, FLGA	-	-	-	A,B	C	B	B	B

Note1: A: Recommended for accelerated endurance test, B: Applicable, C: Applicable when condition are met, -: Not applicable

Note2: One of the following static mechanical tests is performed before or after the rapid temperature change test according to the shape of the component under test.
a) Pull strength test: SMD with gull wing terminals.
b) Shear strength test: Small rectangular SMD to which a pushing jig can be pressed to a side of the device.

Note3: The conduction test is applicable to devices to which a Daisy-chain can be formed on the mounting board or within the device under test itself. Examples are those semiconductor devices not with leads such as BGA, LGA or QFN.

Note4: The monotonic bending limit test is applicable to those components with height or large size to which the resistance measurement test is available and which are not easily deformed. This test is applicable in case the resistance measurement does not give a good criterion for the durability analysis and a mechanical stress is expected to exist in the service.

Note5: The cyclic bending strength test and cyclic drop test are applicable to those components mainly used in portable equipment.
The use of these tests should be specified in the specification of the product.

Note6: Each temperature test is applied in the case of the following alloys.
a) temperature cycling test (Rapid temperature change): Sn-Ag-Cu, Sn-Zn, Sn-Bi and Sn-In
b) High temperature / high humidity test: Sn-Zn
c) High temperature test: Sn-Bi