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**Method of fire resistance test for
elements of building construction**

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Contents

	Page
Introduction	1
1 Scope	1
2 Normative references	2
3 Terms and definitions	2
4 Test specimen	4
5 Test equipment	5
5.1 Composition	5
5.2 Test furnace	7
5.3 Test frame	8
5.4 Loading equipment	8
5.5 Measuring equipment	9
6 Test conditions	19
6.1 General	19
6.2 Furnace temperature and tolerances	20
6.3 Furnace pressure	22
6.4 Load	22
6.5 Restraint and boundary conditions	23
6.6 Ambient conditions	23
7 Test procedure	23
7.1 Summary (heating test)	23
7.2 Installation and bounding of test specimen	23
7.3 Load application	23
7.4 Commencement of test	24
7.5 Measurements and observations	24
7.6 Termination of test	25
8 Test report	26
Annex JA (normative) Water injection test	27
Annex JB (normative) Shock test	28
Annex JC (informative) Comparison table between JIS and corresponding International Standards	30
Annex JD (informative) Comparison table between previous and current editions of this Standard on technically significant revisions	46

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Land, Infrastructure, Transport and Tourism through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Testing Center for Construction Materials (JTCCM)/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 1304**:2011 is replaced with this Standard.

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Method of fire resistance test for elements of building construction

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 834-1:1999** (Edition 1) and its Amendment 1:2012, **ISO 834-4:2000** (Edition 1), **ISO 834-5:2000** (Edition 1), **ISO 834-6:2000** (Edition 1), **ISO 834-7:2000** (Edition 1), **ISO 834-8:2002** (Edition 1), **ISO 834-9:2003** (Edition 1), with some modifications of the technical contents made to reflect the local needs and situations in Japan.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JC. The comparison table between previous and current editions of this Standard on technically significant revisions is given in Annex JD.

The fire resistance test specified in this Standard is a heating test simulating the loading condition in practice. However, where required, post-test observation after completion of heating, or the water injection test or shock test may be additionally applied.

Further, the test results may be evaluated according to other performance criteria than specified in this Standard, if so required by the level of performance specified in the actual order.

1 Scope

This Standard specifies the fire resistance test for structural elements of buildings such as the walls (inclusive of non-loadbearing partitions), columns, beams, floor, roof (inclusive of the ceiling), etc.

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

ISO 834-1:1999 *Fire-resistance tests—Elements of building construction—Part 1: General requirements* and Amendment 1:2012

ISO 834-4:2000 *Fire-resistance tests—Elements of building construction—Part 4: Specific requirements for loadbearing vertical separating elements*

ISO 834-5:2000 *Fire-resistance tests—Elements of building construction—Part 5: Specific requirements for loadbearing horizontal separating elements*

ISO 834-6:2000 *Fire-resistance tests—Elements of building construction—Part 6: Specific requirements for beams*

ISO 834-7:2000 *Fire-resistance tests—Elements of building construction—Part 7: Specific requirements for columns*

ISO 834-8:2002 *Fire-resistance tests—Elements of building construction—Part 8: Specific requirements for non-loadbearing vertical separating elements*

ISO 834-9:2003 *Fire-resistance tests—Elements of building construction—Part 9: Specific requirements for non-loadbearing ceiling elements* (Overall evaluation: MOD)

In addition, 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 C 1602 *Thermocouples*

NOTE : Corresponding International Standard: IEC 60584-1:2013 *Thermocouples—Part 1: EMF specifications and tolerances* (MOD)

JIS C 1605 *Mineral insulated thermocouples*

3 Terms and definitions

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

3.1 elements of building construction

defined construction components, such as a wall, floor, roof, beam or column

NOTE : In this Standard, each of such components is referred to as an element.

3.2 fire resistance

ability of an element of building construction to satisfy the required loadbearing capacity, integrity, insulation and other requirements of fire prevention against the standardized fire heating (hereafter referred to as heating) for a specified amount of time

3.3 fire resistance test

test for evaluating the fire resistance of elements

3.4 integrity

ability of an element of building construction, when exposed to fire on one side, to prevent the passage through it of flames and hot gases or the occurrence of flames on the exposed side

3.5 insulation

ability of an element of building construction, when exposed to fire on one side, to restrict the temperature rise of the unexposed face to below specified levels

3.6 loadbearing capacity

ability of a loadbearing element, when exposed to fire, to support its test load without collapsing and to maintain this support without exceeding specified criteria with respect to both the extent of, and rate of, deformation in the event of a fire

3.7 test furnace

equipment for heating a test specimen under the controlled conditions

3.8 furnace temperature

temperature inside a test furnace during heating operation

3.9 standard time/temperature curve

curve that shows the temporal change of furnace temperature as a test condition

NOTE : It is also referred to as a standard curve.

3.10 duration of heating

duration time of heating a test specimen according to a standard time/temperature curve

3.11 area under the time/temperature curve

integration of a curve that shows the temporal change of temperature during the duration of heating

3.12 pressure in the furnace

pressure inside a test furnace expressed as the difference from the atmospheric pressure outside the test furnace

3.13 exposed surface

surface of the test specimen exposed to the heating effects of the test furnace

3.14 unexposed surface temperature

temperature measured in the unexposed surface of a test specimen, which serves as the index of insulation performance of the test specimen

3.15 flame

visible, luminous body of burning gas emitting radiation during combustion process

3.16 ignition

process where a combustible material initiates self-sustained combustion

3.17 glowing

combustion that does not produce a flame, but produces luminous glow due to heat

3.18 flaming

combustion that produces a visible flame

3.19 fire protection material

material used for covering for the purpose of improving fire resistance

4 Test specimen

The test specimen shall be as follows.

- a) The test specimen shall simulate the construction in practice, and shall include the parts most vulnerable in terms of fire resistance. When in practice joints occur in fire protection material, any test specimen that incorporates such protection shall include a representative joint preferably situated at mid-height.
- b) If having a hollow portion, the test specimen shall be sealed around the circumference and on the reverse side if it is wall floor or roof, and sealed on both ends if it is column or beam.

WARNING Testing of hollow members such as steel pipes and double-sided steel plate panels should be performed with utmost care since they may expand and explode due to the exposure to heat. As a safety measure, the test specimen for these products may be provided with a depressurizing hole, or given other treatment.

Further, heating of concrete and cement products that are high in moisture content, materials containing a large amount of flammable material such as organic thermal insulation material, materials having properties of brittle fracture such as glass, and prestressed materials such as prestressed concrete members may cause explosion, cracking or bursting flames, and testing of these products should be performed with utmost care and with necessary safety measures in place.

- c) The test specimen size shall be a full size i.e. the size of the tested element in the construction in practice. Where this is impracticable, the specimen shall be of the standard size as specified in Table 1.

Table 1 Standard size of test specimen

Element to be tested		Size of exposed surface m	Section
Separating elements	Wall	Height 3.0 or over, width 3.0 or over	Thickness shall be equal to that in the construction in practice.
	Floor and roof (including the ceiling)	a) For elements other than b) and c) : Length 4.0 or over, width 3.0 or over	
		b) For elements supporting the load on two faces in the width direction: Length 4.0 or over, width 2.0 or over	
		c) For floors the top surface of which is exposed to heating: Length 2.0 or over, width 1.8 or over	
Non-separating elements	Column	Length 3.0 or over	Sectional dimensions shall be equal to that in the construction in practice.
	Beam	Length 4.0 or over	

- d) Test specimen shall represent the conditions in practice as well as possible. To determine that the strength and moisture content of the test specimen and its component materials well approximate the conditions in actual service, a representative sample prepared and conditioned in the same manner as the test specimen may be used. The representative sample for checking moisture content shall have the same thickness and exposed surface as the test specimen so that it may represent the moisture loss of test specimen due to evaporation from the surface.

The test specimen, if containing moisture, shall normally be cured to an air-dry state, which refers to the state of equilibrium moisture content in the atmosphere at a temperature of 23 °C and a relative humidity of 50 % or any equivalent state.

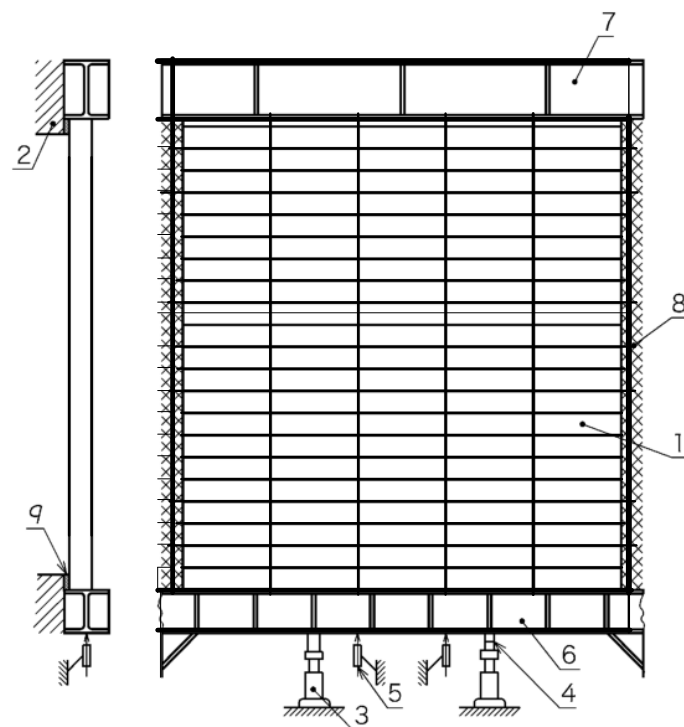
To shorten the curing period, artificial drying, by measures such as placing the specimen in a high-temperature atmosphere, may be performed provided the method does not alter the properties of component materials of the test specimen or the moisture distribution in the test specimen in such a way that the fire behaviour of the test specimen is affected during the test.

- e) The test specimen ends shall be constructed to meet the required boundary and restraint conditions and in such a way that the required loading can be appropriately applied.
- f) In the case of a beam that supports a floor or a roof directly and of which the top surface is not heated, the width of the floor part or roof part shall be either three times the beam width or 600 mm or more. For such a beam, a topping may be used to substitute the construction in practice, provided that it is made of lightweight aerated concrete with a density of $650 \text{ kg/m}^3 \pm 200 \text{ kg/m}^3$ and a thickness of 100 mm or more, and installed in divided sections of 1 m or less in length so that the composite action of strength and rigidity does not exert on the beam.

5 Test equipment

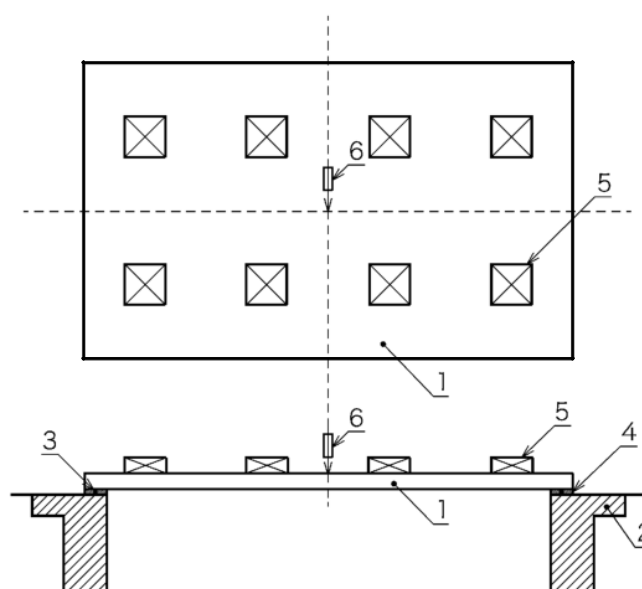
5.1 Composition

Examples of test equipment for different types of elements to be tested are shown in Figure 1 to Figure 4.



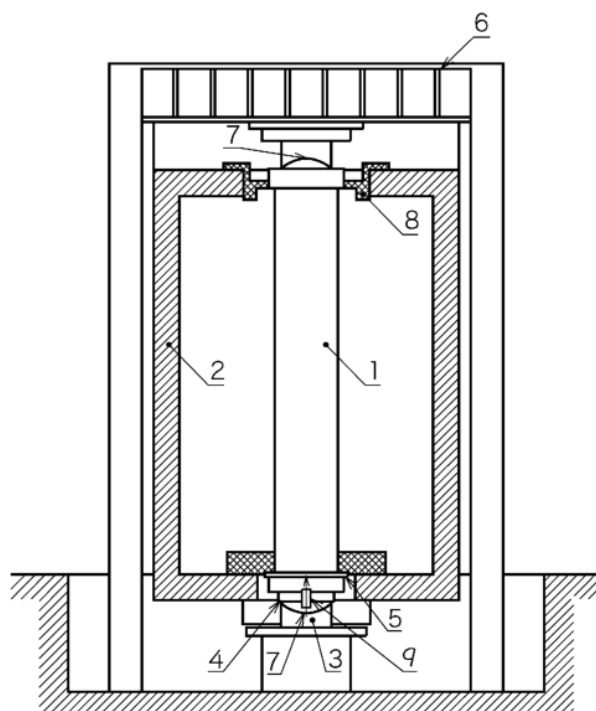
- 1 test specimen (wall) 2 test furnace 3 jack (loading equipment) 4 load cell
5 displacement gauge 6 load-distribution beam 7 test frame (loading frame)
8 and 9 inorganic fibre insulation (filler)

Figure 1 Example of test equipment for loadbearing wall



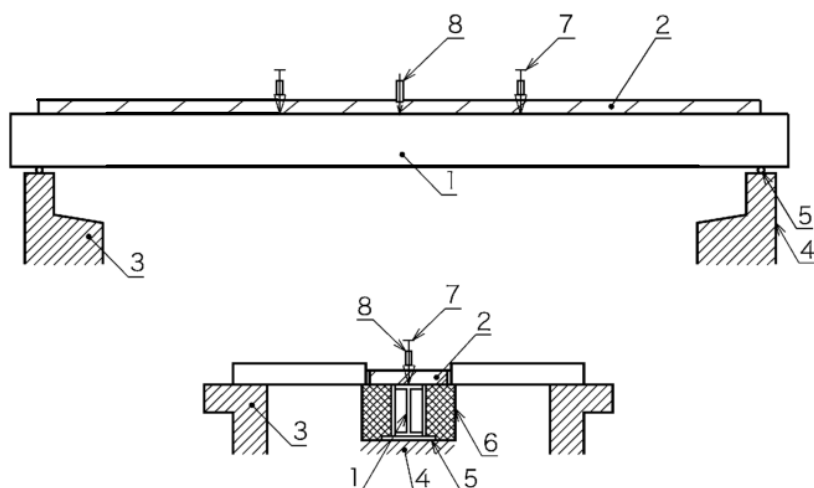
- 1 test specimen (floor and roof) 2 test furnace 3 roller or rod
4 inorganic fibre insulation (filler) 5 weight (loading equipment) 6 displacement gauge

Figure 2 Example of test equipment for floor and roof (simply supported)



- 1 test specimen (column) 2 test furnace 3 jack (loading equipment) 4 load cell
5 loading platens 6 test frame (loading frame) 7 spherical support (pin)
8 inorganic fibre insulation (filler) 9 displacement gauge

Figure 3 Example of test equipment for column



- 1 test specimen (column) 2 topping 3 test furnace 4 support 5 roller or rod
6 inorganic fibre insulation (filler) 7 point of loading 8 displacement gauge

Figure 4 Example of test equipment for beam (simply supported)

5.2 Test furnace

The test furnace shall be as follows.

- a) The test furnace shall be capable of providing the temperature change as specified in 6.2 over the entire exposed surface of specimen.

- b) The heat source of the furnace shall be town gas, propane, fuel oil or other suitable fuel.
- c) The test furnace shall be designed to be suitable for testing each of the tested elements, and shall be capable of
 - 1) heating the vertically installed wall on one face;
 - 2) heating the lower surface (or top surface, if required) of horizontally installed floor and roof (including the ceiling);
 - 3) heating the vertically installed columns on all sides;
 - 4) heating the horizontally installed beams on three (bottom and side surfaces) or four sides, as appropriate.
- d) The furnace linings shall consist of materials with densities less than 1 000 kg/m³ and shall constitute more than half of the internally exposed surface of the furnace.

5.3 Test frame

The test frame shall be as follows.

- a) The test frame shall be of a suitable shape, strength and rigidity for reproducing the required boundary and restraint conditions in the installation of the test specimen, and shall be capable of holding the test specimen with the exposed surface directed towards the specified position.
- b) The test frame shall consist of non-flammable materials which do not melt, crack or severely deform when heated for testing.

5.4 Loading equipment

The loading equipment shall be as follows.

- a) The loading equipment shall be capable of subjecting test specimens to the specified level of loading.

NOTE : The load may be applied hydraulically, mechanically or by the use of weights.

- b) The loading equipment shall be able to simulate conditions of uniform loading or point loading, as appropriate for the element to be tested. The equipment shall be capable of following the maximum deformation and the rate of deformation of the test specimen for the duration of the test.
- c) The loading equipment shall not significantly influence the heat transfer through the test specimen. It shall not interfere with the measurement of unexposed surface temperature and/or deformation and shall permit general observation of the unexposed face. The total area of the contact points between the loading equipment and the test specimen surface shall not exceed 10 % of the total area of the surface of a horizontal test specimen.

5.5 Measuring equipment

5.5.1 Furnace temperature measuring equipment and application thereof

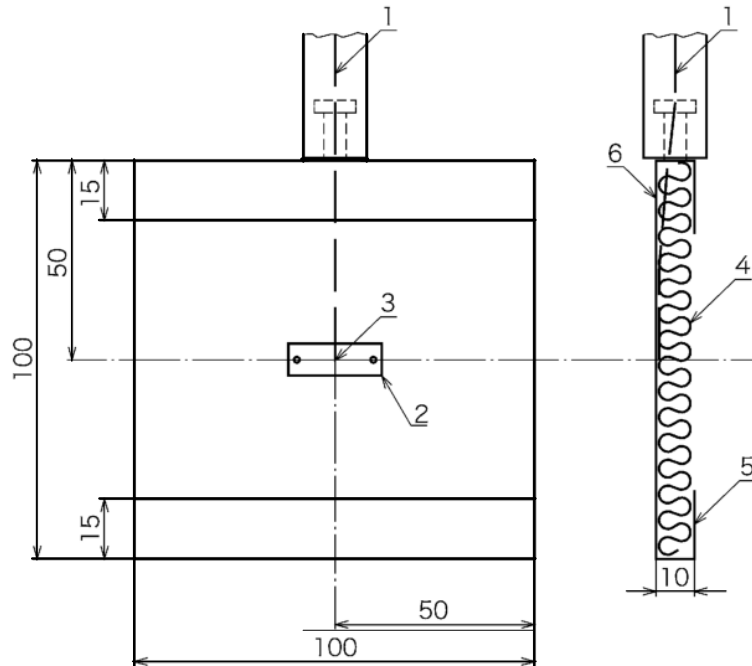
5.5.1.1 Furnace temperature measuring equipment

For measuring and controlling the furnace temperature according to the temperature curve given in **6.2**, a plate thermometer or sheathed thermocouples (hereafter referred to as the furnace temperature measuring equipment) specified in the following shall be employed.

a) Plate thermometer

- 1) The plate part shall be constructed from $150\text{ mm} \pm 1\text{ mm}$ long by $100\text{ mm} \pm 1\text{ mm}$ wide by $0.7\text{ mm} \pm 0.1\text{ mm}$ thick heat-resistant nickel alloy sheet strips folded to the design as shown in Figure 5.
- 2) The thermocouples for the plate thermometer shall be the sheathed thermocouples specified in **JIS C 1605**, of Type SK, with metallic sheath of 1 mm to 3.2 mm outside diameter, and with ungrounded hot junction. The thermocouple hot junction shall be fixed to the geometric centre of the plate in the position shown in Figure 5 by a small steel strip. The steel strip shall be welded to the plate or may be screwed to it with a screw of 2 mm or greater diameter.
- 3) The insulation pad to be fitted at the back of the plate thermometer shall be made of inorganic material and nominally $97\text{ mm} \pm 1\text{ mm}$ by $97\text{ mm} \pm 1\text{ mm}$ by $10\text{ mm} \pm 1\text{ mm}$ thick, density $280\text{ kg/m}^3 \pm 30\text{ kg/m}^3$, and shall endure repeated heating test operations.

Unit: mm



- 1 sheathed thermocouple 2 spot-welded or screwed steel strip
3 hot junction of sheathed thermocouple 4 insulation pad
5 nickel alloy strip (0.7 ± 0.1) mm thick 6 plate face (measuring surface)

Figure 5 Plate thermometer

- 4) Before the plate thermometers are first used, the complete plate thermometer shall be aged by immersing in a pre-heated oven at 1 000 °C for 1 h. Exposure in a fire resistance furnace for 90 min under the standard temperature/time curve specified in **6.2** is considered to be an acceptable alternative to using an oven.
- b) **Sheathed thermocouple**, specified in **JIS C 1605**, of Type SK, with metallic sheath of 3 mm to 3.2 mm outside diameter, and with ungrounded hot junction. The sheathed thermocouple shall be inserted into an iron, magnetic or ceramic protection tube with an open end so that its tip, over the length of 25 mm, protrudes beyond the tube end.

5.5.1.2 Application

The application of the furnace temperature measuring equipment shall be as follows.

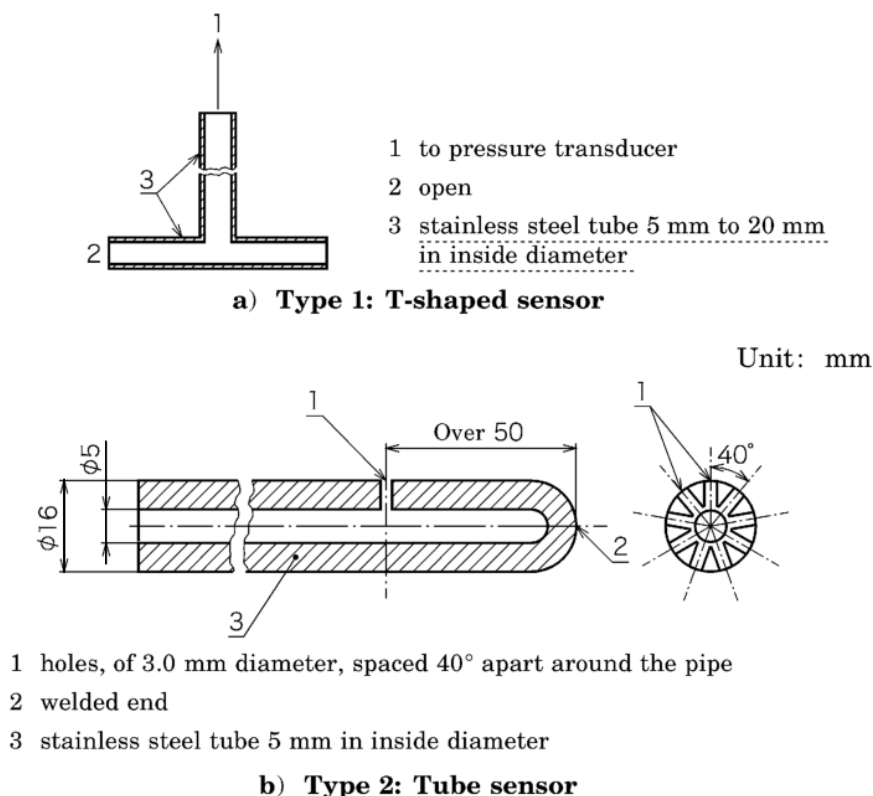
- a) The temperature measurement shall be made at the centre of the plate if using a plate thermometer, and at the position represented by the hot junction if using a sheathed thermocouple. The plate thermometer/sheathed thermocouple shall be installed according to the following.
- 1) The plate thermometers shall be distributed so as to give a reliable indication of the average temperature in the vicinity of the test specimen.
 - 2) At the commencement of the test the plate thermometers shall be 100 mm ± 50 mm from the exposed surface of the test specimen and they shall be maintained at this distance during the test, as far as possible.

- 3) The plate thermometers shall be oriented so that their plate surfaces face the same direction as the exposed surface of the test specimen.
- 4) In addition to the above requirements, the requirements for each type of element described in **b)** in the following shall be followed.
- b) The number of plate thermometers shall be suitable for testing each of the tested elements, and shall be as follows.
 - 1) **For measurement of wall, floor or roof (including the ceiling)** At least four plate thermometers shall be installed. There shall not be fewer than one plate thermometer for every 1.5 m² of the exposed surface area of the test specimen.
 - 2) **For measurement of column** At least six plate thermometers shall be placed at 1/4, 1/2, and 3/4 of the exposed length of the test specimen.
 - 3) **For measurement of beam** There shall be at least two plate thermometers for each metre length of exposed length of the test specimen. There shall be an equal number of the plate thermometers facing the floor as facing the nearer parallel side wall, and more may be added as required by the sectional height of beam, and placed in such a way that the uniform heating in the vertical direction is possible.
- c) At the commencement of the test, the furnace shall include at least the number of plate thermometers (n) that are specified above. If plate thermometers fail and the number of intact plate thermometers falls below $n-1$ during the test, then the laboratory shall immediately replace these to ensure that at least $n-1$ are present.
- d) Plate thermometers are resistant to damage but are subject to damage and deteriorate in continued use, becoming slightly less sensitive with age. Before every test they shall be inspected and checked for proper operation. If there is any evidence of damage, deterioration or improper operation, they shall not be used and shall be replaced.
- e) The method of support shall ensure that plate thermometers do not fall away or become dislodged during the test.
- f) The plate thermometers and the support for them shall not penetrate or be attached to the test specimen. If, for compelling reasons, the support has penetrated or been attached to the test specimen, it shall be arranged so as to have minimal effect on the behaviour of the test specimen.

5.5.2 Furnace pressure measuring equipment and application thereof

5.5.2.1 Furnace pressure measuring equipment

The pressure inside the furnace shall be measured by either T-shaped sensor (Type 1) or tube sensor (Type 2), shown in Figure 6, so that the operation can be controlled within the limits specified in **6.2**.



5.5.2.2 Application

The application of furnace pressure measuring equipment shall be as follows.

- a) The pressure sensors should be located where they will not be subject to direct impingement of convection currents from the flames or in the path of the exhaust gases and installed such that the conditions specified in 6.3 can be provided.
- b) The tubes from the pressure sensor to the pressure transducer shall be horizontal both in the furnace and as they exit through the furnace wall, such that the pressure is relative to the same positional height from the inside to the outside of the furnace. If T-shaped sensors are used, T-branches shall be horizontally oriented. Any vertical section of tube to the measuring instrument shall be maintained at room temperature.
- c) The application of pressure sensors in the test furnace shall be suitable for testing each of the tested elements as follows.
 - 1) **Furnaces for vertical elements** One pressure sensor shall be provided to control furnace pressure, and shall be located within 500 mm of the neutral pressure plane. A second sensor may be used to provide information on the vertical pressure gradient within the furnace. This sensor shall be located within 500 mm of the top of the test specimen.
 - 2) **Furnaces for horizontal elements** Two pressure sensors shall be provided in the same horizontal plane but in different positions relative to the perimeter of the test specimen. One shall be used for control and the second shall serve as a check on the first.

5.5.3 Load measuring equipment and application thereof

When using weights, no further measurement of load in a test is needed. The loads applied by hydraulic loading systems shall be measured by a load cell or other relevant equipment having the same accuracy, or by monitoring the hydraulic pressure at an appropriate point.

5.5.4 Ambient temperature measuring equipment and application thereof

5.5.4.1 Ambient temperature measuring equipment

A sheathed thermocouple shall be used to indicate the ambient temperature within the laboratory. The sheathed thermocouple shall be nominally of 3 mm to 3.2 mm diameter, of Type SK, and Class 2, as defined in **JIS C 1605**.

5.5.4.2 Application

The hot junction shall be protected from radiated heat and draughts from the test specimen and test furnace.

5.5.5 Integrity measuring equipment and application thereof

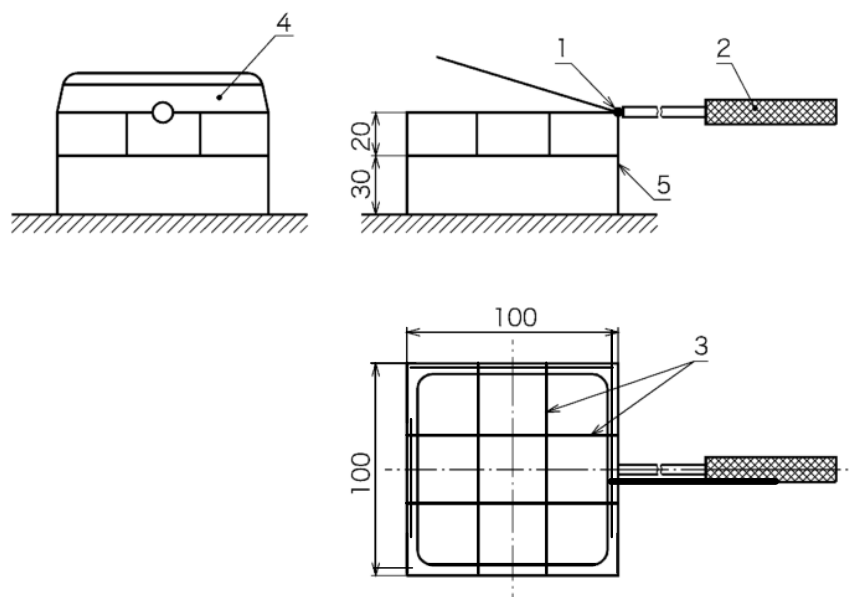
5.5.5.1 Integrity measuring equipment

Measurements of the integrity of the separating elements [wall, floor and roof (including ceiling)] shall normally be made by visual observation. Where necessary, as appropriate to the nature and location of the opening, either cotton wool pad or gap gauge may be used.

Cotton wool pad should only be used in the area of a positive pressure zone within the furnace.

- a) **Cotton wool pad** The cotton wool pad used in the measurement of integrity shall consist of new, undyed and soft cotton fibres without other added fibres, 20 mm thick × 100 mm square, and shall weigh between 3 g and 4 g. It shall be conditioned prior to use by drying in an oven at $100\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ for at least 30 min. After drying, it may be stored in a desiccator or other moisture-proof container until use. For use, it shall be mounted in a wire frame, as shown in Figure 7, provided with a handle and legs.

Unit: mm



- | | |
|--|-----------------------------|
| 1 hinge | 2 handle of suitable length |
| 3 supporting steel wire of 0.5 mm diameter | 4 hinged lid with latch |
| 5 framework of steel wire of 1.5 mm diameter | |

Figure 7 Cotton wool pad holder

- b) **Gap gauge** Two types of gap gauge, as shown in Figure 8, shall be available for the measurement of integrity. They shall be made of cylindrical stainless steel rod of $6 \text{ mm} \pm 0.1 \text{ mm}$ and $25 \text{ mm} \pm 0.2 \text{ mm}$ diameter. They shall be provided with insulated handles of suitable length and material.

Unit: mm

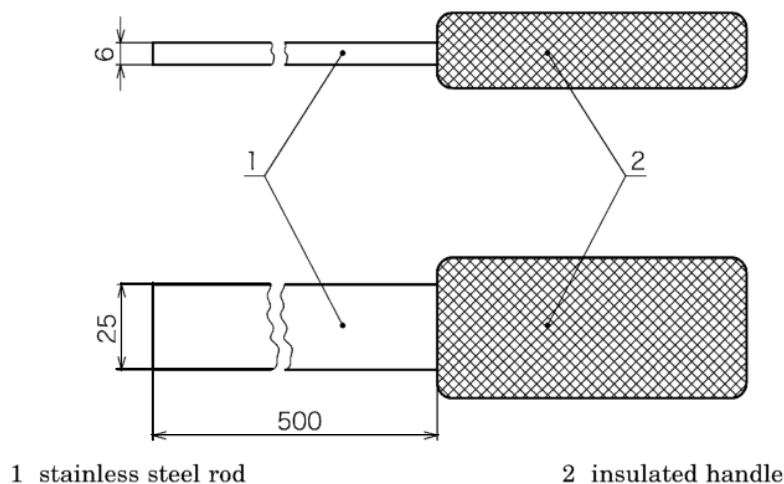


Figure 8 Gap gauges

5.5.5.2 Application

The application of integrity measuring equipment shall be as follows.