

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS Z 3198-5 : 2003
(JWES)

**Test methods for lead-free solders—
Part 5 : Methods for tensile tests
and shear tests on solder joints**

ICS 25.160.50

Reference number : JIS Z 3198-5 : 2003 (E)

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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 tensile tests and shear tests on solder joints of lead-free solders which are environmentally friendly and is positioned as a standard for considering environment.

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 3198-5:2003, First English edition published in 2003-12

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

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the original JIS is to be the final authority.

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Printed in Japan

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Contents

	Page
Introduction	1
1 Scope	1
2 Normative references	1
3 Definitions	1
4 Test piece	2
4.1 Classification of test piece	2
4.2 Shape and dimensions of test piece	2
5 Test material, solder, flux and soldering atmosphere	3
5.1 Test material	3
5.2 Solder	4
5.3 Flux and soldering atmosphere	4
6 Soldering of test material	4
7 Heat treatment of test material	5
8 Test method	5
8.1 Tensile test	5
8.2 Shear test	5
9 Method for obtaining measured value	6
9.1 For tensile test method	6
9.2 For shear test method	7
10 Recording of test results	7

Test methods for lead-free solders— Part 5 : Methods for tensile tests and shear tests on solder joints

Introduction This Japanese Industrial Standard specifies the methods for tensile tests and shear tests on lead-free solder joints 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 a solder connection corresponding to the reduction of an environmental load” carried out in 2000 and 2001.

1 Scope This Standard specifies the methods for tensile tests and shear tests of lead-free solder to be used principally for wiring connection, components 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 G 0202 *Glossary of terms used in iron and steel (testing)*

JIS K 8034 *Acetone*

JIS K 8180 *Hydrochloric acid*

JIS Z 2241 *Method of tensile test for metallic materials*

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 G 0202**, **JIS Z 3001**, **JIS Z 3282** and the following definitions apply.

- a) **lead-free solder** 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) **fillet** A solder part swollen out from a clearance of a joint in a solder joint.
- c) **void** A hollow wherein a solder does not spread in a solder joint.
- d) **tensile strength** A value of dividing the maximum tensile load in a tensile test by the cross section of a test piece.
- e) **shear strength** A value of dividing the maximum shear load of a solder joint by a soldered joint area.
- f) **soldered joint area** The cross section of a soldered joint part.

4 Test piece

4.1 Classification of test piece Test pieces shall be classified according to the type of a test and the shape of a test piece as given in Table 1.

Table 1 Classification of test piece

Classification	Shape
Tensile test piece	Butt joint by plate
No. 1 shear test piece	Shear joint by plate
No. 2 shear test piece	Shear joint by disc plate

4.2 Shape and dimensions of test piece The shape and dimensions of a test piece shall be as follows:

- a) The shape and dimensions of a tensile test piece shall be as given in Fig. 1.

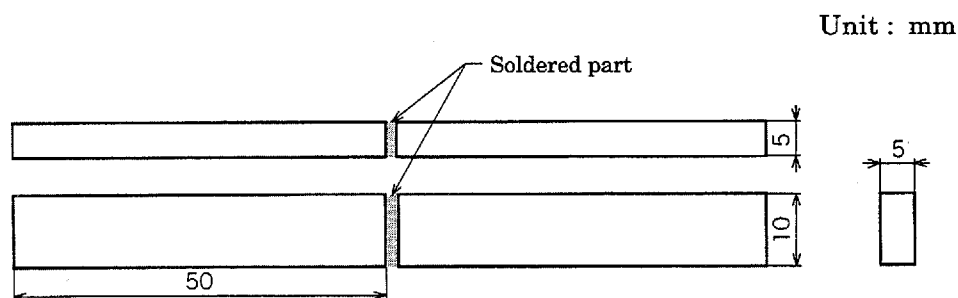


Fig. 1 Tensile test piece

- Remarks 1 The joint part of a test piece shall be finished by machining after soldering and the fillet shall be completely removed.
- 2 The surface roughness of a soldered joint part shall be $R_{\max}25S$.
- 3 A joint part after bonding shall be sufficiently soldered to the edge part by bonding the test piece with a bonding machine capable of heating the test piece uniformly.

- b) The shape and dimensions of No. 1 shear test piece shall be as given in Fig. 2.

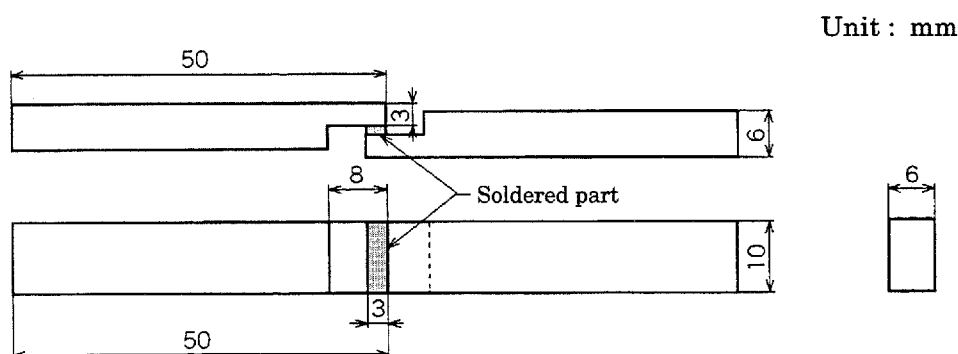


Fig. 2 No. 1 shear test piece

- Remarks 1 The fillet of the joint part of a test piece shall be completely removed.
- 2 The surface roughness of a solder joint part shall be $R_{\max}25S$.
- 3 A test piece shall be bonded by using a bonding machine capable of heating uniformly and after bonding, the joint part shall be sufficiently soldered to the edge part.
- c) The shape and dimensions of a No. 2 shear test piece shall be as given in Fig. 3.

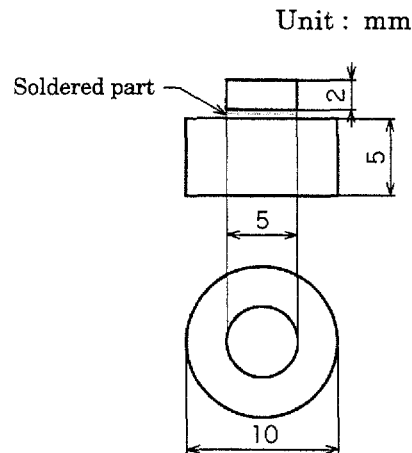


Fig. 3 No. 2 shear test piece

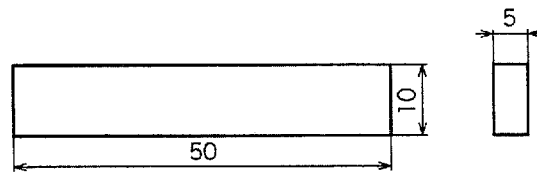
- Remarks 1 The fillet of the joint part of a test piece shall be completely removed.
- 2 The surface roughness of a solder joint part shall be $R_{\max}25S$.

5 Test material, solder, flux and soldering atmosphere

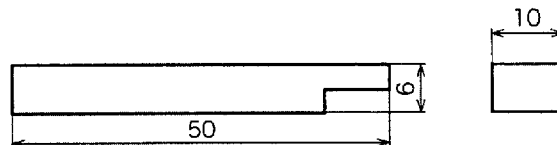
5.1 Test material A test material (a base metal) shall be as follows:

- a) For a test material, the material quality is determined according to the purpose of a test and the shape and dimensions thereof shall be as given in Fig. 4.
- The number of tensile test pieces of test material and No. 1 shear test piece of test material is two pieces for each, and the number of tensile test pieces of test material and No. 2 shear test pieces of test material is one piece for each.
- b) The soldering surface of a test material is finished by machining or the like.
- c) The soldering surface is cleaned by a degreasing agent conforming to **JIS K 8034** and an acid cleaning liquid conforming to **JIS K 8180**.
- d) Plating treatment may be carried out on a soldering surface according to the purpose of a test.

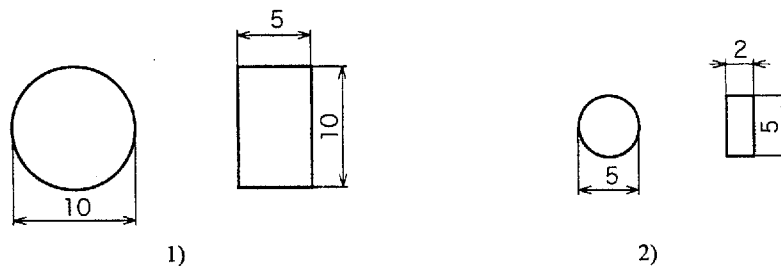
Unit : mm



a) Test material of tensile test piece



b) Test material of No. 1 shear test piece



c) Test material of No. 2 shear test piece

Fig. 4 Shape and dimensions of test material

5.2 Solder A solder to be used for a test shall be as follows:

- The type, shape and supply method of a solder to be used for a test is selected as agreed between the purchaser and the supplier and shall be that capable of forming a sound joint which is free from defects such as voids and the like.
- The amount of solder to be used for a test shall be enough for filling the clearance of a solder joint.
- The surface of solder to be used for a test shall be cleaned by a suitable method.

5.3 Flux and soldering atmosphere The flux and the soldering atmosphere shall be as follows:

- Flux and the soldering atmosphere which are suitable for the relevant soldering is used.
- Coating of the flux shall be uniformly carried out over the whole surface of the soldering surface.

6 Soldering of test material Soldering of a test material shall be as follows:

- a) When soldered, a suitable jig is used in order to prevent slippage of the test material.
- b) The clearance of a solder joint shall be within the range of 50 μm to 400 μm . In order to compare test results, the comparison shall be carried out by selecting those having almost the same clearance.
- c) Though a soldering apparatus is not specified, the apparatus shall be capable of measuring a soldering temperature.
- d) A soldering temperature shall be within a suitable soldering temperature range of solder to be used.
- e) Temperature conditions of heating and cooling speed, preheating temperature and the like in soldering shall be specified according to the purpose of a test.
- f) A solder thickness shall be uniform and free from deformation as far as possible over the whole surface of a joint.
- g) Excess solder swollen from a solder joint shall be completely shaved off.
- h) After soldering, the flux adhering to the test material shall be completely removed by a suitable method.
- i) For the test material, a warp after soldering shall not be reformed.

7 Heat treatment of test material Heat treatment of a test material shall be as follows:

- a) When a strength after heat treatment of a solder joint is measured, the test material after soldering is heat-treated.
- b) Though a heat-treating apparatus is not specified, an apparatus capable of measuring a heat treatment temperature is used.
- c) A test treatment temperature and a retention time are specified according to the purpose of a test.

8 Test method

8.1 Tensile test A test method by a tensile test piece shall be as follows:

- a) For the test method, the tensile test method specified in **JIS Z 2241** is used.
- b) During a test, do not apply a force in a bending direction to the test piece.
- c) A tensile speed is 1 mm/min to 50 mm/min.
- d) A test temperature shall be within the range of 10 °C to 35 °C and the test temperature is recorded. Especially when a temperature control is required, the test temperature shall be 23 °C $\pm$ 5 °C.

8.2 Shear test

8.2.1 Test by No. 1 shear test piece A test method by No. 1 test piece shall be as follows:

- a) For a test method, the tensile test method specified in **JIS Z 2241** is used.
- b) During the test, do not apply a force in the bending direction to the test piece.
- c) A tensile speed is 1 mm/min to 50 mm/min.
- d) A test temperature is within the range of 10 °C to 35 °C and the test temperature is recorded. Especially when temperature control is necessary, the temperature shall be $23\text{ °C} \pm 5\text{ °C}$.

8.2.2 Test by No. 2 shear test piece A test method by No. 2 test piece shall be as follows:

- a) The test apparatus given in Fig. 5 is used and a test is carried out by the tensile test method specified in **JIS Z 2241**.
- b) The surface of a shear jig which contacts with a test piece shall be plane.
- c) The height of a shear jig is adjustable in a precision of 0.1 mm.
- d) Fixing a test piece is suitably carried out so as not to move during loading.
- e) The height of a shear jig is within the range of adding 0.2 mm to 0.7 mm to the thickness of a solder layer from a reference surface.
- f) The test speed is within the range of 1 mm/min to 50 mm/min.
- g) The test temperature is 10 °C to 35 °C and the test temperature is recorded. Especially when temperature control is required, the test temperature shall be $23\text{ °C} \pm 5\text{ °C}$.

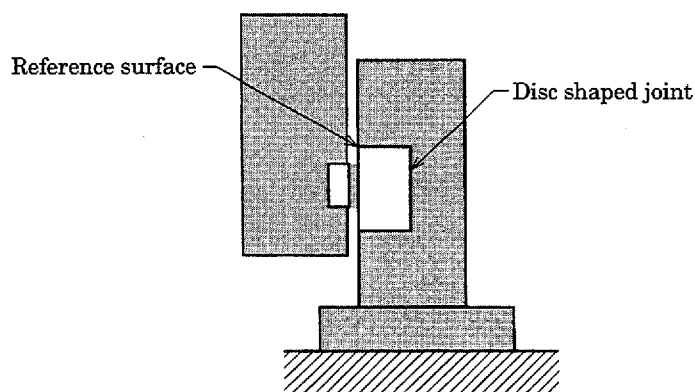


Fig. 5 Structural example of test apparatus

9 Method for obtaining measured value A method for obtaining a measured value shall be as follows:

9.1 For tensile test method The method for obtaining a measured value in a tensile test method shall be as follows:

- a) The area after soldering shall be a value of multiplying a joint width by a joint thickness by measuring both of the joint width and the joint thickness to the nearest 0.1 mm with a suitable measuring instrument.

- b) The tensile strength of a solder joint is obtained according to the following formula.

$$\sigma = \frac{P}{A}$$

where, σ : tensile strength of solder joint (N/mm²)
 P : maximum rupture load of solder joint (N)
 A : soldering area before test (mm²)

- c) Whether a rupture position is in a solder or on an interface is observed with a suitable observing device.

9.2 For shear test method The method for obtaining a measured value in a shear test method shall be as follows:

- a) The area of No. 1 shear test piece after soldering shall be a value of multiplying a joint width by a joint thickness by measuring both of the joint width and the joint thickness to the nearest 0.1 mm with a suitable measuring instrument.
- b) The area of No. 2 shear test piece after soldering shall be an area of a circle wherein two lengths assumed as the average diameter crossing mutually at right angles are measured to the nearest 0.1 mm with a specific measuring instrument and their average is taken as a diameter of the circle.
- c) The tensile strength of a solder joint is obtained according to the following formula.

$$\tau = \frac{P_s}{A}$$

where, τ : shear strength of solder joint (N/mm²)
 P_s : maximum rupture load of solder joint (N)
 A : soldering area before test (mm²)

- d) Whether a rupture position is in a solder or on an interface is observed with a suitable observing apparatus.

10 Recording of test results Recording of test results shall be as follows:

- a) Date of test
- b) Test place
- c) Name and classification of test material
- d) Presence of plating and classification of plating
- e) Classification of test piece
- f) Type of solder
- g) Type of flux and conditions for soldering temperature
- h) Soldering method (heating method, preheating temperature, soldering temperature, retention time, heating speed, cooling speed and the like)

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Z 3198-5 : 2003

- i) Presence of heat treatment and conditions for heat treatment (temperature and retention time)
- j) Thickness of solder layer
- k) Tensile strength or shear strength of soldering joint
- l) Ruptured position
- m) Test temperature

Informative standard:

JIS Z 3192 *Methods of tensile and shear tests for brazed joint*

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*.

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