



JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS Z 3198-4 : 2003
(JWES)

**Test methods for lead-free solders—
Part 4 : Methods for solderability
test by a wetting balance method
and a contact angle method**

ICS 25.160.50

Reference number : JIS Z 3198-4 : 2003 (E)

PROTECTED BY COPYRIGHT

8 S

Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from The Japan Welding Engineering Society (JWES), with a draft of Industrial Standard based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

Soldering is called HANDAZUKE (Japanese), a technique to be used for mounting electronic and electrical machinery and apparatus, communication equipment and the like and its use field is wide and expectation for high reliability of the connection is large.

Though there are standards inside and outside Japan as well as International Standards like IEC or ISO, this Standard uses results of "standardization of test methods and the like necessary for solder connection corresponding to the reduction of an environmental load" based on the research and development by contract of New Energy and Industrial Technology Development Organization.

This Standard concerns the methods for solderability test (wetting balance method and a contact angle method) of lead-free solders which are environmentally friendly and is positioned as a standard for considering environment.

Being in conformance with this Standard may come under the use of the following patent rights:

- ① Denomination of invention Patent: Plane direction detecting appliance
Date of registration of the invention: August 16, 2002
- ② Denomination of invention Patent: Plane direction detecting appliance
Date of decision of grant a patent: October 22, 2002
- ③ Denomination of invention Patent: Contact angle measuring appliance
Date of decision of grant a patent: September 3, 2002

Besides, this description does not affect to any extent the validity, the scope and the like of the above patent rights.

The holders of these patent rights give guarantee to the Japanese Industrial Standards Committee with respect to his willingness to permit anyone to exercise the relevant patent right under the nondiscriminatory and reasonable conditions. In this regard, however holders of other industrial properties related to this Standard are subject to permit their inventions' exercises in exactly same condition above mentioned.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

JIS Z 3198 includes the following 7 parts with the general title *Test methods for lead-free solders*

Part 1 : Methods for measuring of melting temperature ranges

Part 2 : Methods for testing of mechanical characteristics—tensile test

Part 3 : Methods for spread test

Part 4 : Methods for solderability test by a wetting balance method and a contact angle method

Part 5 : Methods for tensile tests and shear tests on solder joints

Part 6 : Methods for 45° pull test of solder joints on QFP lead

Part 7 : Methods for shear strength of solder joints on chip components

Date of Establishment: 2003-06-20

Date of Public Notice in Official Gazette: 2003-06-20

Investigated by: Japanese Industrial Standards Committee

Standards Board

Technical Committee on Welding

JIS Z 3198-4:2003, First English edition published in 2003-12

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

© JSA 2003

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

PROTECTED BY COPYRIGHT

Contents

	Page
Introduction	1
1 Scope	1
2 Normative references	1
3 Definitions	1
4 Test method	2
4.1 Outline of test	2
4.2 Reagent and material	2
4.3 Apparatus and instruments	3
4.4 Procedure of test	3
4.5 Test conditions	5
5 Recording results	6
6 Evaluation	7
Annex 1 (normative) Characteristics of apparatus in a wetting balance method	9
Annex 2 (normative) Characteristics of apparatus in a contact angle method	10

Test methods for lead-free solders— Part 4 : Methods for solderability test by a wetting balance method and a contact angle method

Introduction This Japanese Industrial Standard specifies the methods for solderability test by a wetting balance method and a contact angle method of a lead-free solder which are based on occupational results by contract of New Energy and Industrial Technology Department Organization concerning “the standardization of test methods and the like necessary for solder connection corresponding to the reduction of an environmental load” carried out in 2000 and 2001.

1 Scope This Standard specifies the methods for solderability test of a wetting balance method and a contact angle method of lead-free solder to be used principally for wiring connection, parts connection and the like of electrical machinery and apparatus, electronic apparatus, communication equipment and the like.

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS H 3100 *Copper and copper alloy sheets, plates and strips*

JIS H 3260 *Copper and copper alloy wires*

JIS K 5902 *Colophonium*

JIS K 8034 *Acetone*

JIS K 8180 *Hydrochloric acid*

JIS K 8839 *2-Propanol*

JIS Z 3001 *Welding terms*

JIS Z 3282 *Soft solders—Chemical compositions and forms*

3 Definitions For the purposes of this Standard, the definitions given in **JIS Z 3001** and the following definitions apply:

- a) **lead-free solder** It is the generic term of “a tin based solder” not containing lead as an alloy component. It is “a solder not containing lead” for a use corresponding to that of “a tin-lead based solder”, which is used for mounting an electrical, electronic, communication equipment and the like.
- b) **wetting force** It is a value obtained by adding a buoyance to an action force when a metal piece is dipped vertically into a molten solder. It is also called a bonding strength.
- c) **contact angle** It is an angle made by a tangent drawn from a point contacting a solid surface of a solder liquid drop to a liquid surface and the solid surface, or an angle made by a tangent direction of a meniscus (a curved surface of a liquid) and a vertical axis when a metal piece is dipped vertically into the molten solder.

- d) **solder bath (HANDA YOKU)** It is a solder tank filled with molten solder having a mechanism capable of being held at a specific temperature by heating and melting the solder.

4 Test method

4.1 Outline of test For the test method, the following two methods are specified, in which the solderability of lead-free solder being tested is evaluated by being compared with that of a standard solder by using a specified test piece and a standard flux.

- (1) **Method A (Wetting balance method)** A method for measuring a wetting time and a wetting force of the solder being tested.
- (2) **Method B (Contact angle method)** A method for measuring the contact angle at the tip of a fillet of the solder being tested.
 - a) Fill a lead-free solder as the test object or a standard solder for comparison into a solder tank and heat it at a specific test temperature to provide a solder bath.
 - b) Attach a test piece to the holder and hang it on the tester (see Fig. 1).
 - c) Raise the tester or lower the test piece so that the test piece comes in contact with the molten solder surface of the solder bath and the test piece is dipped to a specific depth.
 - d) For method A, detect the action force operating on the test piece from the point of dipping the test piece to pulling it out and display it by recording continuously as a function of time on the recorder through a signal converter.
 - e) For test method B, measure the contact angle of the solder wetted on the test piece from the point of dipping the test piece to pulling it out and display it by recording.

4.2 Reagent and material The reagent and material shall be as follows:

- a) **Deionized water**
- b) **Acetone** is specified in **JIS K 8034**.
- c) **2-Propanol** is specified in **JIS K 8839**.
- d) **Acid cleaning liquid** is provided by diluting 5 g (35 %) of hydrochloric acid specified in **JIS K 8180** with 95 g of deionized water. (1.75 %)
- e) **Standard flux A⁽¹⁾** (nonactive rosin flux) is provided by dissolving 25 g $\pm$ 0.1 g of rosin specified as class 2 in **JIS K 5902** in 75 g $\pm$ 0.1 g of 2-propanol specified in **JIS K 8839**.
- f) **Standard flux B⁽¹⁾** (halogen activated rosin flux) Add 75 g $\pm$ 0.1 g of 2-propanol specified in **JIS K 8839** to 25 g $\pm$ 0.1 g of rosin and heat. Thereafter, add 0.39 g $\pm$ 0.01 g of diethylamine hydrochloride⁽²⁾ and dissolve by stirring quietly. After cooling, weigh and add 2-propanol of the evaporated content. This flux contains 0.5 % of the chlorine amount for every content of rosin. Put the standard flux into a hermetically sealed container and preserve by avoiding light, heat and extreme low temperatures.

Notes (1) Fluxes A and B may be selected as agreed between the purchaser and the supplier.

(2) For diethylamine hydrochloride, dry at $(110\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C})$ for 2 h.

g) **Standard solder** Sn63Pb37A or Sn63Pb37E specified in **JIS Z 3282**.

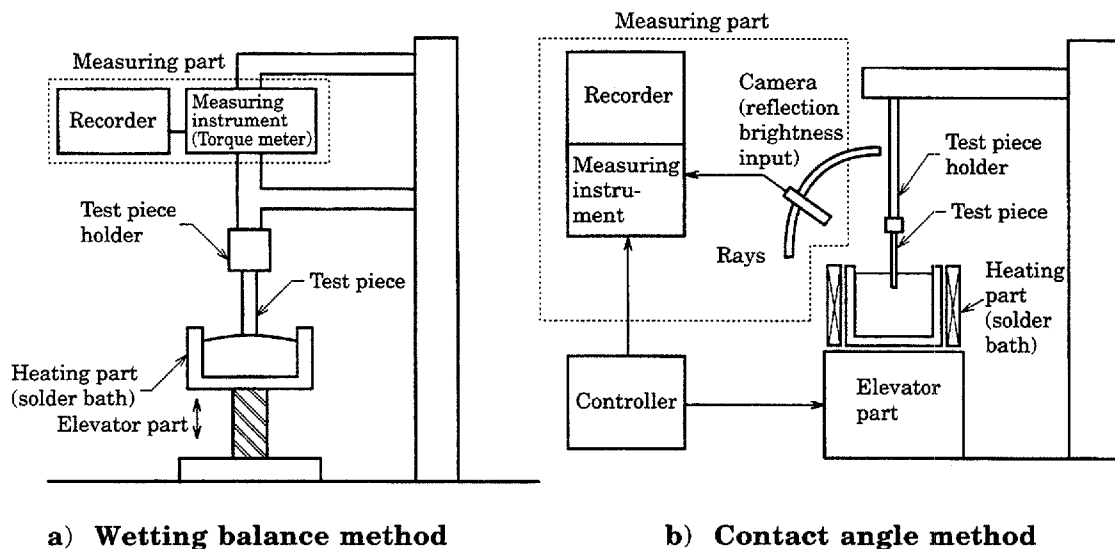


Fig. 1 Structural example of tester

4.3 Apparatus and instruments A structural example of an apparatus suitable for this test is shown in Fig. 1.

A tester shall be constituted of the measuring part for measuring and recording the test results, the elevator part capable of controlling elevation of the solder bath and the heating part for heating a test piece. Characteristics of the tester are specified in Annexes 1 and 2. The apparatus to be used for this test shall be as follows.

- A solder bath and an auxiliary instrument for a wetting balance method and a contact angle method A solder tank for a solder bath shall be a square or cylindrical container 15 mm or over in depth wherein any part of the test piece shall be separated by 15 mm or over from the tank wall and the temperature of molten solder can be held in a precision of the test temperature $\pm 3\text{ }^{\circ}\text{C}$.
- Recorder (computer controlling)
- Tabletop ultrasonic cleaner
- Spatula, pincettes or tongs
- Petri dish and filter paper
- A pair of gloves shall be used to avoid handling the test piece with bare hands

4.4 Procedure of test

a) Preparation of test piece

- Test piece** A test piece to be used for a wetting balance method (method A) and a contact angle method (method B) shall be made of a phosphorus

deoxidized copper specified in **JIS H 3100** and for a platy test piece, C1201P or C1220P shall be used. Further, for a linear test piece to be used for a wetting balance method (method A), a tough pitch copper wire C1100W-0 or C1100W1/2H specified in **JIS H 3260** shall be used. The end surface of a test piece to be dipped into a solder shall be free from flash and flaws. Dimensions of the test piece are shown in Table 1. For handling the test piece, clean pincettes or tongs shall be used.

Table 1 Shape and dimensions of test piece

Unit: mm

Application	Shape	Thickness	Width	Length
Methods A and B	platy	0.3 ± 0.03	10 ± 0.01	30 ± 0.1
Only method A	linear	diameter 0.6 ± 0.03	—	30 ± 0.1

- 2) **Acid cleaning treatment of test piece** Clean by degreasing the test piece by acetone specified in **JIS K 8034** and dry at a room temperature. Thereafter, put it into an acid cleaning liquid and clean with an ultrasonic cleaner for 1 min. Then, take it out from the acid cleaning liquid. After cleaning sufficiently by deionized water, dip into acetone specified in **JIS K 8034** and dry at room temperature.

Further, in order to prevent reoxidizing due to exposure to the open air for a long time, carry out acid cleaning treatment of the test piece just before execution of the test.

b) Test The test shall be as follows:

- 1) Melt solder in a solder tank and hold a temperature at $250 \text{ }^{\circ}\text{C} \pm 3 \text{ }^{\circ}\text{C}$. The test temperature may be agreed upon between the purchaser and the supplier according to the solder.
- 2) Put standard flux A or B in a petri dish.
- 3) Dip a test piece into the flux by a depth of 4 mm to 5 mm from the edge for 5 s. However, do not go beyond 3 mm more than the dipping depth into molten solder. Treat the test piece with clean pincettes or tongs or by wearing gloves.
- 4) Take out the test piece from the flux. When taking it out, slant the test piece as pulling it up so that excess flux does not attach to it. Further, when excess flux can be visually observed in a spherical state, clean the test piece with corners of a clean filter paper.
- 5) Attach the test piece to the test piece holder so as to become normal to the molten solder surface of the solder bath. Remove the oxidized film on the molten solder surface of the solder bath with a spatula.
- 6) For method A, raise the solder bath or lower the test piece, and start the recorder. Then, record on a chart the change of a load over time from the point where the test piece contacts the molten solder surface to the wetting under the dipping conditions given in Table 3.

- 7) For method B, raise the solder bath or lower the test piece, and start the recorder. Then, record on the chart the time change of the contact angle from the point where the test piece contacts the molten solder surface to the wetting under the dipping conditions given in Table 3.
- 8) In order to avoid temperature rise of a test piece due to radiant heat from the solder bath and consumption of the flux, start the recording within 1 min after attaching the test piece.
- 9) Carry out operations of 1) to 8) for a standard solder and a testing lead-free solder. In this case, the time and procedure of the operation item in each process shall be as given in Table 2 (see the explanation in Fig. 2). The number of test pieces shall be five. Further, the time sequence explanation figure of the test operating items is given in Fig. 2.

Table 2 Time sequence of test operation items

Unit: s

Operation item	Time	Continuing time
(1) Dipping into flux	0	5
(2) Attachment of a test piece to a holder	15	—
(3) Removal of the oxidized film from a solder bath surface	20	—
(4) Start of lowering of the test piece	30	—
(5) Dipping into the solder bath	60 or under	10

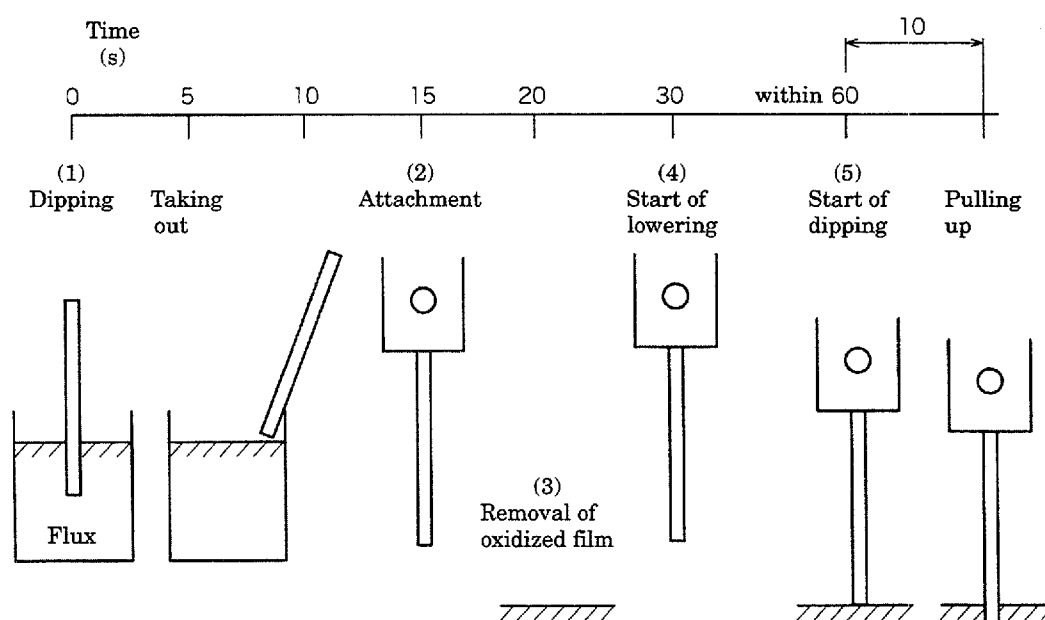


Fig. 2 Time sequence explanation figure of test operation items

4.5 Test conditions Test conditions shall be as follows:

- a) **Functioning conditions of tester** Functioning conditions of a tester are given in Table 3.

Table 3 Functioning conditions of tester

Item	Conditions
Dipping depth	2 mm
Dipping speed	2 mm/s to 5 mm/s
Dipping time	10 s

- b) **Temperature conditions** For the temperature conditions of a solder bath, those of Type I or Type II given in Table 4 shall be used.

Table 4 Temperature conditions

System	Dipping time s	Temperature °C
Type I	10	250
Type II	10	Solidification start temperature +20

- c) **Temperature measuring position** When, for structural reasons, measuring the molten solder temperature of the test piece immersion part is impractical, if the temperature of a suitable position of the solder tank can sufficiently and closely approximate it, the measurement is carried out at this position. However, an error from the temperature at the lower end of the test piece shall not exceed ± 3 °C in this case.

5 Recording results Recording results shall be as follows:

- a) **For method A** Obtain the wetting starting time and the wetting finishing time from the curve appeared on recording paper (see Fig. 3) and record it. For the time when wetting starts, measure the distance from point 0 to point A in Fig. 3. For the time when the wetting is finished, measure the distance from point A to point B (2/3 of the maximum wetting force) and express it in time. Further, if necessary, obtain the maximum wetting force. For the maximum wetting force, measure the distance from point $F_{\max}$, wherein the width between the reference line and the recording line becomes maximum, to the reference line and express it as a wetting force (mN).
- b) **For method B** Measure the contact angle after a specific time has elapsed from the stop of immersion (8 s later) and record it.

Remarks 1 Evaluation of wetting may be based on the wetting time (t), obtained by adding a wetting start time (t_0) to a wetting finish time (t_1).

- 2 It is recommended that a dipping speed is set to slow (2 mm/s) when a copper wire is used as the test piece and to fast (4 mm/s) when a copper sheet is used.

Information : For selection of a standard flux and a test piece, in the case of solder of good wetting, use of standard flux A and a copper sheet not having an activity makes it easy to confirm the difference.

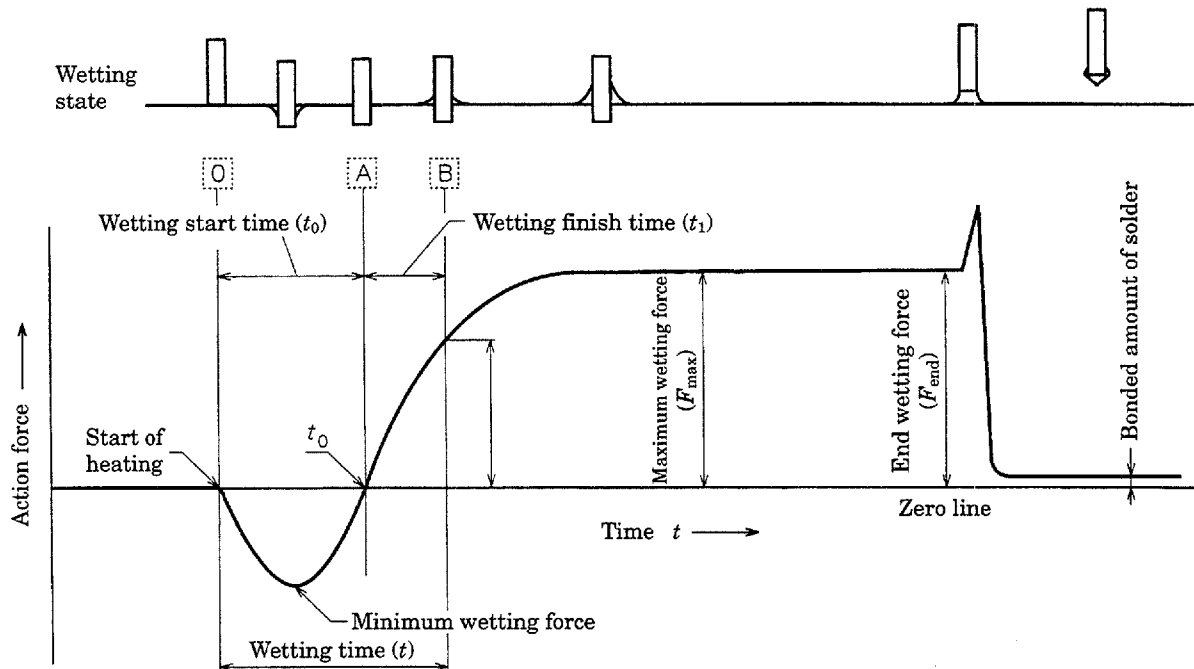


Fig. 3 Evaluation of wetting—when buoyancy is not considered

6 Evaluation Quality of wetting shall be evaluated by relative comparison to wetting of standard solder based on the following wetting indices.

a) **For method A**

Wetting time t_0 and t_1 (or t)

Maximum wetting force $F_{\max}$

b) **For method B**

Contact angle θ

An example of an evaluation result table is given in Table 5.

Table 5 Evaluation result table

Lead-free solder

	Method A						Method B
	Wetting start time	Wetting finish time	Wetting time	Maximum wetting force 2/3	Maximum wetting force	End wetting force	Contact angle
	t_0 [s]	t_1 [s]	t [s]	$2/3F_{\max}$ [mN]	$F_{\max}$ [mN]	F_{end} [mN]	θ
No. 1							
No. 2							
No. 3							
No. 4							
No. 5							
Minimum							
Maximum							
Average							
Standard deviation							

Standard solder

	Method A						Method B
	Wetting start time	Wetting finish time	Wetting time	Maximum wetting force 2/3	Maximum wetting force	End wetting force	Contact angle
	t_0 [s]	t_1 [s]	t [s]	$2/3F_{\max}$ [mN]	$F_{\max}$ [mN]	F_{end} [mN]	θ
No. 1							
No. 2							
No. 3							
No. 4							
No. 5							
Minimum							
Maximum							
Average							
Standard deviation							

Annex 1 (normative)

Characteristics of apparatus in a wetting balance method

1 Scope This Annex 1 specifies the characteristics of an apparatus used for a solderability test method by a wetting balance method of a lead-free solder.

2 Characteristics of apparatus The testing apparatus shall have the following characteristics:

- a) The measuring part shall conform to the following performance:
 - 1) The force measuring range of a measuring instrument shall be -50 mN to $+50\text{ mN}$ and in the maximum sensitivity range, a force can be detected within a range of -2 mN to $+2\text{ mN}$.
 - 2) The sensor displacement sensitivity of the measuring instrument shall be $1\text{ mN}/2\text{ }\mu\text{m}$ or under.
 - 3) The resolution of the measuring instrument shall be 0.01 mN or under in maximum sensitivity.
 - 4) The recording instrument shall draw an action force transition curve with a recorder using recording paper or with a personal computer or the like.
 - 5) For the response time of the recording element (a pen or the like) of the recorder, a return to the zero point of the centre from the maximum load shall be completed within 0.3 s and the excessive amount shall be 1% or under of the maximum reading.
 - 6) An action force transition curve is drawn by variation of a continuous action force and can read variation of the action force of 0.1 s or under.
- b) The heating part shall maintain the temperature given in Table 4 of the text **4.5 b) temperature conditions**.
- c) The elevator part shall conform to the following performance:
 - 1) For the elevator part, the speed can be varied and the maximum elevating speed shall be 5 mm/s or over.
 - 2) The controller shall be that capable of controlling the maximum error of the depth of dipping a test piece into the molten solder of a solder bath within $\pm 0.1\text{ mm}$.
- d) The recorder part shall conform to the following performance:
 - 1) The recording part shall draw an action force transition curve by a recorder using recording paper or by a personal computer and the like.
 - 2) For the response time of the recording element (a pen or the like) of the recording part, a return to the zero point of the centre from the maximum load shall be completed within 0.3 s and the excess amount shall be 1% or under of the maximum reading.
 - 3) The action force transition curve is drawn by variation of continuous action force and shall be able to read an action force variation 0.1 s or under.

Annex 2 (normative)

Characteristics of apparatus in a contact angle method

1 Scope This Annex 2 specifies the characteristics of an apparatus used for a solderability test method by the contact angle method of lead-free solder.

2 Characteristics of apparatus The testing apparatus shall have the following characteristics.

a) The measuring part shall conform to the following performance:

- 1) The measuring instrument shall be that capable of measuring a contact angle simultaneously with variation of wetting force in point of time (or force acting on the test piece).
- 2) The measuring instrument shall be that capable of specifying the position for measuring a contact angle and the positional resolution shall be 100 μm or under.
- 3) The precision for measuring a contact angle of the measuring instrument shall be that capable of measuring within a range of $\pm 1^\circ$.
- 4) The measuring instrument shall be that capable of calibrating an angle. Further, the precision shall be $\pm 1^\circ$.
- 5) The recorder shall be that capable of drawing the shape of a fillet formed by solder wetting onto the test piece by using a personal computer, a printer and the like.
- 6) The recorder shall be that capable of displaying an angle measurement result and the time lapse.

b) The heating part shall conform to the following performance:

- 1) The heating part shall be that capable of maintaining the temperature given in Table 4 of the text 4.5 b) temperature condition.

c) The elevator part shall conform to the following performance:

- 1) The elevator part shall be that capable of varying the speed and the maximum elevating speed shall be 5 mm/s or over.
- 2) The controller shall be that capable of controlling the maximum error of a depth wherein the test piece is dipped into the molten solder of a solder bath within ± 0.1 mm.

Errata for JIS (English edition) are printed in *Standardization Journal*, published monthly by the Japanese Standards Association, and also provided to subscribers of JIS (English edition) in *Monthly Information*.

Errata will be provided upon request, please contact:
Standardization Promotion Department, Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN
TEL. 03-3583-8002 FAX. 03-3583-0462

100% Recycled paper

~~~~~  
PROTECTED BY COPYRIGHT