

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS A 1439 : 2010

(JSIA/JSA)

**Testing methods of sealants for
sealing and glazing in buildings**

ICS 91.100.50

Reference number : **JIS A 1439 : 2010 (E)**

PROTECTED BY COPYRIGHT

Date of Establishment: 1997-08-20

Date of Revision: 2010-04-20

Date of Public Notice in Official Gazette: 2010-04-20

Investigated by: Japanese Industrial Standards Committee
Standards Board
Technical Committee on Architecture

JIS A 1439:2010, First English edition published in 2012-04

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 2012

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	2
3 Terms and definitions	3
4 Test substrates	4
4.1 Aluminium substrates.....	4
4.2 Mortar substrates	5
4.3 Glass substrates.....	5
5 Tests	5
5.1 Slump test	5
5.2 Determination of elastic recovery	7
5.3 Determination of tensile properties	11
5.4 Determination of adhesion properties at maintained elongation	14
5.5 Determination of adhesion properties after compressive heating and tensile cooling.....	15
5.6 Determination of adhesion properties after extension/compression cycle	17
5.7 Determination of adhesion properties after exposure to heat, water and artificial light through glass	17
5.8 Determination of adhesion properties at maintained extension after immersion in water	19
5.9 Determination of adhesion properties after immersion in water	20
5.10 Determination of resistance to compression	20
5.11 Determination of change in mass and volume (loss), and determination of density	21
5.12 Determination of extrudability of one-component sealants in cartridge	23
5.13 Determination of extrudability using an extrusion device.....	25
5.14 Determination of extrudability using a test cartridge	27
5.15 Determination of initial water resistance.....	29
5.16 Determination of low temperature storage stability	30
5.17 Determination of durability	30
5.18 Determination of usable life	36
5.19 Determination of tack-free	36
5.20 Determination of tensile adhesion	36
5.21 Record of test results	41
Annex JA (informative) Comparison table between JIS and corresponding International Standard	43

Annex JB (informative)	Comparison table between previous and current editions of this Standard on technically significant revisions	50
------------------------	--	----

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee as the result of proposal of revision of Japanese Industrial Standard submitted by Japan Sealant Industry Association (JSIA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS A 1439**:2004 is replaced with this Standard.

This **JIS** document is protected by the Copyright Law.

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. 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.

Testing methods of sealants for sealing and glazing in buildings

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 6927, ISO 7389, ISO 7390, ISO 8339, ISO 8340, ISO 8394, ISO 9046, ISO 9047, ISO 9048, ISO 10563, ISO 10590, ISO 10591, ISO 11431, ISO 11432 and ISO 13640**, with some modifications of their technical contents so as to reflect the actual situation in Japan. In addition, the requirements that are not given in the above corresponding International Standards are added in this Standard, which are: determination of extrudability using a test cartridge (**5.14**), determination of initial water resistance (**5.15**), determination of low temperature storage stability (**5.16**), determination of durability (**5.17**), determination of application life (**5.18**), determination of tack-free (**5.19**), determination of tensile adhesion (**5.20**), and the report of test results (**5.21**).

The portions with continuous sidelines or dotted underlines are the matters in which the contents of the corresponding International Standards have been modified. A list of modifications with explanations is given in Annex JA.

A table of comparison between previous and current editions of this Standard on technically significant revisions is given in Annex JB.

1 Scope

This Standard specifies testing methods of sealants for building purposes (hereafter referred to as “sealants”) that are to be applied in the joint between building component materials such as metal, concrete and glass in an unformed state so that after drying, they adhere to the components and ensure water-tightness and air-tightness of the joint.

NOTE : The International Standards corresponding to this Standard and the symbol of degree of correspondence are as follows:

ISO 6927:1981 *Building construction—Jointing products—Sealants—Vocabulary*

ISO 7389:2002 *Building construction—Jointing products—Determination of elastic recovery of sealants*

ISO 7390:2002 *Building construction—Jointing products—Determination of resistance to flow of sealants*

ISO 8339:2005 *Building construction—Sealants—Determination of tensile properties (Extension to break)*

ISO 8340:2005 *Building construction—Sealants—Determination of tensile properties at maintained extension*

ISO 8394:1988 *Building construction—Jointing products—Determination of extrudability of one-component sealants*

ISO 9046:2002 *Building construction—Jointing products—Determination of adhesion / cohesion properties of sealants at constant temperature*

ISO 9047:2001 *Building construction—Jointing products—Determination of adhesion / cohesion properties of sealants at variable temperatures*

ISO 9048:1987 *Building construction—Jointing products—Determination of extrudability of sealants using standardized apparatus*

ISO 10563:2005 *Building construction—Sealants—Determination of change in mass and volume*

ISO 10590:2005 *Building construction—Sealants—Determination of tensile properties of sealants at maintained extension after immersion in water*

ISO 10591:2005 *Building construction—Sealants—Determination of adhesion / cohesion properties of sealants after immersion in water*

ISO 11431:2002 *Building construction—Jointing products—Determination of adhesion / cohesion properties of sealants after exposure to heat, water and artificial light through glass*

ISO 11432:2005 *Building construction—Sealants—Determination of resistance to compression*

ISO 13640:1999 *Building construction—Jointing products—Specifications for test substrates* (Overall evaluation: MOD)

The symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

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

JIS A 1415 *Methods of exposure to laboratory light sources for polymeric material of buildings*

JIS B 0202 *Parallel pipe threads*

NOTE : Corresponding International Standard: ISO 228-1 *Pipe threads where pressure-tight joints are not made on the threads—Part 1: Dimensions, tolerances and designation* (MOD)

JIS B 1101 *Slotted head screws*

NOTE : Corresponding International Standard: ISO 2009 *Slotted countersunk flat head screws (common head style)—Product grade A* (NEQ)

JIS B 1354 *Parallel pins*

NOTE : Corresponding International Standard: ISO 2338 *Parallel pins, of unhardened steel and austenitic stainless steel* (MOD)

JIS B 7505-1 *Aneroid pressure gauges—Part 1: Bourdon tube pressure gauges*

JIS B 7507 *Vernier, dial and digital callipers*

JIS B 7516 *Metal rules*

JIS H 4000 *Aluminium and aluminium alloy sheets, strips and plates*

NOTE : Corresponding International Standard: ISO 209-1:1989 *Wrought aluminium and aluminium alloys—Chemical composition and forms of products—Part 1: Chemical composition* (MOD)

JIS H 4100 *Aluminium and aluminium alloy extruded shape*

NOTE : Corresponding International Standard: ISO 209-1:1989 *Wrought aluminium and aluminium alloys—Chemical composition and forms of products—Part 1: Chemical composition* (MOD)

JIS H 8601 *Anodic oxide coatings on aluminium and aluminium alloys*

NOTE : Corresponding International Standard: ISO 7599:1983 *Anodizing of aluminium and its alloys—General specifications for anodic oxide coatings on aluminium* (MOD)

JIS K 6257 *Rubber, vulcanized or thermoplastic—Determination of heat ageing properties*

JIS K 7350-1 *Plastics—Methods of exposure to laboratory light sources Part 1: General guidance*

NOTE : Corresponding International Standard: ISO 4892-1:1994 *Plastics—Methods of exposure to laboratory light sources—Part 1: General guidance* (IDT)

JIS K 7350-2 *Plastics—Methods of exposure to laboratory light sources—Part 2: Xenon-arc lamps*

NOTE : Corresponding International Standard: ISO 4892-2 *Plastics—Methods of exposure to laboratory light sources—Part 2: Xenon-arc lamps* (MOD)

JIS K 9703 *2,2,4-Trimethylpentane (Reagent)*

JIS R 3202 *Float glass and polished plate glass*

JIS R 5201 *Physical testing methods for cement*

JIS R 5210 *Portland cement*

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply.

3.1 to seal

to place the appropriate products in the joint in order to prevent the penetration of moisture and/or the passage of air between the elements, components, and assemblies made of the same or dissimilar materials

3.2 sealant

a material which, applied in an unformed state to a joint, seals it by adhering to appropriate surfaces within the joint

3.3 one-component sealant

sealant prepared in the condition ready for application

3.4 two-component sealant

sealant supplied in the form of base and curing agent to be mixed together with colorant or the like before use

3.5 primer

surface coating applied to the faces of the joint before placing the sealant in order to ensure its adhesion

3.6 cohesion failure

rupture in the body of a sealant

3.7 adhesion

property of a sealant to stick to a given substrate

3.8 adhesion failure

rupture at the interface between a sealant and a substrate

3.9 elastic recovery

property of a sealant whereby the initial shape and dimensions of the material are wholly or partially restored on removal of the forces causing deformation

3.10 slump

flow of a sealant out of a joint having a vertical surface

3.11 application life

time after mixing a two-component sealant, or after opening a sealed container of a one-component sealant, within which the material may be successfully applied to a joint, at a stated temperature

3.12 tack-free time

time after which a sealant surface loses its tackiness so that it no longer adheres to fingers

3.13 cure

irreversible transformation of a sealant from a liquid or paste-like state into a hardened or rubber-like solid state

3.14 sealant durability

probable service life of a sealant during the given conditions of use

4 Test substrates

4.1 Aluminium substrates

The aluminium substrates shall be the aluminium alloy specified in **JIS H 4000** or **JIS H 4100** or the said aluminium alloy anodized in accordance with **JIS H 8601**.

4.2 Mortar substrates

Mortar substrates shall be prepared as follows: make mortar using Portland cement specified in **JIS R 5210** according to **10.4** of **JIS R 5201**, and fill it in a mould as given in **10.1** of **JIS R 5201**. Remove it from the mould in an elapse of 24 h, and after curing under water for 13 days at ordinary temperature, store at $(23 \pm 2)^\circ\text{C}$ and $(50 \pm 5)\%$ relative humidity (RH) for 14 days or longer. The substrate surface shall be the bottom surface as cast in a mould, or the cut surface.

4.3 Glass substrates

The glass substrates shall be that specified in **JIS R 3202**.

When testing a sample of high modulus, an aluminium plate should be used for the reinforcement of glass substrate.

5 Tests

5.1 Slump test

5.1.1 Test apparatus

The test apparatus shall be as follows.

- a) **U-profile container**, made of anticorrosion metal¹⁾, having a configuration as shown in figure 1 or figure 2.

A U-profile container may alternatively be (10 ± 0.2) mm in width and (10 ± 0.2) mm in length.

The material of the container shall be anticorrosion metals such as brass or stainless steel. Aluminium alloy may also be used, in which case the aluminium alloys specified in **JIS H 4000** or **JIS H 4100** or the said aluminium alloys anodized in accordance with **JIS H 8601** should be used.

- b) **Strips of polyethylene sheet**, having a minimum thickness of 0.5 mm, and a width to cover the inner backside of the U-profile container.
- c) **Ventilated convection-type temperature controlled oven**, capable of being maintained at $(50 \pm 2)^\circ\text{C}$ or $(70 \pm 2)^\circ\text{C}$.
- d) **Temperature controlled oven**, capable of being maintained at $(5 \pm 2)^\circ\text{C}$.
- e) **Metal rule**, of Class 1 with minimum graduation 0.5 mm as specified in **JIS B 7516**.

5.1.2 Preparation of test specimens

Preparation of test specimens shall be as follows. Three test specimens for each test temperature shall be prepared.

- a) Place a strip of polyethylene sheet specified in **5.1.1 b)** along the backside base of each U-profile container specified in **5.1.1 a)**, overlapping at the top and fixed at the outer reverse side.

The U-profile container shall be cleaned and dried prior to use.

- b) Fill the U-profile container specified in **5.1.1 a)** with sealant which has been stored for at least 24 h at the temperature of $(23 \pm 2) ^\circ\text{C}$. The following precautions shall be taken:
 - 1) the sample shall be pressed on the inner profile surfaces of the U-profile container specified in **5.1.1 a)**, so as to avoid inclusion of air;
 - 2) the sample surface shall be trimmed so that it is flush with the face and ends of the U-profile container specified in **5.1.1 a)**.

5.1.3 Test procedures

The test procedures shall be as follows.

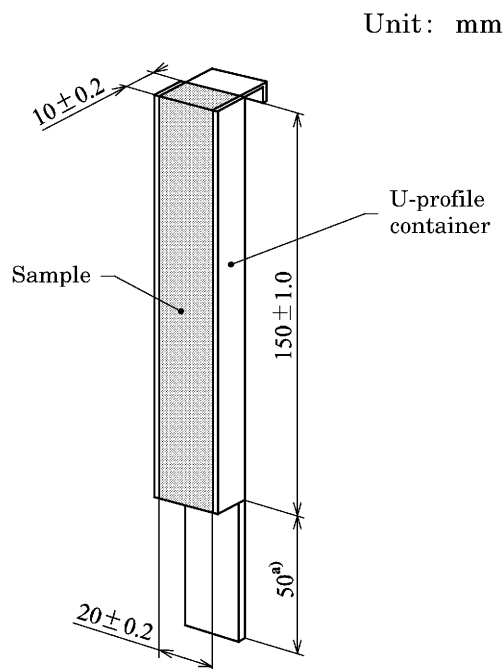
- a) The test temperatures shall be $5 ^\circ\text{C}$, $50 ^\circ\text{C}$ and $70 ^\circ\text{C}$.
- b) For vertical slump test, immediately after the preparation, suspend the test specimen vertically as shown in figure 1 and cure it at the test temperature specified in **5.1.3 a)** for 24 h. Using a metal rule specified in **5.1.1 e)**, measure the distance that the bottom edge of the sealant of each test specimen has moved downwards below the lower edge of the U-profile container specified in **5.1.1 a)**.

Use the ventilated convection-type temperature controlled oven specified in **5.1.1 c)** for test temperatures of $50 ^\circ\text{C}$ and $70 ^\circ\text{C}$, and the temperature controlled oven specified in **5.1.1 d)** for the test temperature of $5 ^\circ\text{C}$.

- c) For horizontal slump test, immediately after the preparation, place the test specimen horizontally as shown in figure 2 and cure it at the test temperature specified in **5.1.3 a)** for 24 h. Using a metal rule specified in **5.1.1 e)**, measure the distance that the bottom edge of the sealant of each test specimen has projected beyond the front of the U-profile container specified in **5.1.1 a)**.

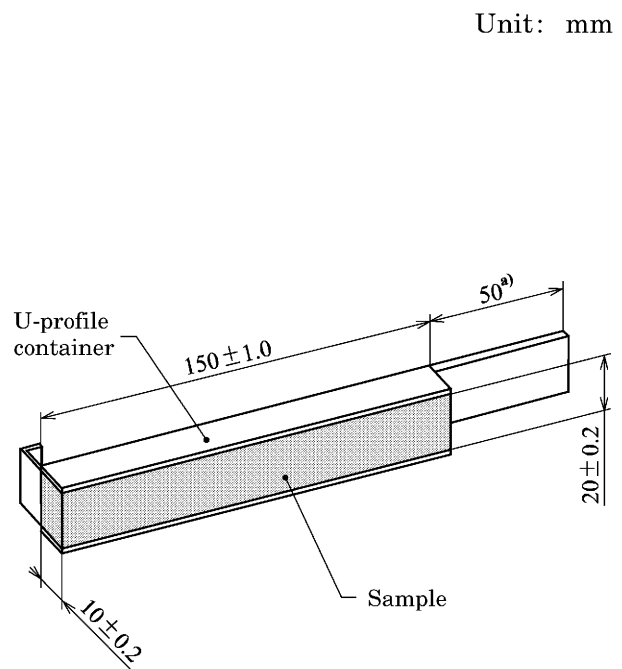
Use the ventilated convection-type temperature controlled oven specified in **5.1.1 c)** for test temperatures of $50 ^\circ\text{C}$ and $70 ^\circ\text{C}$, and the temperature controlled oven specified in **5.1.1 d)** for the test temperature of $5 ^\circ\text{C}$.

- d) Record the measured values of each test specimen, and the arithmetic mean of the measured values rounded off to an integer.



Note a) This length may be 0.

Figure 1 Vertical slump test



Note a) This length may be 0.

Figure 2 Horizontal slump test

5.2 Determination of elastic recovery

5.2.1 Test apparatus

The test apparatus shall be as follows.

- a) **Substrates**, of aluminium as specified in 4.1, having a shape and dimensions as shown in figure 3.
The substrates shall be cleansed with solvents such as methylethylketone, and wiped with a clean cotton cloth or the like.
- b) **Spacers for preparation of test specimens**, of a material not adhering to the sealant, or of which the surface is made anti-adherent with a fluororesin series tape or the like, its shape and dimensions as shown in figure 3.
- c) **Spacers for holding the test specimens**, of such materials as an aluminium plate which will not deform during the test, and which is capable of maintaining the joint of the test specimen (15.0 ± 0.1 mm, (19.2 ± 0.1 mm, and (24.0 ± 0.1 mm.
- d) **Spacers for holding the test specimens used for shear deformation test**, of such materials as an aluminium plate which will not deform during the test, capable of producing a shear deformation of (3.6 ± 0.1 mm in the length direction of the test piece and fixing it.
- e) **Anti-adherent substrate**, for preparation of test specimens, which is a plate made anti-adherent with e.g. polyethylene film.
- f) **Vernier calliper**, as specified in JIS B 7507 with the minimum graduation of 0.1 mm.

- g) **Tensile test machine**, capable of extending at a rate of (5.5 ± 0.7) mm/min.
- h) **Ventilated convection-type temperature controlled oven**, capable of maintaining at (70 ± 2) °C.

Unit: mm

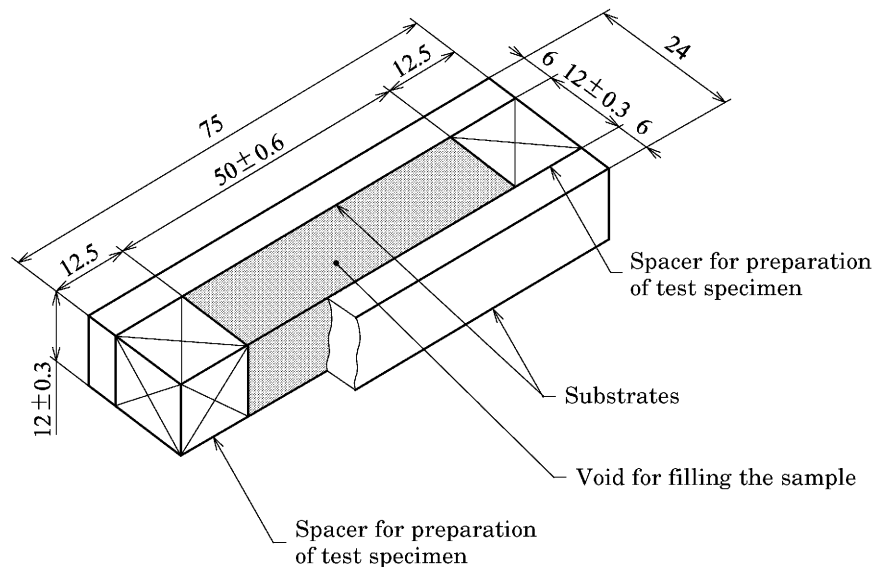


Figure 3 Test specimen for elastic recovery test

5.2.2 Preparation of test specimens

Preparation of test specimens shall be as follows. For each joint width, three test specimens shall be prepared.

Three additional test specimens shall be prepared for the shear deformation test, if the test is conducted.

- a) On the anti-adherent substrate specified in **5.2.1 e)**, assemble the substrates specified in **5.2.1 a)** and the spacers for preparation of test specimens specified in **5.2.1 b)**, to create a hollow void for filling the sample, as shown in figure 3.
- b) Fill the sample, which has been cured at the temperature of (23 ± 2) °C for at least 24 h, into the void as specified in **a)**.

The following precautions shall be taken:

- 1) where a primer is used, the primer manufacturer's instructions shall be followed;
 - 2) the sample shall be pressed on the substrate surface so as to avoid inclusion of air;
 - 3) the sample surface shall be trimmed so that it is flush with the faces of the substrates specified in **5.2.1 a)** and the spacers for preparation of test specimens specified in **5.2.1 b)**.
- c) For curing the test specimen, store the specimen as shown in figure 4 so as to facilitate hardening or drying of the sample, and remove the anti-adherent substrate specified in **5.2.1 e)** as soon as possible.

The spacers specified in **5.2.1 b)** shall be maintained in place during this curing.

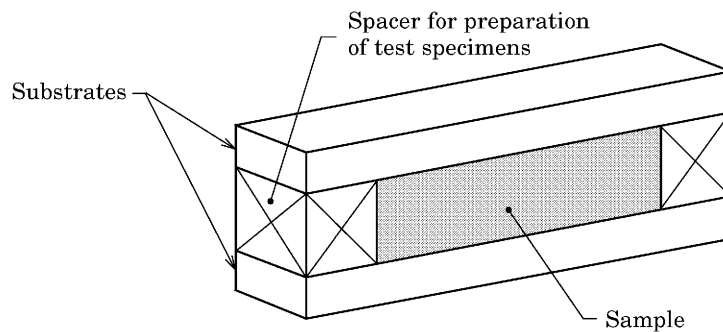


Figure 4 Storage of the test specimen for curing

5.2.3 Curing of test specimens

Test specimens shall be cured under either of the following conditions.

- a) **Curing method A** The test specimens shall be cured for 28 days at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{RH}$.
- b) **Curing method B** After cured according to curing method A, the test specimens shall be subsequently subjected three times to the following storage cycle. This cycle may be carried out alternatively in the sequence: **3**), **4**), **1**), **2**).

The test specimens after cured according to method B shall be stored for a further period of at least 24 h at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{RH}$.

- 1) 3 days in the ventilated convection-type temperature controlled oven specified in **5.2.1 h**) at $(70 \pm 2) ^\circ\text{C}$;
- 2) 1 day in water at $(23 \pm 2) ^\circ\text{C}$;
- 3) 2 days in the ventilated convection-type temperature controlled oven specified in **5.2.1 h**) at $(70 \pm 2) ^\circ\text{C}$;
- 4) 1 day in water at $(23 \pm 2) ^\circ\text{C}$.

5.2.4 Test procedure

The test procedure shall be as follows.

- a) The test shall be carried out at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{RH}$.
- b) The elastic recovery shall be tested according to the following procedure:
 - 1) Remove the spacers for preparation of test specimens specified in **5.2.1 b**), and measure the joint width at both ends of each test specimen by means of a vernier calliper specified in **5.2.1 f**) and take the arithmetic mean of the respective measurements at both ends as the initial joint width (l_0). Place the specimens in the tensile test machine specified in **5.2.1 g**) and extend them at a rate of $5.5 \pm 0.7 \text{ mm/min}$ to 25 %, 60 % or 100 % of initial width. Measure the joint width at both ends of each test specimen by means of a vernier calliper specified in **5.2.1 f**) and take the arithmetic mean of the respective measurements at both ends as the joint width under elongation (l_1).
 - 2) Maintain the elongation for 24 h using the spacers for holding the test specimens specified in **5.2.1 c**), with the specimen elongated to the specified width.

After this time remove the spacers for holding the test specimens specified in **5.2.1 c)** and place the test specimens on a smooth low-friction surface such as a glass plate as shown in figure 5. After 1 h, measure the joint width at both ends of each test specimen by means of a vernier calliper specified in **5.2.1 f)** and take the arithmetic mean of the respective measurements at both ends as the joint width after elastic recovery (l_2).

- 3) Calculate the elastic recovery (R_{el}) by formula (1), and record the calculated values of each test specimen and the arithmetic mean of the obtained calculated values, both rounded to integers.

$$R_{el} = \frac{l_1 - l_2}{l_1 - l_0} \times 100 \dots\dots\dots (1)$$

where, R_{el} : elastic recovery (%)
 l_0 : initial joint width (mm)
 l_1 : joint width under elongation (mm)
 l_2 : joint width after elastic recovery (mm)

- c) The elastic recovery in the case of shear deformation shall be tested in accordance with the following procedures.

- 1) In the case of shear deformation test, without changing the joint width, maintain the shear deformation of 30 % of the joint width applied in the length direction of the test specimen, and measure the amount of deformation at this time at both ends of test specimen by means of the vernier calliper specified in **5.2.1 f)** and take the arithmetic mean of the respective measurements at both ends as the amount of deformation under shear deformation (l_{s1}). When the initial joint width is 12.0 mm, the shear deformation rate of 30 % is equal to 3.6 mm in the amount of shear deformation.
- 2) Maintain the shear deformation as described above by means of the spacers for holding the test specimens used for shear deformation test specified in **5.2.1 d)** for 24 h. After this time remove the spacers for holding the test specimens used for shear deformation test and place the test specimens on a smooth low-friction surface such as a glass plate as shown in figure 5. After 1 h, measure the deformation at both ends of each test specimen by means of a vernier calliper specified in **5.2.1 f)** and take the arithmetic mean of the respective measurements at both ends as the shear deformation after elastic recovery (l_{s2}).
- 3) Calculate the elastic recovery (R_{e2}) in the case of shear deformation according to formula (2) and record the calculated values and the arithmetic mean of the calculated values rounded to an integer.

$$R_{e2} = \frac{l_{s1} - l_{s2}}{l_{s1}} \times 100 \dots\dots\dots (2)$$

where, R_{e2} : the elastic recovery in the case of shear deformation (%)
 l_{s1} : the amount of deformation under shear deformation (mm)

l_{s2} : the amount of shear deformation after elastic recovery (mm)

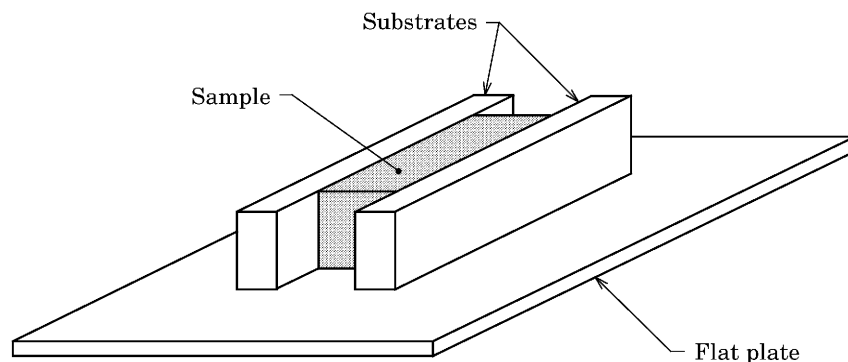


Figure 5 Storage of test specimen

5.3 Determination of tensile properties

5.3.1 Test apparatus

The test apparatus shall be as follows.

- a) **Substrates**, as specified in clause 4, having a shape and dimensions as shown in figure 6 in the case of aluminium and glass substrates, and those shown in figure 7 in the case of mortar substrates²⁾. The substrates shall be cleaned with the following means in order to obtain clean substrate surfaces.

Note ²⁾ The test specimens shown in figure 6 and figure 7 are referred to as ISO-type test specimens.

- 1) **Aluminium substrates**, cleansed with solvents such as methylethylketone, and wiped with a clean cotton cloth or the like.
- 2) **Mortar substrates**, with polished surface³⁾, and powder adhering to it having been brushed off.
- 3) **Glass substrates**, cleansed with solvents such as methylethylketone, and wiped with a clean cotton cloth or the like.

Note ³⁾ A polishing paper available on the market should be used.

- b) **Spacers for preparation of test specimens**, specified in 5.2.1 b).
- c) **Tensile test machine**, controllable to a tensile rate of (5.5 ± 0.7) mm/min when the maximum test force during the test is 15 % to 85 % of its capacity, provided with a temperature controlled oven for tensile test capable of being maintained at (-20 ± 2) °C, and also provided with a recording device which continuously monitors the force and displacement so that a force/displacement diagram can be obtained.
- d) **Low temperature oven**, capable of being maintained at (-20 ± 2) °C.
- e) **Anti-adherent substrate**, specified in 5.2.1 e).

Unit: mm

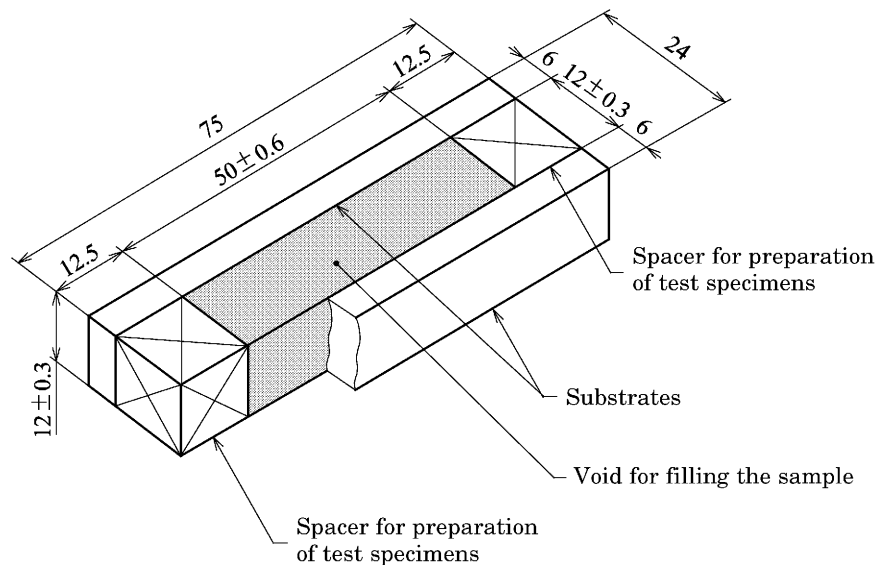


Figure 6 Shape and dimensions of test specimen using aluminium and glass substrates (ISO-type test specimen)

Unit: mm

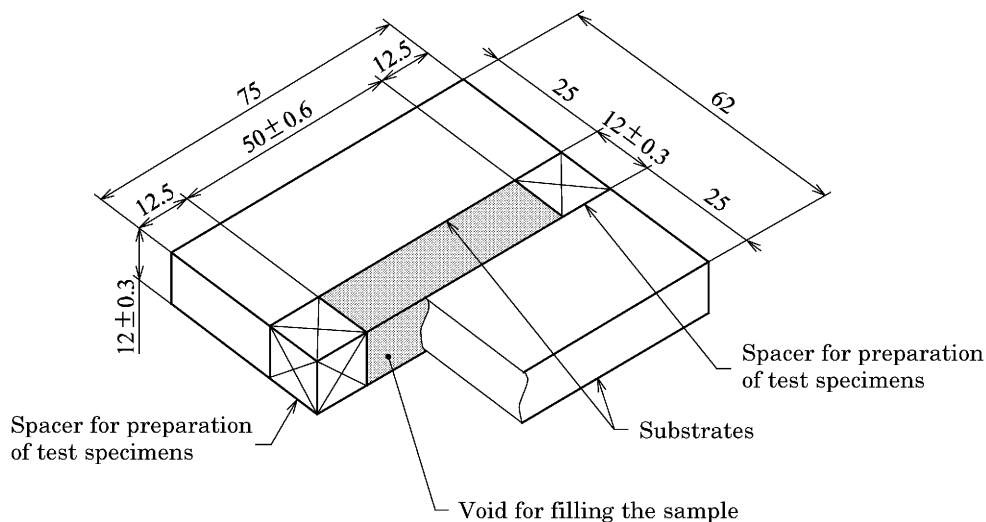


Figure 7 Shape and dimensions of test specimen using mortar substrates (ISO-type test specimen)

5.3.2 Preparation of test specimens

Preparation of test specimens shall be as follows. The type of substrates to be used shall be selected from among those given in 5.3.1 a), and three test specimens shall be prepared for each test temperature.

Alternatively, test specimens may be prepared in accordance with 5.17.2.

- a) On the anti-adherent substrate specified in 5.3.1 e), assemble the substrates specified in 5.3.1 a) and the spacers for preparation of test specimens specified in 5.3.1 b), to create a hollow void for filling the sample, as shown in figure 6 and figure 7.

- b) Fill the sample, which has been cured at the temperature of $(23 \pm 2) ^\circ\text{C}$ for 24 h, into the void as specified in **a)**. At this time, the precautions as given in **1)** to **3)** of **5.2.2 b)** shall be taken.
- c) With the spacers specified in **5.3.1 b)** maintained in place, store the specimen as shown in figure 4. Remove the anti-adherent substrate specified in **5.2.1 e)** as soon as possible so as to facilitate hardening or drying of the sample.

5.3.3 Curing of test specimens

Curing of test specimens shall be as specified in **5.2.3**.

5.3.4 Test procedure

The test procedure shall be as follows.

- a) The test temperature shall be $(23 \pm 2) ^\circ\text{C}$ and $(-20 \pm 2) ^\circ\text{C}$. In the case of applying $(-20 \pm 2) ^\circ\text{C}$, store the test specimens in the low temperature oven specified in **5.3.1 d)** at $(-20 \pm 2) ^\circ\text{C}$ for at least 4 h.
- b) Remove the spacers for preparation of test specimens specified in **5.3.1 b)**, and place the test specimen in the tensile test machine specified in **5.3.1 c)**. Extend the specimen at a rate of $(5.5 \pm 0.7) \text{ mm/min}$ until breakage occurs, and record the force/displacement diagram by the tensile test machine specified in **5.3.1 c)**.
- c) Obtain the force (P) at a chosen elongation rate from the force/displacement diagram recorded, and calculate the tensile stress (σ) at the chosen elongation rate according to formula (3) in which the force (P) is divided by the sectional area (A) of sample before the tensile adhesion test of test specimen. Record the mean value of the measured values of each test specimen rounded off to one decimal place.
- d) In the case of Class 12.5 P and 7.5 P, obtain the elongation at break (L_b) from the force/displacement diagram recorded, and calculate the elongation rate at break (E_b) according to formula (4) in which L_b is divided by the joint width before the tensile adhesion test (L_s). Record the calculated values of each test specimen and the arithmetic mean of the calculated values rounded off to an integer.

$$\sigma = \frac{P}{A} \dots\dots\dots (3)$$

$$E_b = \frac{L_b}{L_s} \times 100 \dots\dots\dots (4)$$

where, σ : the tensile stress at a chosen elongation rate (N/mm^2)
 P : the force at a chosen elongation rate (N)
 A : the sectional area of sample before tensile adhesion test (600 mm^2)
 E_b : the elongation rate at break (%)
 L_s : the joint width before tensile adhesion test (12 mm)
 L_b : the elongation at break (mm)