
Reaction to fire tests for floorings —

Part 2:

**Determination of flame spread at a heat
flux level of 25 kW/m²**

Essais de réaction au feu des revêtements de sol —

*Partie 2: Détermination de la propagation de flamme à un niveau de
flux énergétique de 25 kW/m²*



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Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Apparatus	2
5 Test specimen	14
6 Conditioning	14
7 Calibration procedure	14
8 Standard test procedure	16
9 Expression of results	17
10 Precision	17
11 Test report	17
Annex A (informative) Gas and air supplies	18
Annex B (informative) Precision of the test method	19
Bibliography	20

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9239-2 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

ISO 9239 consists of the following parts, under the general title *Reaction to fire tests for floorings*:

- *Part 1: Determination of the burning behaviour using a radiant heat source*
- *Part 2: Determination of flame spread at a heat flux level of 25 kW/m²*

Introduction

ISO/TR 5658-1 describes the development of standard tests for flame spread and explains the theory of flame spread, including horizontal flame spread over floorings.

Floorings are not readily involved in fires but if fire develops due to other contents of a building burning, then floorings may ignite and it is necessary to be able to determine whether the flooring will propagate flames.

This part of ISO 9239 provides a simple method by which horizontal surface spread of flame on a horizontal specimen can be determined for comparative purposes.

Fire is a complex phenomenon: its behaviour and its effects depend upon a number of interrelated factors. The behaviour of materials and products depends upon the characteristics of the fire, the method of the use of the materials and the environment in which they are exposed. The philosophy of "reaction to fire" tests is explained in ISO/TR 3814.

A test such as is specified in this part of ISO 9239 deals only with a simple representation of a particular aspect of the potential fire situation typified by a radiant heat source and flame; it cannot alone provide any direct guidance on behaviour or safety in fire.

CAUTION:

The possibility of a gas-air fuel explosion in the test chamber should be recognized. Suitable safeguards consistent with sound engineering practice should be installed in the panel fuel supply system. These should include at least the following:

- a gas feed cut-off which is immediately activated when air and/or gas supply fail;
- a temperature sensor or a flame detection unit directed at the panel surface that stops fuel flow when the panel flame goes out.

Attention is drawn to the possibility that toxic or harmful gases may be produced during exposure of the specimens. In view of the potential hazard from products of combustion, the exhaust system shall be designed and operated so that the laboratory environment is protected from smoke and gas. The operator shall be instructed to minimize his exposure to combustion products by following sound safety practice, e.g., ensuring that the exhaust system is working properly, wearing appropriate clothing etc. The operator should also be aware that the walls and fittings of the test chamber become hot during the test and gloves should be worn to avoid burns.

Reaction to fire tests for floorings —

Part 2:

Determination of flame spread at a heat flux level of 25 kW/m²

1 Scope

This part of ISO 9239 specifies a method for assessing the burning behaviour of horizontally mounted flooring systems exposed to a heat flux gradient in a test chamber, when ignited with pilot flames. The radiant heat gradient is higher than the one described in ISO 9239-1 in order to simulate conditions in a corridor adjacent to a room containing a fully developed fire (post-flashover).

This method is applicable to all types of flooring such as textile carpets, cork, wood, rubber and plastic coverings as well as coatings. Results obtained by this method reflect the performance of the flooring, including any substrate if used. Modifications of the backing, bonding to a substrate, underlay, or other changes of the flooring may affect test results.

This part of ISO 9239 is applicable to the measurement and description of the properties of floorings in response to heat and flame under controlled laboratory conditions. It should not be used alone to describe or appraise the fire hazard or fire risk of floorings under actual fire conditions.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13943:2000, *Fire safety — Vocabulary*

ISO/TR 14697:1997, *Fire tests — Guidance on the choice of substrates for building products*

3 Terms and definitions

For the purposes of this document, the definitions given in ISO 13943, together with the following apply.

3.1

heat flux

incident heat energy (both radiant and convective) per unit area (kW/m²)

3.2

critical heat flux at extinguishment

CHF

incident heat flux at the surface of a specimen at the point where the flame ceases to advance and may subsequently go out

3.3

heat flux at X min

HF-X

total heat flux received by the specimen at the most distant spread of flame position after X min of testing

3.4

flux profile

curve relating radiant flux on the specimen plane to distance from the zero point

NOTE The zero point of the radiant flux profile is specified as the inner edge of the hottest side of the specimen holder.

3.5

flashing

existence of flame on or over the surface of the specimen for periods of less than 1 s

3.6

transitory flaming

existence of flame on or over the surface of the specimen for periods of between 1 s and 4 s

3.7

sustained flaming

existence of flame on or over the surface of the specimen for periods of more than 4 s

3.8

flame front

furthest extent of flame spread of a sustained flame along the length of the test specimen within a given time

3.9

flooring

upper layer of a floor, comprising any surface finish, with or without attached backing and with any accompanying underlay, interlayer and adhesive

3.10

substrate

floor on which the flooring is mounted or the material that represents the floor

4 Apparatus

4.1 Test chamber

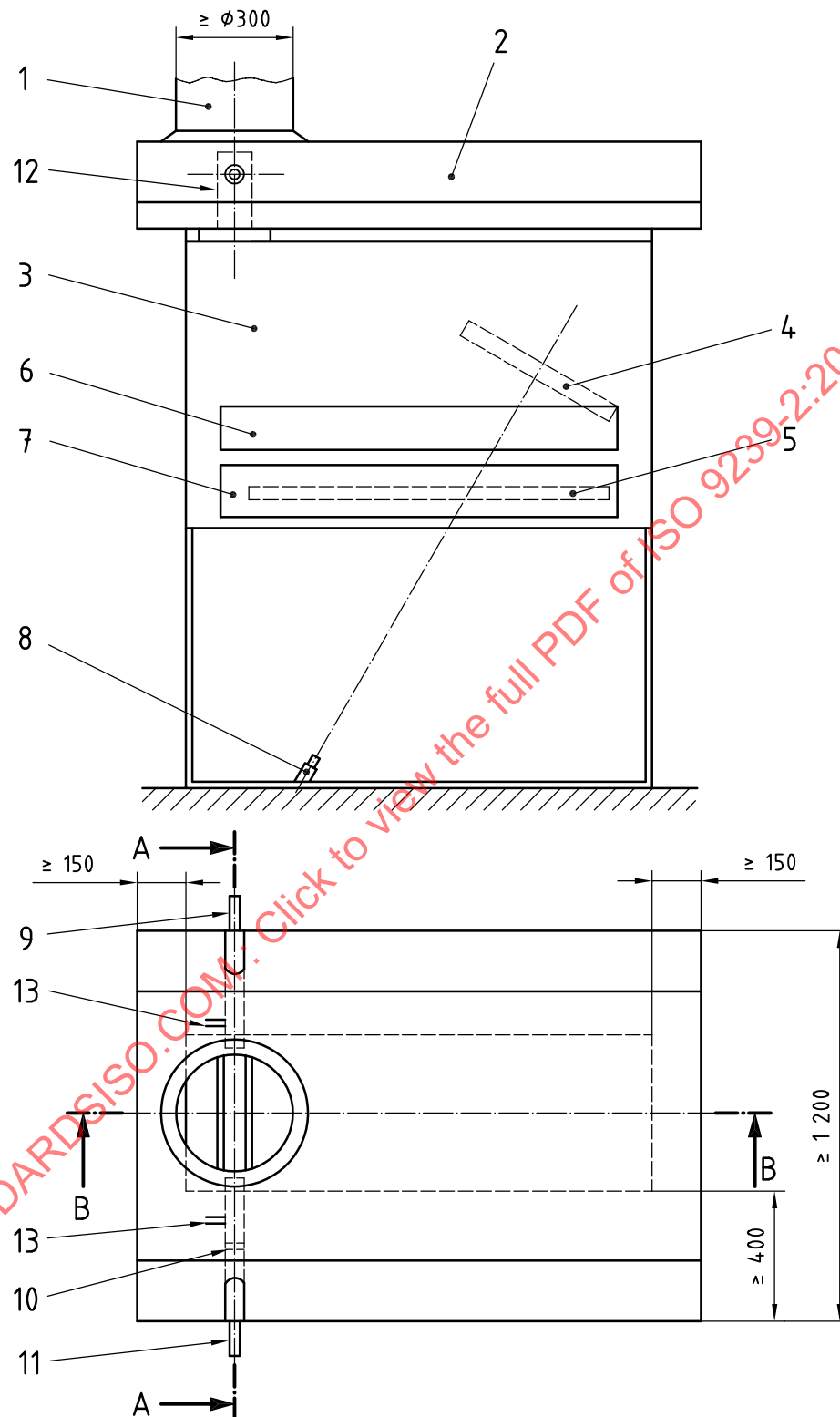
4.1.1 Location of chamber

The test apparatus shall be placed in a room with a clearance of at least 0,4 m to the walls and the ceiling.

4.1.2 Construction of chamber

The test chamber shall have the dimensions shown in Figures 1 to 4. The chamber shall be made of calcium silicate boards of (13 ± 1) mm thickness and 650 kg/m^3 nominal density, with a tightly fitting panel of fire-resistant glass of dimensions $(110 \pm 10) \text{ mm} \times (1\,100 \pm 100) \text{ mm}$ situated at the front, so that the whole length of the specimen can be observed during the test. The chamber may have an outside metal cladding. Below this observation window, a tightly closing door shall be provided through which the test specimen platform can be moved in and out.

Dimensions in millimetres

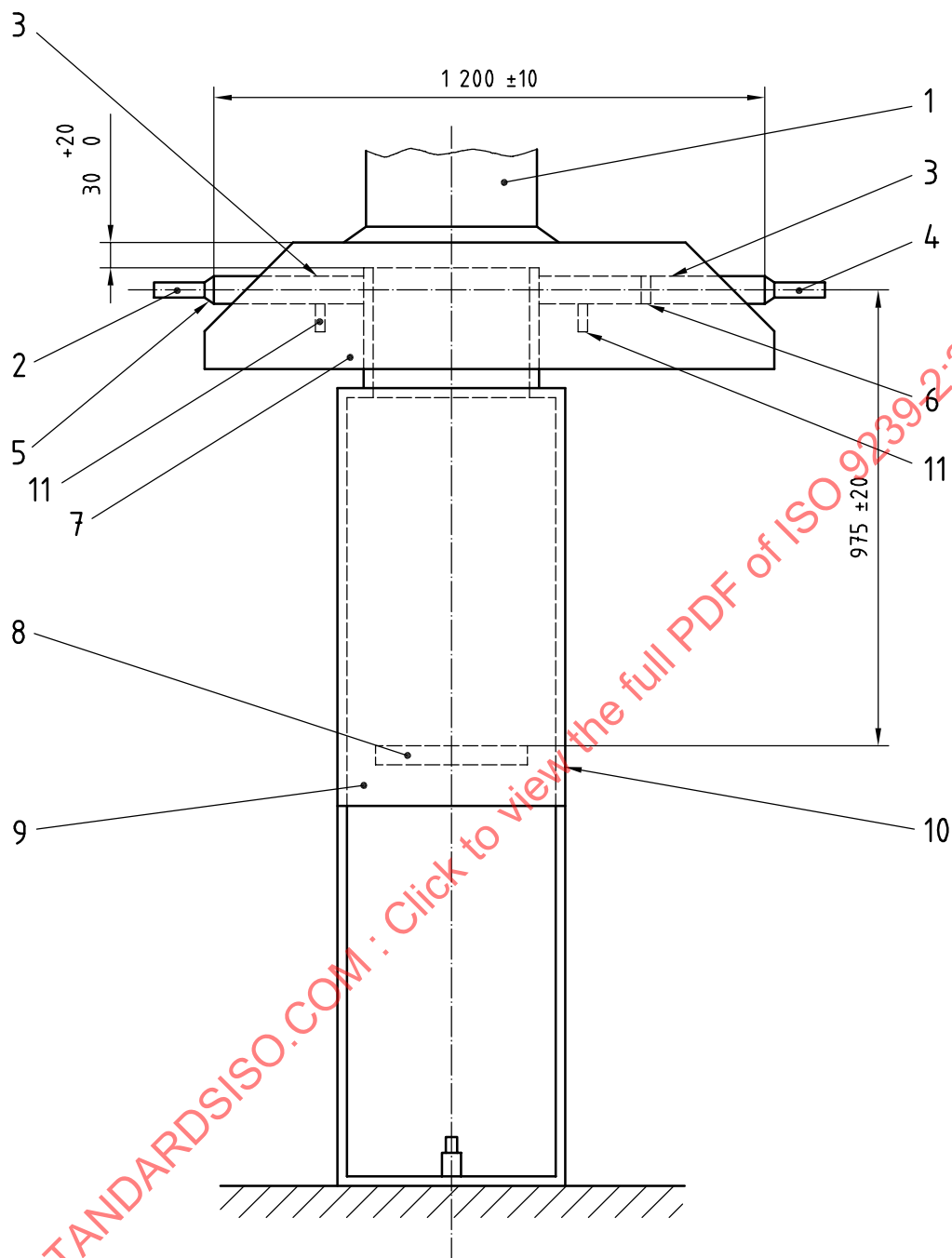


Key

- | | | |
|---------------------------------|--|---------------------------------|
| 1 exhaust duct | 6 observation window | 11 light receiver (optional) |
| 2 exhaust hood | 7 door for insertion and removal of specimen | 12 exhaust stack |
| 3 test chamber | 8 pyrometer | 13 tubes for purging air supply |
| 4 gas-fired radiant panel | 9 illumination unit (optional) | |
| 5 specimen holder with specimen | 10 slot for calibration filters | |

Figure 1 — Side and plan view of test equipment

Dimensions in millimetres

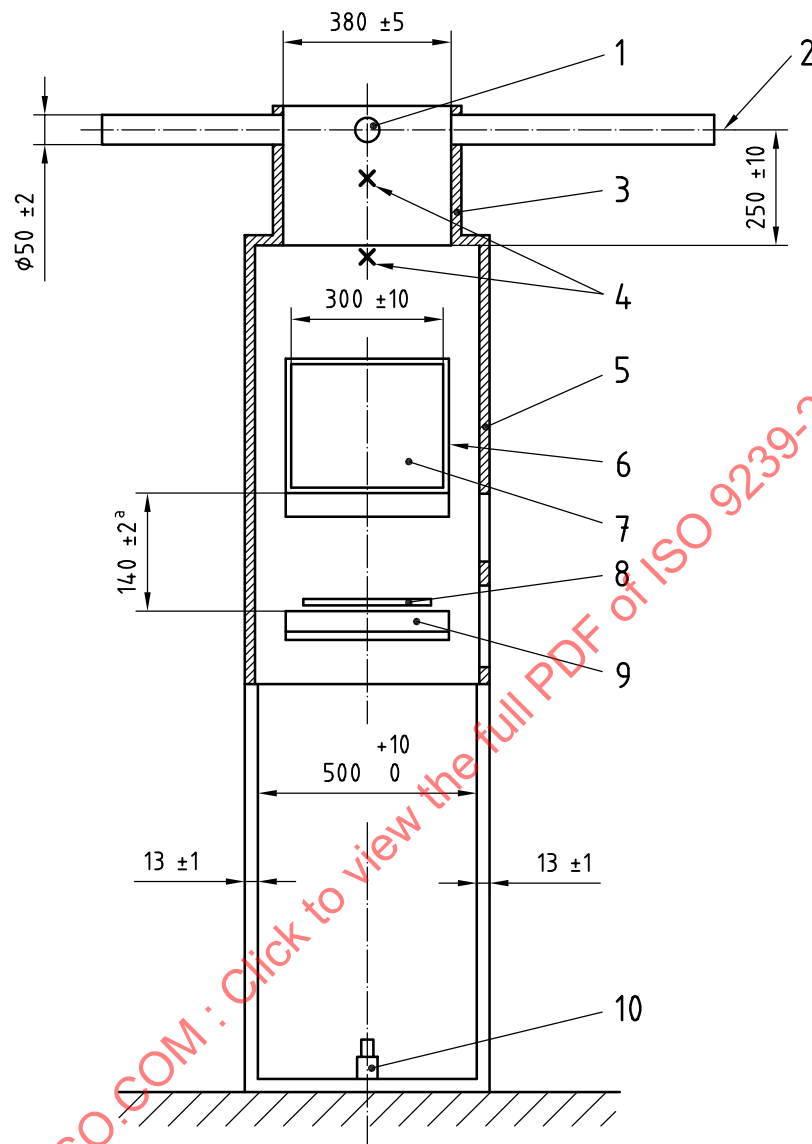


Key

- | | |
|---|---|
| 1 exhaust duct | 7 exhaust hood |
| 2 illumination unit (optional) | 8 specimen holder with specimen |
| 3 steel tubes for light measuring system (optional) | 9 test chamber |
| 4 light receiver (optional) | 10 door for insertion and removal of specimen |
| 5 collar or rubber rings | 11 tubes for purging air supply |
| 6 slot for calibration filters | |

Figure 2 — End view of test equipment

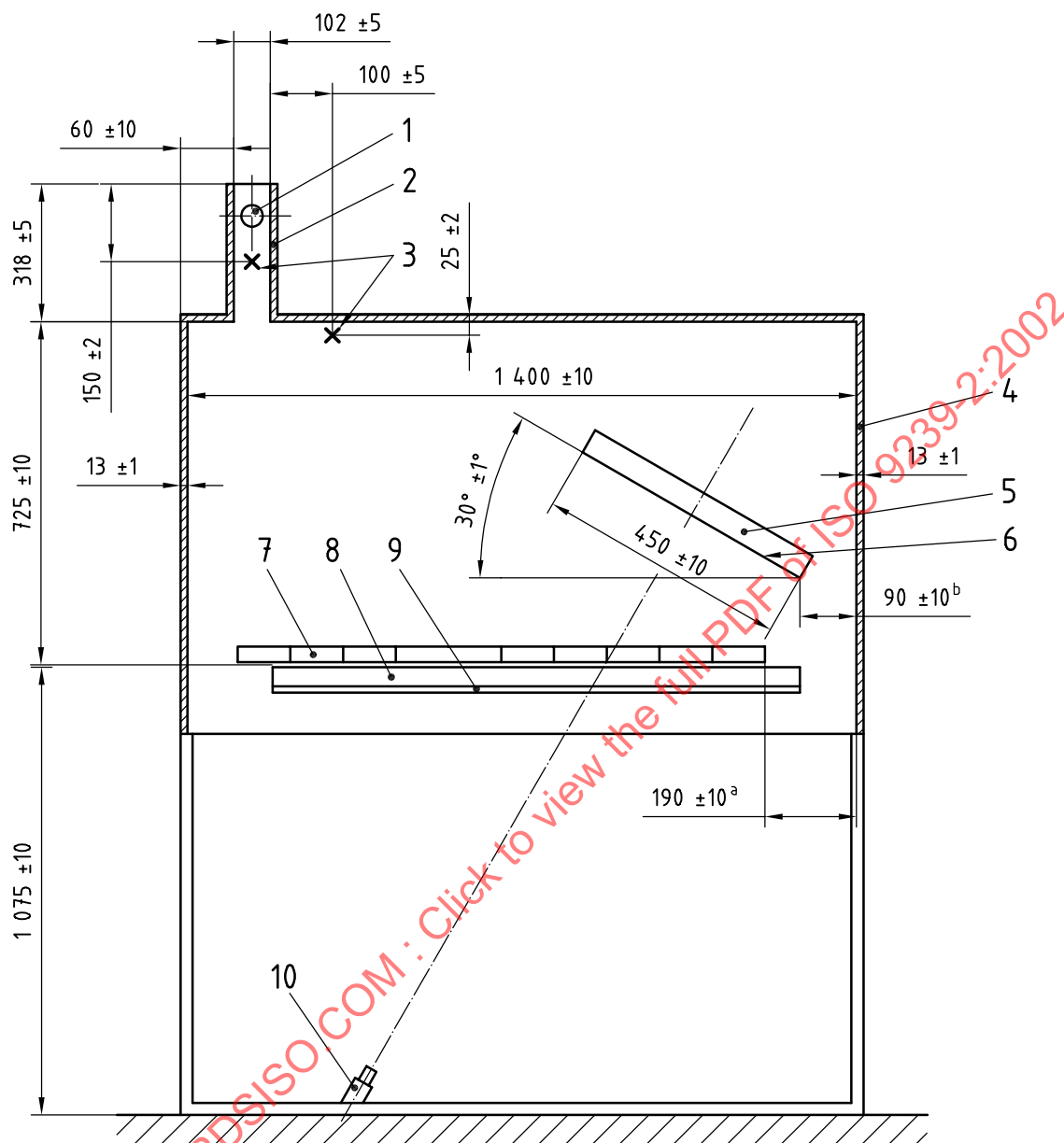
Dimensions in millimetres

**Key**

- | | |
|-----------------------------------|---------------------------------|
| 1 position for anemometer | 6 gas-fired radiant panel |
| 2 light measuring beam (optional) | 7 radiating surface |
| 3 exhaust stack | 8 pilot burner |
| 4 thermocouples | 9 specimen holder with specimen |
| 5 test chamber | 10 pyrometer |

^a Dimension measured from the exposed surface of the specimen to the bottom edge of the radiating panel.

Figure 3 — Section A-A of test equipment

**Key**

- | | |
|---|---------------------------------|
| 1 opening for light measuring system (optional) | 6 radiating surface |
| 2 exhaust stack | 7 scale |
| 3 thermocouples | 8 specimen holder with specimen |
| 4 test chamber | 9 specimen transport system |
| 5 gas-fired radiant panel | 10 pyrometer |

^a Dimension measured from the zero point (the inner edge of the specimen holder) to the inner surface of the chamber wall.

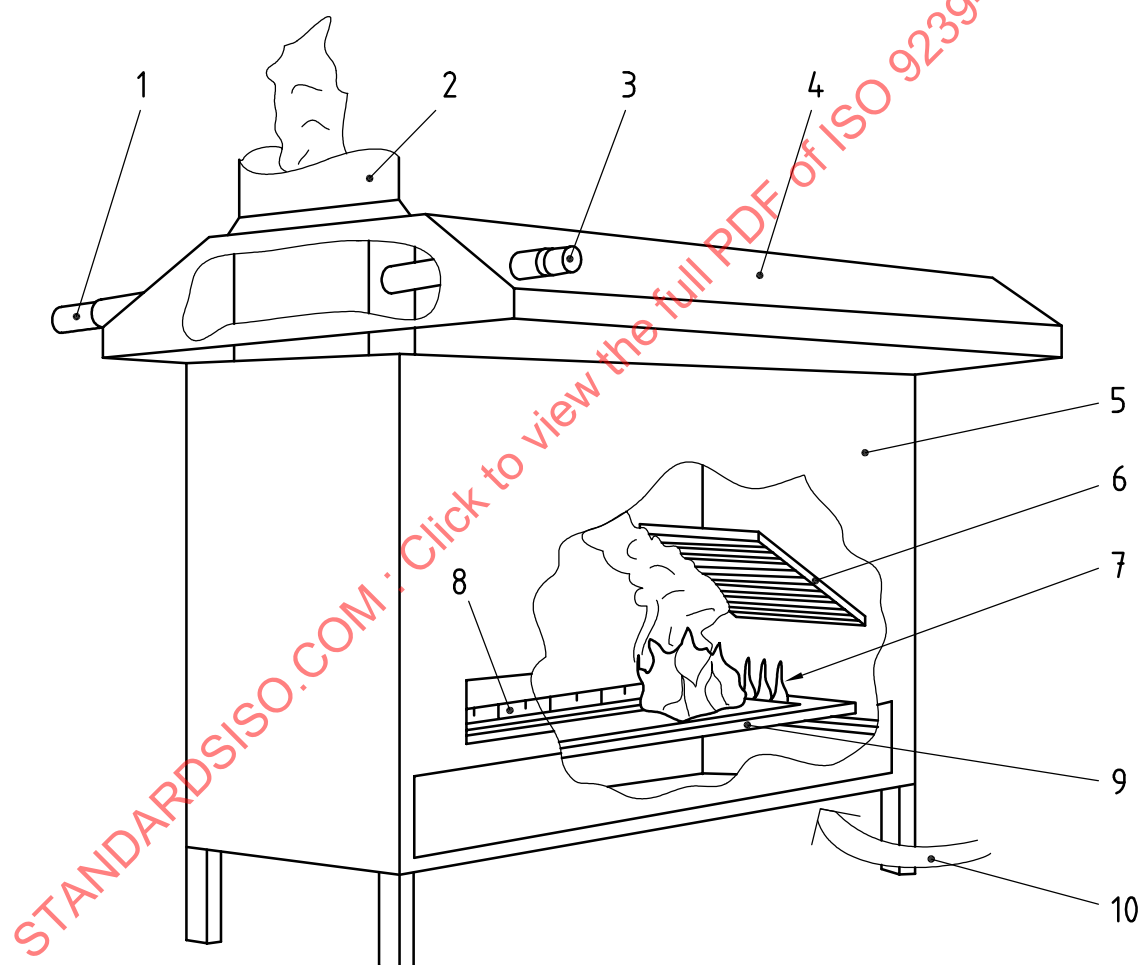
^b Dimension measured from the bottom edge of the radiating panel to the inner surface of the chamber wall.

Figure 4 — Section B-B of test equipment

4.1.3 Ventilation into chamber

The bottom of the chamber shall consist of a sliding platform, which shall have provision for rigidly securing the test specimen holder in a fixed and level position (see Figure 5). The total air access area between the chamber and the test specimen holder shall be $(0,06 \pm 0,02) \text{ m}^2$ and the base of the chamber shall be constructed so that the air enters at the hotter end of the exposed specimen. A ventilation control board, cut from $(13 \pm 1) \text{ mm}$ thick and 650 kg/m^3 nominal density calcium silicate board, shall be inserted from the side of the chamber (see Figure 6). Other materials such as 1 mm thick steel sheet have also proved to be suitable for construction of the ventilation control board.

An alternative way of creating a suitable air inlet is to fix calcium silicate boards to the sides of the specimen tray (see Figure 7). This arrangement has the advantage that the black body temperature of the panel may be measured using the radiation pyrometer in its normal position.

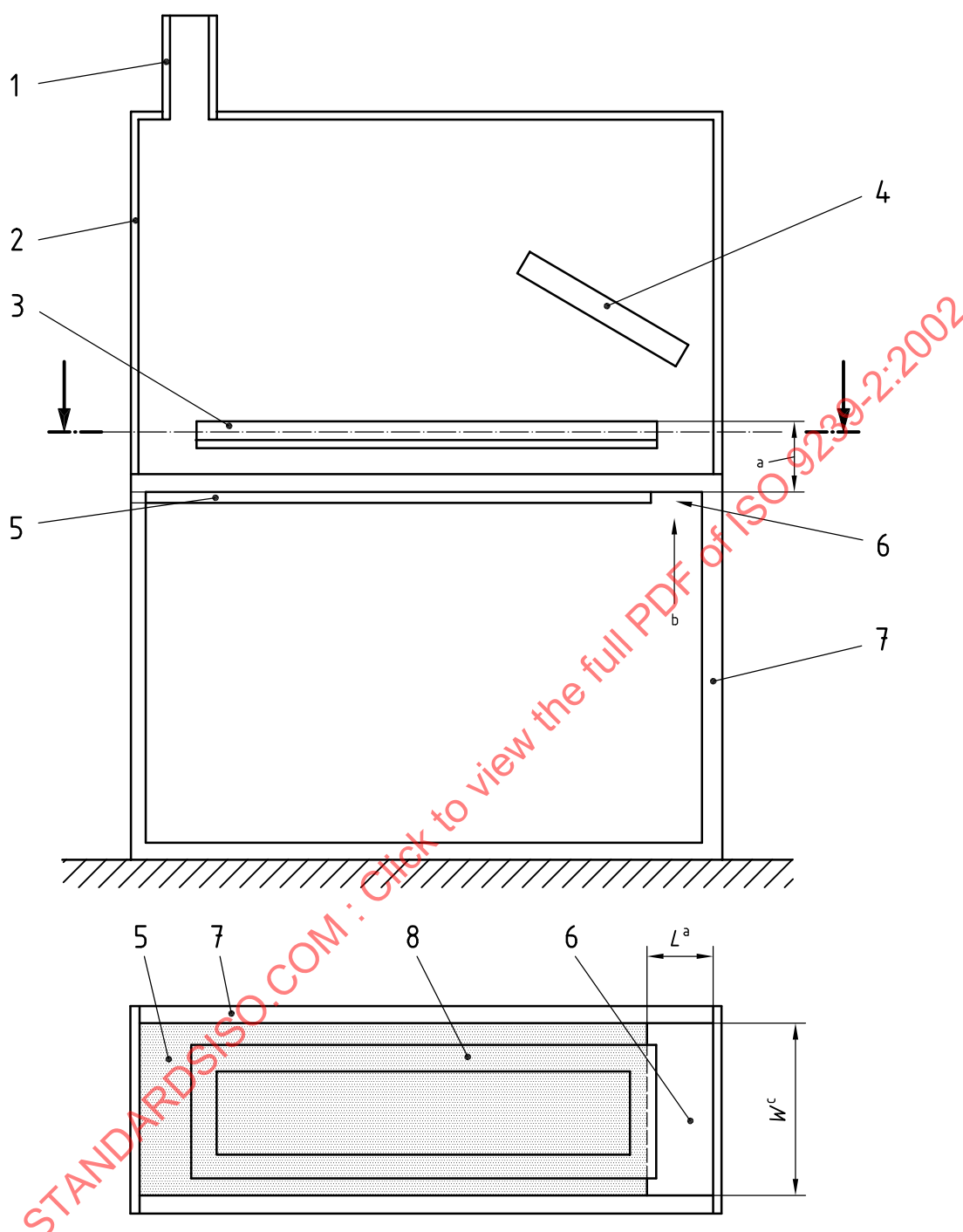


Key

- | | |
|--------------------------------|---|
| 1 illumination unit (optional) | 6 gas-fired radiant panel |
| 2 exhaust duct | 7 pilot flames from line burner |
| 3 light receiver (optional) | 8 scale |
| 4 exhaust hood | 9 specimen holder with specimen and with sliding platform |
| 5 test chamber | 10 air inlet at hotter end of specimen at bottom of chamber |

Figure 5 — Perspective view showing test principle

Dimensions in millimetres

**Key**

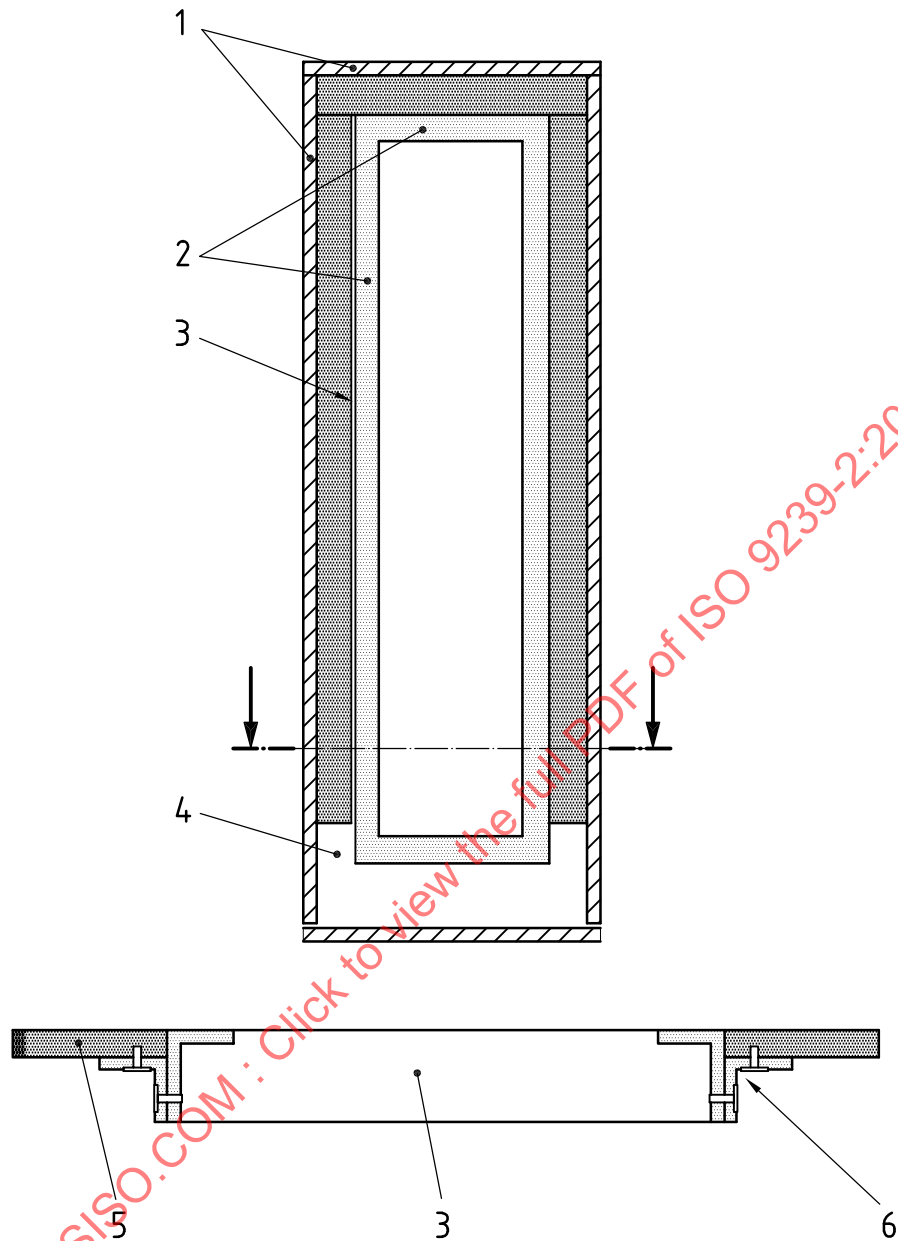
- | | |
|-------------------|---|
| 1 exhaust stack | 5 ventilation control board attached to underside of supporting framework |
| 2 test chamber | 6 air inlet |
| 3 specimen holder | 7 supporting framework |
| 4 radiant panel | 8 position of specimen holder |

^a Dimension is approximately 170 mm.

^b Air.

^c L and W dimensions are dependant upon specific apparatus construction such that $W \times L = 0,06 \text{ m}^2 \pm 0,01 \text{ m}^2$.

Figure 6 — Typical location of ventilation control board for air inlet

**Key**

- | | |
|------------------------------|---|
| 1 chamber walls | 4 air inlet 0,06 m ² |
| 2 fill boards (to block air) | 5 fill boards the same thickness and density as chamber walls |
| 3 sliding specimen tray | 6 fill boards fastened to specimen tray with angle iron and fasteners |

Figure 7 — Air inlet configuration with calcium silicate boards fastened to the sides of the specimen tray

4.2 Radiant panel

The source of radiant heat energy shall be a panel of porous refractory material mounted in a cast iron frame, with a radiation surface of $(300 \pm 10) \text{ mm} \times (450 \pm 10) \text{ mm}$.

The panel shall be capable of withstanding temperatures of up to 900°C and use a fuel gas/air mixing system with suitable instrumentation (see annex A) to ensure consistent and repeatable operation.

The radiant heat panel shall be mounted in the chamber with its longer dimension at $(30 \pm 1)^\circ$ to the horizontal plane (see Figure 4).

Propane/air mixtures have been proved to be suitable but other fuel gas/air mixtures can be utilised as well.

4.3 Test specimen holder

The test specimen holder is fabricated from heat resistant L-profile stainless steel of $(2,0 \pm 0,1) \text{ mm}$ thickness to the dimensions shown on Figure 8. The test specimen is exposed through an opening $(200 \pm 3) \text{ mm} \times (1\,015 \pm 10) \text{ mm}$. The test specimen holder is fastened to the sliding steel platform by means of two bolts on each end.

The test specimen holder shall be provided with means to secure the specimen (e.g. steel bar clamps).

The overall thickness of the holder is $(22 \pm 2) \text{ mm}$.

A steel scale marked with 10 mm and 50 mm intervals starting at the inner edge of the test specimen holder shall be mounted on both sides of the test specimen.

4.4 Pilot burner

The pilot burner, used to ignite the test specimen, shall be of stainless steel with nominal diameters of 6 mm (ID) and 10 mm (OD), 250 mm in width with 2 lines of 19 evenly-spaced 0,7 mm diameter holes drilled radially along the centreline and 16 evenly spaced 0,7 mm diameter holes drilled radially 60° below the centreline (see Figure 9). It is important to keep the holes in the pilot burner clean. A soft wire brush has been found suitable for removing surface contaminants. Nickel-chromium or stainless steel wire, 0,5 mm outside diameter, is suitable for opening the holes. In operation, the propane flow shall be adjusted to $(0,026 \pm 0,002) \text{ l/s}$ flow rate.

The pilot burner shall be positioned so that the flames generated from the lower line of holes will impinge on the specimen $(10 \pm 2) \text{ mm}$ from the zero point (see Figure 10). The pilot burner shall be 3 mm above the edge of the specimen holder when the burner is in the ignition position. The gas used shall be 95 % minimum propane having a calorific value of approximately 83 MJ/m^3 . When not being applied to the test specimen the burner shall be capable of being moved at least 50 mm away from the zero point of the test specimen. With the propane gas flow properly adjusted and the pilot burner in the test position, the pilot flame will vary in height from approximately 60 mm to approximately 120 mm across the width of the burner (see Figure 10).

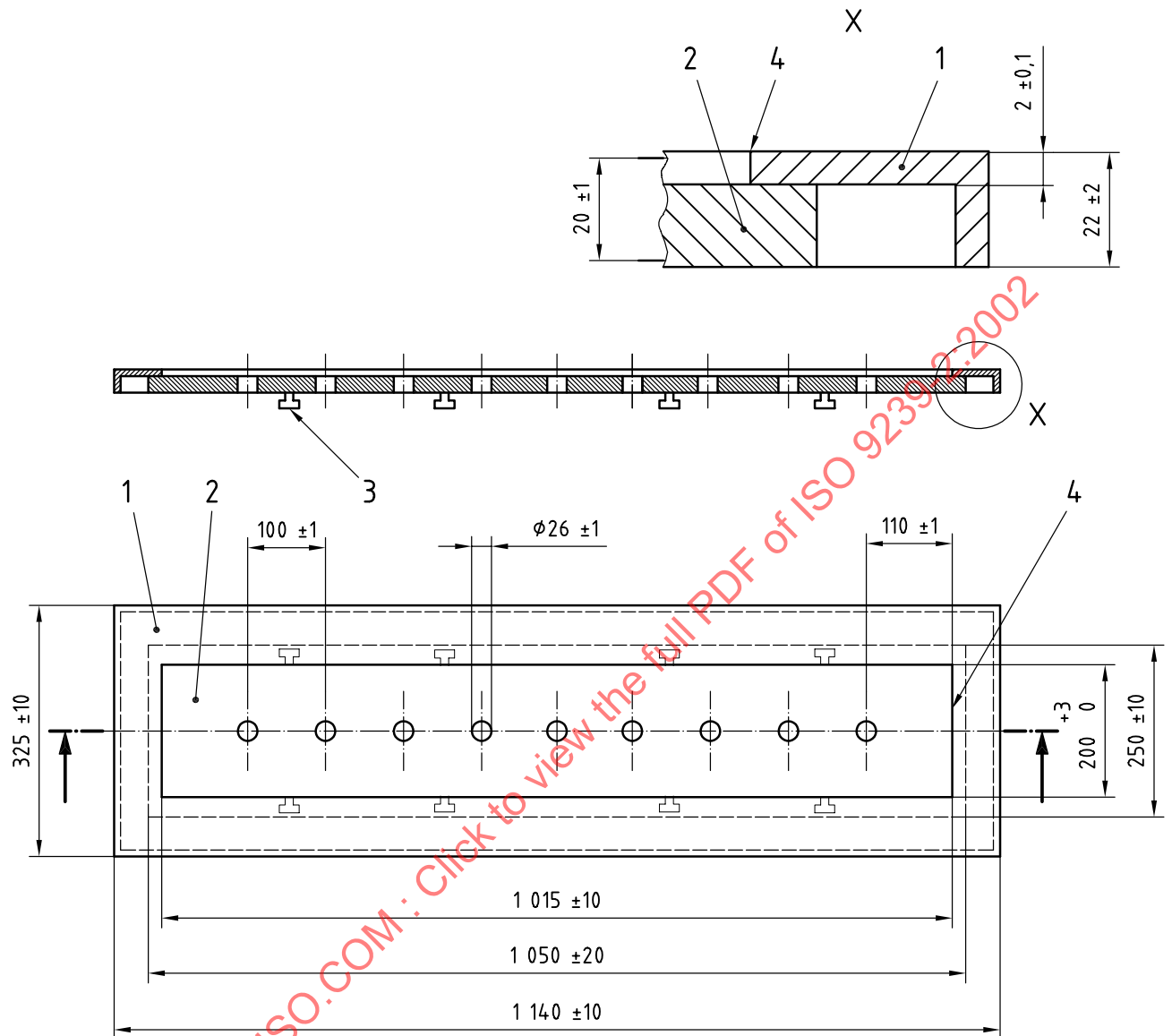
4.5 Exhaust system

An exhaust system, decoupled from the exhaust stack, shall be used to extract the products of combustion. With the panel turned off, dummy specimen in place and the access door closed, the air velocity in the exhaust stack shall be $(2,5 \pm 0,2) \text{ m/s}$ (see Figures 1 and 2).

4.6 Anemometer

An anemometer with a range up to 3,0 m/s and with an accuracy of $\pm 0,1 \text{ m/s}$ shall be provided for measuring the air velocity in the exhaust stack. It shall be fitted in the exhaust stack, in such a way that its measuring point coincides with the centre line of the exhaust stack at $(250 \pm 10) \text{ mm}$ above the lower edge of the exhaust stack (see Figure 3).

Dimensions in millimetres



Key

- 1 specimen holder
- 2 dummy specimen
- 3 fixing clamps
- 4 zero point

Figure 8 — Specimen holder with dummy specimen

Dimensions in millimetres

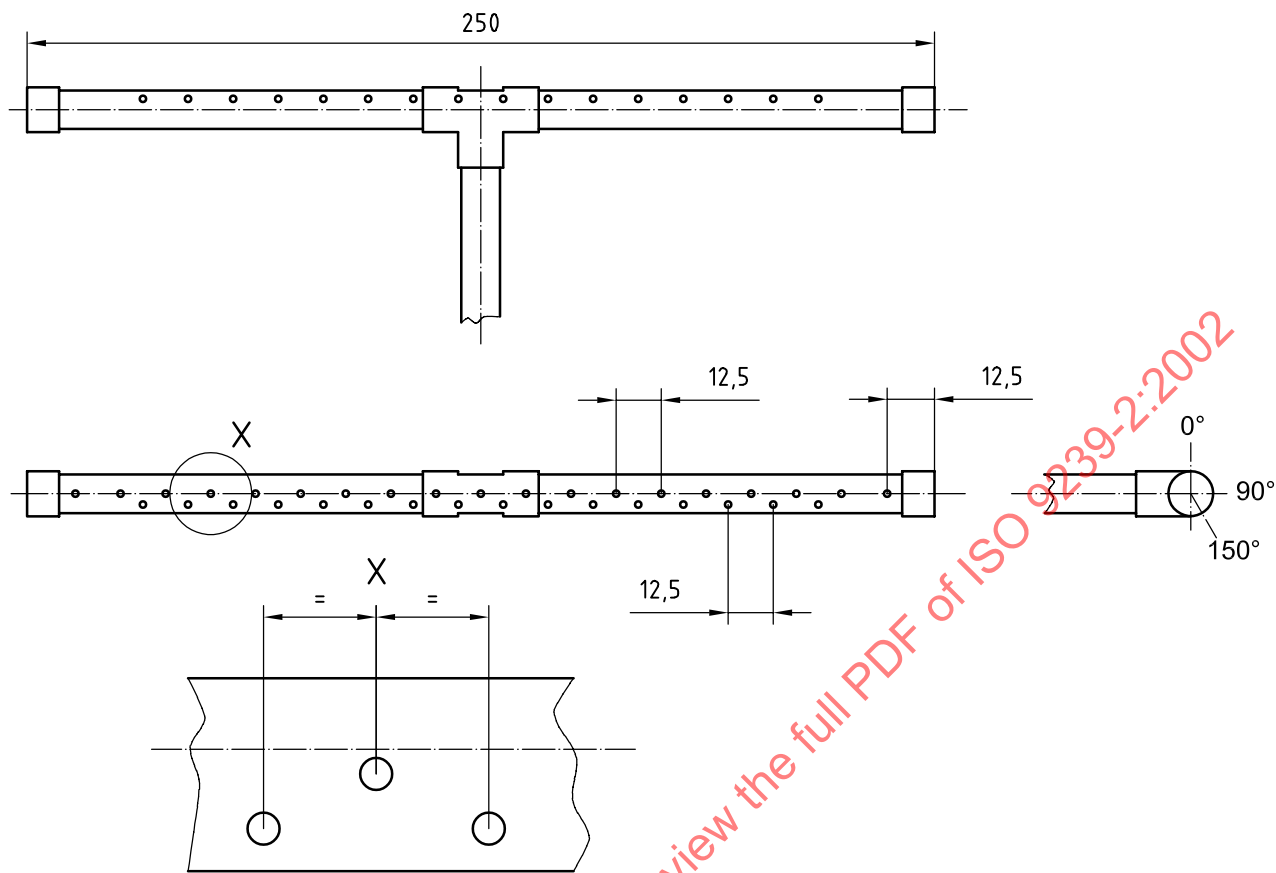


Figure 9 — Pilot burner

4.7 Radiation pyrometer

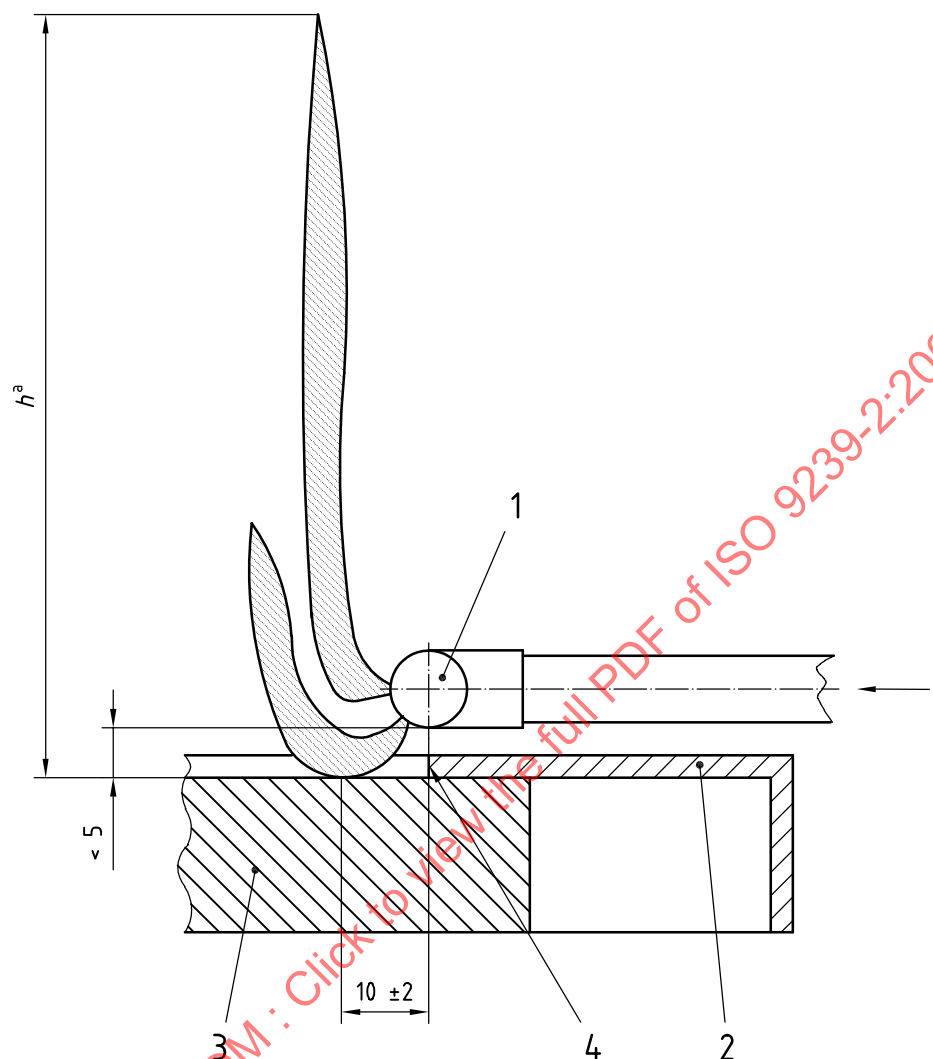
In order to control the thermal output of the radiant panel, use may be made of a radiation pyrometer with a range of 480 °C to 900 °C (black body temperature) and an accuracy of ± 5 °C suitable for viewing a circular area 250 mm in diameter at a distance of about 1.4 m.

The sensitivity of the pyrometer shall be substantially constant between the wave lengths of 1 μm and 9 μm .

4.8 Thermocouples

A 3,2 mm stainless steel sheathed earthed junction chromel-alumel thermocouple shall be mounted in the flooring of the radiant panel test chamber. It shall be located in the longitudinal central vertical plane of the chamber, 25 mm down from the top and 100 mm back from the inside wall of the exhaust stack (see Figures 3 and 4).

A second thermocouple may be inserted centrally in the exhaust stack, at a distance of (150 ± 2) mm from the top of the exhaust stack. The thermocouples shall be cleaned after each test.

**Key**

- 1 pilot burner
- 2 specimen holder
- 3 specimen
- 4 zero point

- a h is the height of pilot flames.
- b Gas flow.

Figure 10 — Arrangement of pilot burner above specimen during ignition period

4.9 Heat flux meter

The heat flux meter used to determine the heat flux profile to the test specimen shall be of the Schmidt-Boelter type without window and a diameter of 25 mm. Its range shall be from 0 kW/m² to 50 kW/m², and shall be calibrated over the operating flux level range from 1 kW/m² to 30 kW/m². A source of cooling water with a temperature range of 15 °C to 25 °C shall be provided for this instrument.

The heat flux meter shall have an accuracy of ± 3 % of the measured value.

4.10 Dummy specimen

The dummy specimen used for calibration shall be made of (20 ± 1) mm thick uncoated calcium silicate board of (850 ± 100) kg/m³ density. It shall be (250 ± 10) mm wide and $(1\ 050 \pm 20)$ mm long (see Figure 8), with (26 ± 1) mm diameter holes centred on and along the centreline at 110 mm, 210 mm through to 910 mm locations, measured from the zero point of the test specimen.

5 Test specimen

5.1 The test specimen shall be representative of the flooring system and simulate actual installation practice, especially adhesives and substrates in so far as is possible or necessary.

5.2 Cut the specimens $(1\ 050 \pm 5)$ mm $\times$ (230 ± 5) mm. Prepare 6 specimens, 3 in the production direction of the sample and 3 perpendicular to the production direction.

NOTE If the thickness of the specimen is more than 19 mm, the length can be reduced to $(1\ 025 \pm 5)$ mm.

5.3 For flooring systems consisting of tiles, they shall be mounted in such a way that a transverse joint is situated 250 mm from the zero point. If the tiles are not glued, the edges of the specimen shall be secured by mechanical means on the substrate. No supplementary mechanical means shall be used with the exception of the edge frame.

5.4 The flooring system shall be mounted in its intended end use on a substrate which simulates the actual floor. The adhesive which is used for the specimens shall be the same as that used in practice.

If in practice different adhesives are used, either specimens with each of the intended adhesives shall be prepared or specimens without adhesives.

5.5 Flooring systems utilizing an underlay(s) or interlayment in the actual end use shall be tested with this underlay(s) or interlayment, or as specified in the product standard.

5.6 Materials that, due to shrinkage, withdraw from the specimen holder frame, can show different results depending on the fixing. Special attention shall therefore be given to the use of good fixing techniques for materials with a tendency to shrinking during heat exposure.

5.7 Washing and cleaning procedures to examine the durability of the flooring in terms of the fire performance shall be in accordance with the procedures specified in the product standards for floorings.

6 Conditioning

Condition the specimens in accordance with ISO/TR 14697.

For floorings which are glued to the substrate, the glueing shall be done before the test specimens are conditioned and the curing time shall be at least 3 d. This time can be part of the conditioning.

7 Calibration procedure

7.2 The following calibration procedures shall be determined after each essential change of the apparatus, or at least once a month. If there are no changes in subsequent calibrations, this interval can be extended to 6 months.

7.2 Position the sliding platform and the mounting frame in the chamber together with the dummy specimen. Measure the airflow rate velocity in the exhaust stack with the exhaust on and the access door closed, and if necessary, adjust it to $(2,5 \pm 0,2)$ m/s. Ignite the radiant panel.

Allow the unit to heat for at least one hour until the chamber temperature has stabilized (see 8.1). The pilot burner shall be off during this period.

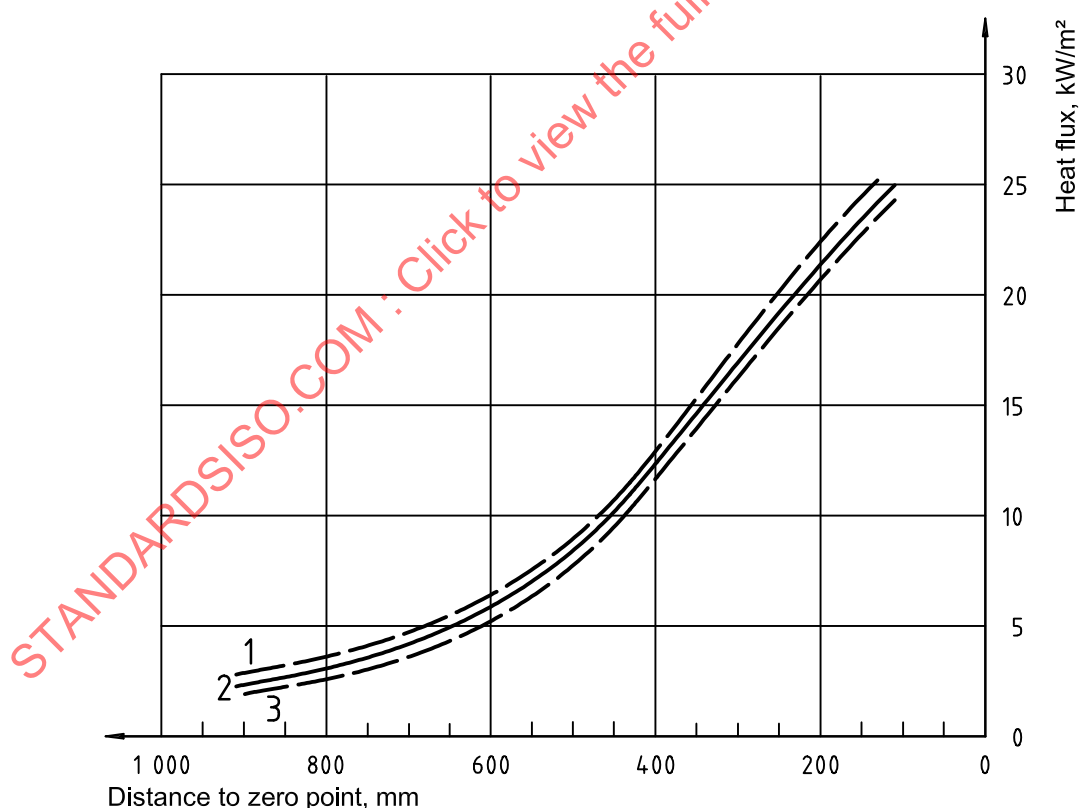
7.3 Measure the heat flux level at the 410 mm point with the heat flux meter. Insert the heat flux meter in the opening so that its detecting surface is between 2 mm and 3 mm above and parallel to the plane of the dummy specimen. Read its output after 30 s. If the level is $(12 \pm 0,6)$ kW/m² start the flux profile determination. If it is not, make the necessary adjustments in flowrate to the gas/air flows to the panel. It is important to ensure that the detecting surface of the heat flux meter is horizontal since small misalignments cause variations in heat flux measurements.

7.4 Perform the calibration under the conditions given in 7.2 and 7.3.

Insert the heat flux meter in each hole in turn, starting with the 110 mm and ending with the 910 mm. Ensure the detecting plane of the meter and the time of measurement agree with 7.3. To determine whether the heat flux level has changed during these measurements, check the reading at 410 mm after the 910 mm reading.

7.5 Record the radiant heat flux data as a function of distance along the specimen plane. Carefully draw a smooth curve through the data points. This curve is the heat flux profile curve (see Figure 11).

If the heat profile curve is within the tolerances of Table 1, the test equipment is in calibration and the heat flux profile determination is completed. If not, carefully adjust the fuel flowrate and allow at least 10 min to ensure that the chamber temperature is stabilized. Repeat the procedure until the heat flux profile is within the specification in Table 1.



Key

- 1 upper limit
- 2 nominal value
- 3 lower limit

Figure 11 — Heat flux profile curve

Table 1 — Required total heat flux distribution onto the calibration board

Distance to zero point of specimen mm	Total heat flux kW/m ²	Tolerances kW/m ²
110	25,2	± 1,0
210	21,5	± 0,6
310	16,5	± 0,6
410	12,0	± 0,6
510	8,3	± 0,6
610	5,8	± 0,4
710	4,2	± 0,4
810	3,3	± 0,4
910	2,6	± 0,4

7.6 Remove the dummy specimen and close the door. After 5 min measure the black body temperature of the panel with a radiation pyrometer and measure the temperature of the chamber. Record the results for the calibration values.

7.7 Some designs of ventilation control board will not allow a pyrometer to be used to measure the black body temperature of the panel. For this type of equipment, the heat flux level at the 110 mm and 410 mm points shall be measured daily.

8 Standard test procedure

8.1 Measure the black body temperature of the radiant panel with the sliding platform in the test chamber and the door closed but without the test specimen. If the black body temperature differs by more than $\pm 5^\circ\text{C}$ from that established by the calibration procedure, adjust the gas/air input to the radiant panel, then check the temperature of the chamber. If the temperature is equal to the value of the calibration ($\pm 10^\circ\text{C}$), the apparatus is ready for use. If a pyrometer cannot be used with the equipment (see 7.7), a daily calibration of the heat flux level at the 110 mm and 410 mm points shall be carried out.

8.2 Insert the test specimen, including any underlay(s) and substrate into the specimen holder. Place the steel bar clamps across the back of the assembly and tighten the nuts firmly or apply other fixing means. Raise the pile of textile floorings using a vacuum cleaner if applicable and mount the test specimen and its holder on to the sliding platform.

Ignite the pilot burner keeping it at least 50 mm away from the intended zero point of the test specimen. Move the sliding platform into the chamber and immediately close the door. This is the start of the test. Start the timing and recording devices.

Move the pilot burner flame into contact with the test specimen at the 10 mm distance described in 4.4. Leave the pilot burner flames in contact with the test specimen for 10 min, then withdraw the pilot burner to a position at least 50 mm away from the zero point of the specimen. Extinguish the pilot burner flames. During the test both the gas and airflow to the radiant panel shall be kept constant.

8.3 At 10 min intervals from the start of the test and at the flame-out time, measure the distances between the flame front and the zero point to the nearest 10 mm. Observe and record any significant phenomena such as melting, blistering, time and location of glowing combustion after flame-out, penetration of the flame through to the substrate, flashing or transitory flaming.

Note the times when the flame front reaches each 50 mm mark and the most distant point reached measured to the nearest 10 mm.

The test shall be terminated after 30 min, unless the sponsor requires a longer test duration.