
**Reaction-to-fire tests for sandwich panel
building systems —**

**Part 1:
Test method for small rooms**

*Essais de réaction au feu des systèmes de fabrication de panneaux de type
sandwich —*

Partie 1: Méthode d'essai pour des chambres de petite taille



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Printed in Switzerland

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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 3.

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 part of ISO 13784 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13784-1 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

ISO 13784 consists of the following parts, under the general title *Reaction-to-fire tests for sandwich panel building systems*:

- *Part 1: Test method for small rooms*
- *Part 2: Test method for large rooms*

Annexes A, B and C form a normative part of this part of ISO 13784. Annex D of this part of ISO 13784 is for information only.

Introduction

Fire is a complex phenomenon, its behaviour and effects dependent upon a number of interrelated factors. The behaviour of materials and products depends upon the characteristics of the fire, the method of use of the materials and the environment in which they are exposed (for the philosophy of reaction-to-fire tests, see ISO/TR 3814).

The need for improved insulation of buildings has led to the increased use of insulating sandwich panel systems in different parts of the building industry. Sandwich panel systems are applied as external cladding on factory buildings, in internal envelopes with controlled atmospheres and in cold stores — varying from small rooms to large, cool houses. Other applications are in modular building rooms and, sometimes, retail premises. These systems can also be used for roof applications in traditional constructions. Multi-layered panels with other facings (e.g. plasterboard) or sandwich panel systems can also be applied to walls as internal linings or insulation; however, this is not within the scope of ISO 13784.

There exist three primary fire-related threats to the walls and ceilings or roofs of a building insulated with freestanding or frame-supported types of sandwich panel systems:

- a) an interior compartment fire impinging directly onto the joints of the wall, typical ignition sources being welding torches, burning items near the wall and fire in an adjacent room;
- b) an external fire or combustibles (rubbish, vegetation, vehicles, etc.) accumulated near the wall;
- c) fire spread to outside spaces.

Moreover, such a fire can spread in several ways:

- over a combustible exterior surface;
- by travelling vertically and horizontally through the combustible cores of cavities within the external wall or ceiling/roof;
- through combustible gases which have developed due to the pyrolysis of the combustible components and which will ignite on the surface;
- as burning debris or flaming droplets.

This part of ISO 13784 deals with a simple representation of a fire scenario involving a sandwich panel system — such as that typified by a local fire impinging directly on the internal face of a sandwich panel building construction. The test method specified can be used to provide a small-room scale, end-use evaluation of all aspects of sandwich panel systems, including constructional techniques (supporting frameworks, jointing detail, etc.)

The test method is intended for evaluating products which, by their nature, are not normally used as internal linings and are unsuitable for assessment using ISO 9705, which evaluates fire growth from a surface product. Nevertheless, this part of ISO 13784 provides a means by which a freestanding or frame-supported sandwich panel building construction can be built and evaluated.

Testing of this type can be used for comparative purposes or to ensure the existence of a certain quality of performance considered to have a bearing on fire performance generally; it does not rely on the use of asbestos-based materials.

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Reaction-to-fire tests for sandwich panel building systems —

Part 1:

Test method for small rooms

SAFETY PRECAUTIONS — In order that suitable precautions can be taken to safeguard health, the attention of all concerned in fire tests is drawn to the possibility that toxic or harmful gases can be evolved during combustion of test specimens.

The test procedures concerned involve high temperatures and combustion processes — from ignition to a fully developed room fire. Therefore, hazards can exist for burns, ignition of extraneous objects or clothing. Operators should use protective clothing, helmet, face-shield and equipment for avoiding exposure to toxic gases.

Laboratory safety procedures shall be set up which ensure the safe termination of tests on sandwich panel products. Specimens with combustible content burning inside metallic facings may be difficult to extinguish with standard laboratory fire fighting equipment. Adequate means of extinguishing such a fire shall be provided.

When tests are conducted using the freestanding room construction, specimens could emit combustion products from their back face, especially if joints open up. Specimen collapse into the laboratory space can also occur. Laboratory safety procedures shall be set up to ensure safety of personnel with due consideration to such situations.

1 Scope

This part of ISO 13784 specifies a test method for evaluating the reaction-to-fire performance of sandwich panel building systems for small rooms and the resulting flame spread on or within the sandwich panel building construction when it is exposed to heat from a simulated internal fire with flames impinging directly on its internal corner. The test method is not intended for evaluating a product's fire resistance.

This part of ISO 13784 is applicable to both freestanding and self-supporting, and frame-supported, sandwich panel systems. It is not applicable to sandwich panel products that are glued, nailed, bonded or similarly supported by an underlying wall or ceiling construction.

NOTE Because of their design, some systems might be unsuitable for testing using this part of ISO 13784. Nevertheless, such systems could be suitable for testing using ISO 13784-2, in which case the field of application of the test report might be restricted. For testing of products used as internal linings, see ISO 9705.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13784. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13784 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 9705, *Fire tests — Full-scale room test for surface products*

ISO 13784-2, *Reaction-to-fire tests for sandwich panel building systems — Part 2: Test method for large rooms*

ISO 13943, *Fire safety — Vocabulary*

IEC 60584-2, *Thermocouples — Part 2: Tolerances*

3 Terms and definitions

For the purposes of this part of ISO 13784, the terms and definitions given in ISO 13943 and the following apply.

3.1

composite

combination of materials generally recognized in building construction as discrete entities

EXAMPLE Coated or laminated materials.

3.2

exposed surface

surface of the product subjected to the heating conditions of the test

3.3

product

material, composite or assembly

3.4

constant mass

state of a test specimen when two successive weighing apparatus operations carried out at an interval of 24 h do not differ by more than 0,1 % of the mass of the specimen or by 0,1 g, whichever is greater

3.5

surface product

any part of a building constituting an exposed surface on the walls or ceiling/roof, or on both

EXAMPLE Panel or board.

3.6

insulating sandwich panel

multilayered product consisting of three or more layers bonded together

NOTE One layer is an insulating material, such as mineral or glass wool, cellular plastics or a natural material (e.g. corkboard), protected by facings on both sides. Facings can be selected from a variety of materials and can be either flat or profiled. The most widely used facing is coated steel. The composite can vary from a simple construction to a complex composite system with specific fixing joints and supports, depending on the application and on the performance requirements.

3.7

specimen

assembly representing the end-use construction

4 Principle

The reaction to fire performance of a sandwich panel assembly is assessed when it is exposed to flames impinging directly on the internal corner of a small sandwich panel assembly. The different kinds of flame spread, for example, within the internal core, on the surface or through joints, by ignited combustible gases and falling debris or melting droplets of the sandwich panel assembly. The assessment allows determination of the following possible fire hazards:

- the contribution of the system to fire development up to flashover;
- the potential for transmitting an interior fire to outside spaces or other compartments or adjacent buildings;

- the possibility of the structure's collapse;
- the development of smoke and fire gases inside the test room.

5 Types of structure

The test method is applicable to the following two types of structure, representative of those used in practice both in respect of construction and materials.

a) Frame-supported structures

Sandwich panel systems are mechanically fixed to the outside or the inside of a structural framework — normally steel — through the thickness of the panel. The ceiling/roof could be built traditionally or using sandwich panel systems. A widespread example is the external cladding of industrial buildings. In most cases, this kind of sandwich panel system is used on a building's exterior wall, roof or both.

Deformation of the frame can influence the fire behaviour of the sandwich panels. Where the frame is protected in practice because of fire resistance requirements, this should also be the case for the frame under test. Protection can be obtained by means of insulating boards or coatings.

b) Freestanding structures

Sandwich panel systems are assembled together to provide a room or enclosure that does not depend for its stability on any other structural framework (e.g. cold stores, food or clean rooms, generally constructed within a weatherproof shell). Normally situated inside a building, the ceilings of these constructions may be supported from above.

6 Test specimen

The test specimen shall consist of the requisite number of panels required for the test to be performed. In all cases, the test specimen shall be representative of that used in practice, both in construction and materials. All constructional details of joints, fixings, etc., shall be reproduced and positioned in the test specimen as in practice. If the type of sandwich panel under test is used in practice with an inside or outside structural framework, this shall be included in the test.

The test specimen should be built by those suitably qualified in the construction of this type of structure.

If, in practice, ceiling panels are different from wall panels, a test may be performed with the correct combination of wall and ceiling panels.

If the sandwich panel building system is intended for use with decorative paint or film facings, these shall be present on the test specimen.

7 Test room design and construction

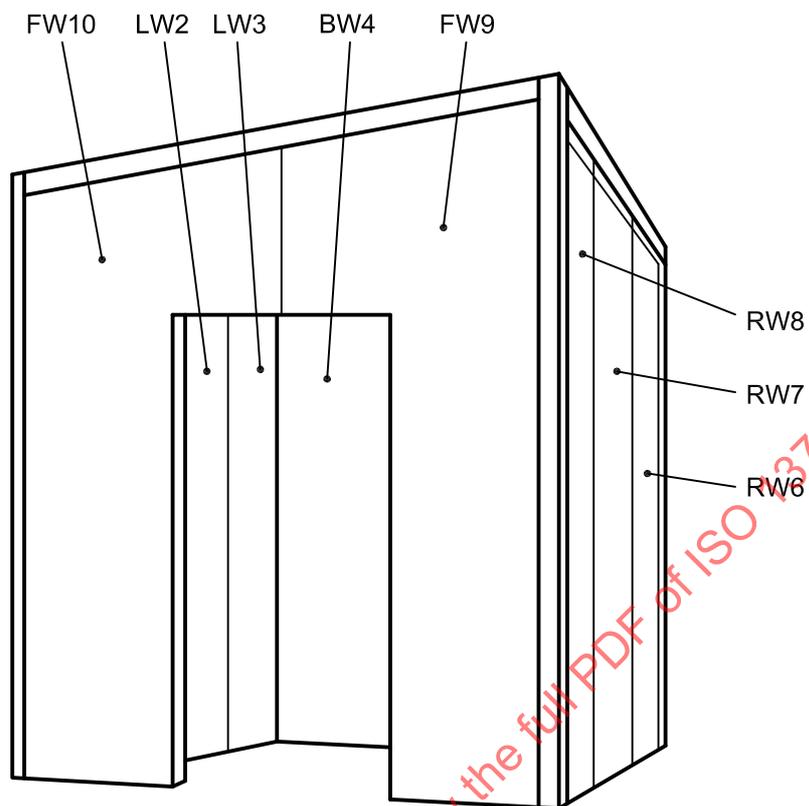
7.1 The test method consists of a procedure by which sandwich panel assemblies are assessed in their end-use scale and with the constructional details incorporated in their end use. Products are evaluated with end-use joints and fixings; where a supporting steel framework is part of the construction, testing is done with this framework also in place. Where the panels are self-supporting, for safety reasons an unconnected external framework should be used.

7.2 Construct a room using the components of the sandwich panel systems in accordance with clause 6. The room shall have four walls at right angles and a ceiling, and shall be located on a rigid, non-combustible floor surface. The means of securing wall panels together, and the means of attaching walls to floor and ceiling to walls, shall be representative of end use. The room shall have the following inner dimensions. See Figure 1.

Length: $(3,6 \pm 0,05)$ m

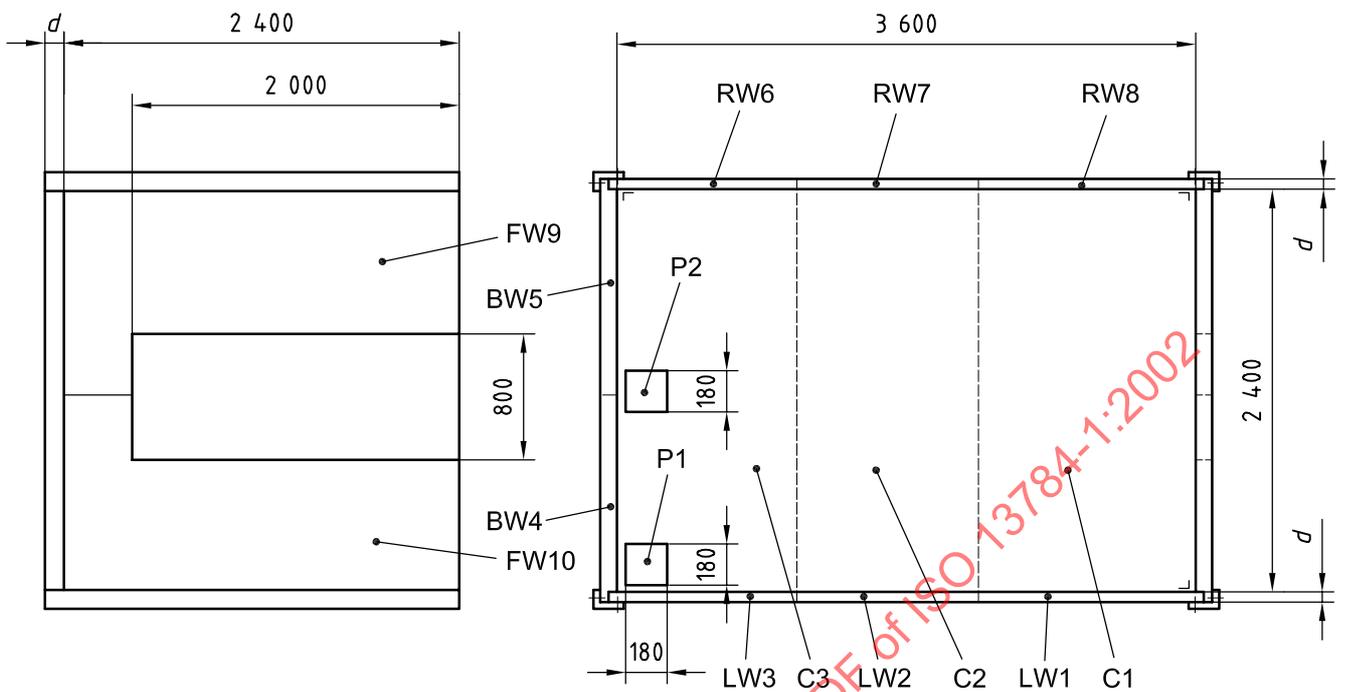
Width: $(2,4 \pm 0,05)$ m

Height: $(2,4 \pm 0,05)$ m



a) Isometric elevation

Figure 1 — Example of test specimen



b) Plan showing alternative burner position

Key

C	Ceiling panel
d	Thickness of panel
P1	Burner position 1, at corner
P2	Burner position 2, at joint
LW	Left wall panel
BW	Back wall panel
RW	Right wall panel
FW	Front wall panel

Figure 1 — Example of test specimen

7.3 Provide a doorway in the centre of one of the 2,4 m × 2,4 m walls; no other wall, floor or ceiling shall have any openings allowing ventilation. The doorway shall have the following dimensions.

Width: $(0,8 \pm 0,01)$ m

Height: $(2,0 \pm 0,01)$ m

7.4 The room shall be located indoors. Tests shall not be conducted unless the temperature within the room is between 10 °C and 30 °C.

7.5 The connections between the panels, and between the walls and the ceiling, shall represent those in the end-use application of the product being tested.

7.6 If the system includes any additional bracing, support members, etc., these shall also be installed in the test specimen construction. If the type of sandwich panel system under test is used in practice with an inside or outside structural framework, this shall be used in the test. See Figures 2 and 3.

NOTE The number of panels and their thickness can of course be different from those shown in the examples, depending on the type of panels tested. In addition, the type of supporting frame will depend on the practical end-use mounting. Only the inner dimensions of the room and the door opening are mandatory.

Dimensions in millimetres

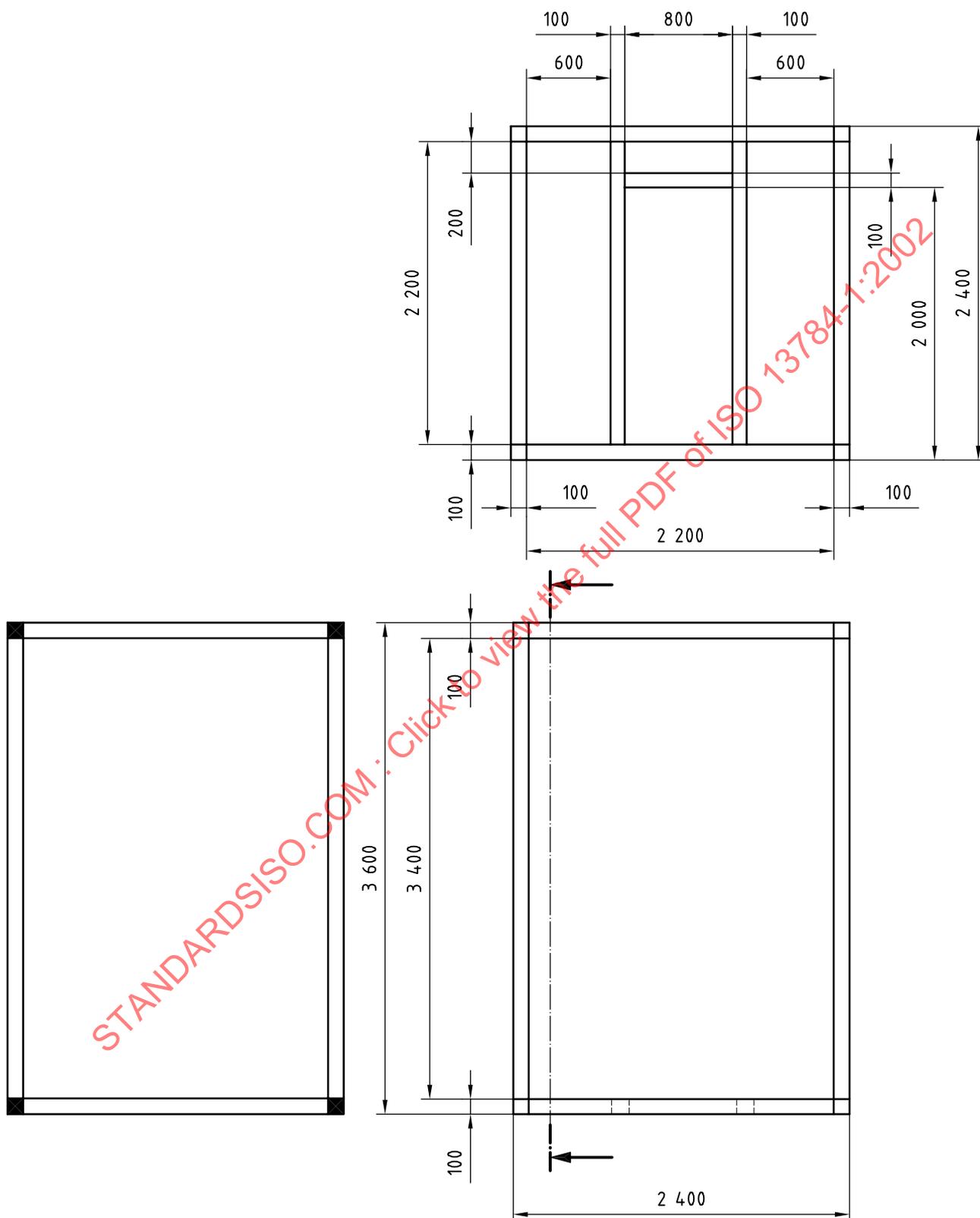


Figure 2 — Example of internal structural framework

Dimensions in millimetres

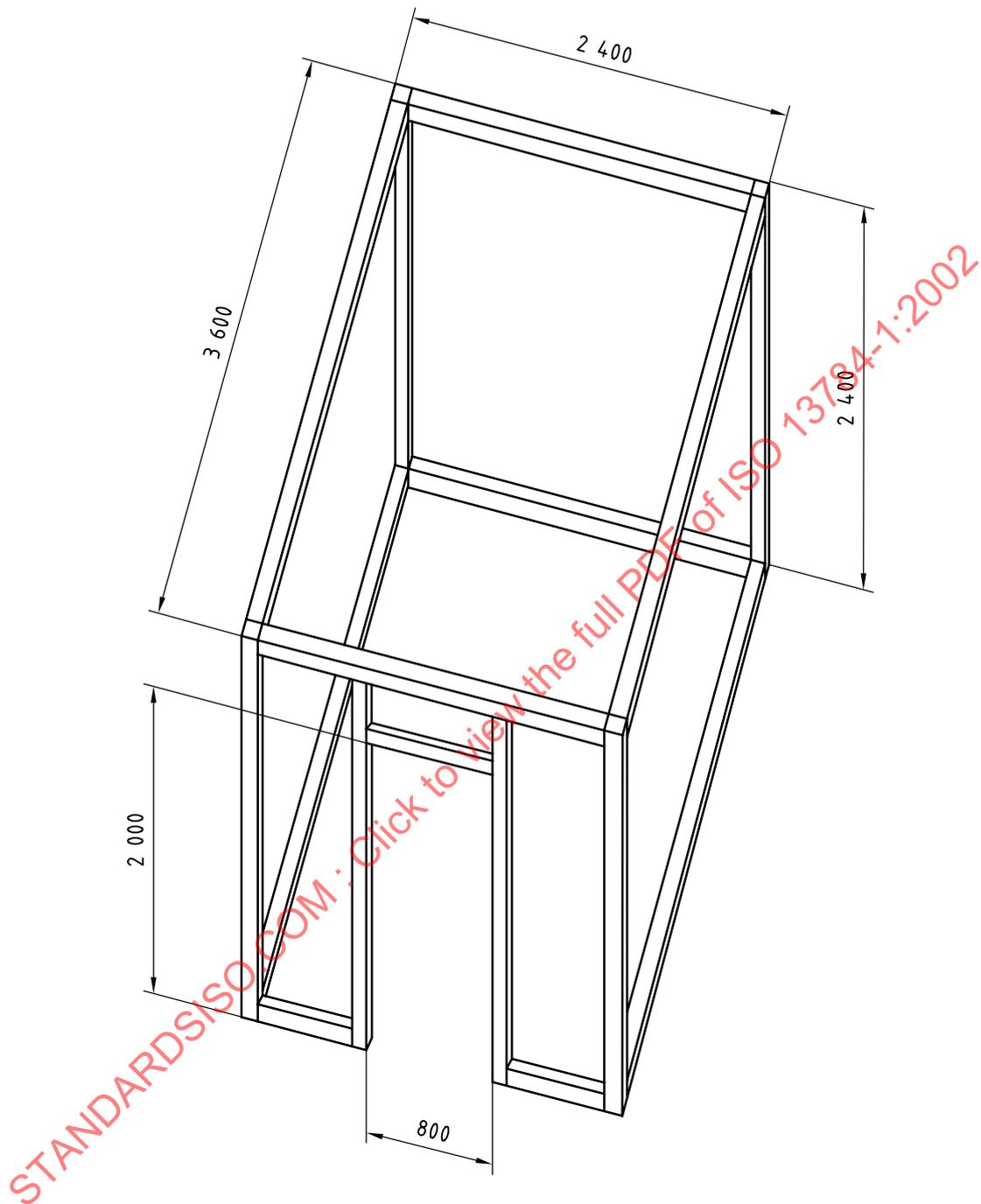


Figure 3 — Example of internal structural framework — Isometric elevation

7.7 The test room shall be positioned below the exhaust hood in accordance with clause 9. However, if, for reasons of product development or quality control, or at the special request of the sponsor or regulatory body, heat release or smoke production or both are excluded from the test procedure, the test room need not be positioned under the hood.

8 Ignition source

WARNING — The ignition source is a propane gas burner that consumes relatively large amounts of gas. All equipment (tubes, couplings, flow meters, etc.) should be approved for propane. The installations shall be performed in accordance with existing regulations. For reasons of safety, the burner should be equipped with a remote-controlled ignition device, for example, a pilot flame or glow wire. There should be a warning system for leaking gas and a valve for immediate and automatic cut-off of the gas supply in case of extinction of the ignition flame.

8.1 The ignition source shall be a propane gas burner having a square top surface layer of sand. The burner shall have face dimensions of 170 mm × 170 mm and a height of 200 mm above the floor (see Figure 4). The construction shall be such that an even gas flow is achieved over the entire opening area.

8.2 The burner shall be placed on the floor in a corner opposite the wall with the doorway, and shall be in contact with the specimen. If there is a structural framework member such as a column directly in the corner, the burner shall be placed at the joint nearest the corner on the back wall. This joint shall be not less than 300 mm from the corner column. See Figure 1.

If the structural member prevents contact, the burner shall be raised and adjusted such that it is in contact with the specimen.

8.3 The burner shall be supplied with natural-grade propane (95 % purity). The gas flow to the burner shall be measured with an accuracy of at least ± 3 %. The heat output to the burner shall be controlled within ± 5 % of the prescribed value.

8.4 The burner heat output, based on the net (lower) calorific value of propane, shall be 100 kW during the first 10 min of the test and shall then be increased to 300 kW for a further 10 min. After 20 min, another 10 min of observations shall be made with no power output to the burner.

9 Apparatus

9.1 Thermocouples, positioned on the external surface of each of the panels and within their core, installed from the rear of the panel in such a way that flame spread within the core can be monitored.

One thermocouple should be installed on the external surface of each panel, sited on the centreline, and another within the core, one third of the distance from top to bottom of the panel for wall panels and in the centre for ceiling panels. Thermocouples shall also be positioned in the upper third of the door opening. See Figure 5. Only thermocouples 02, 06 and 010 in the door opening are mandatory; all others are optional.

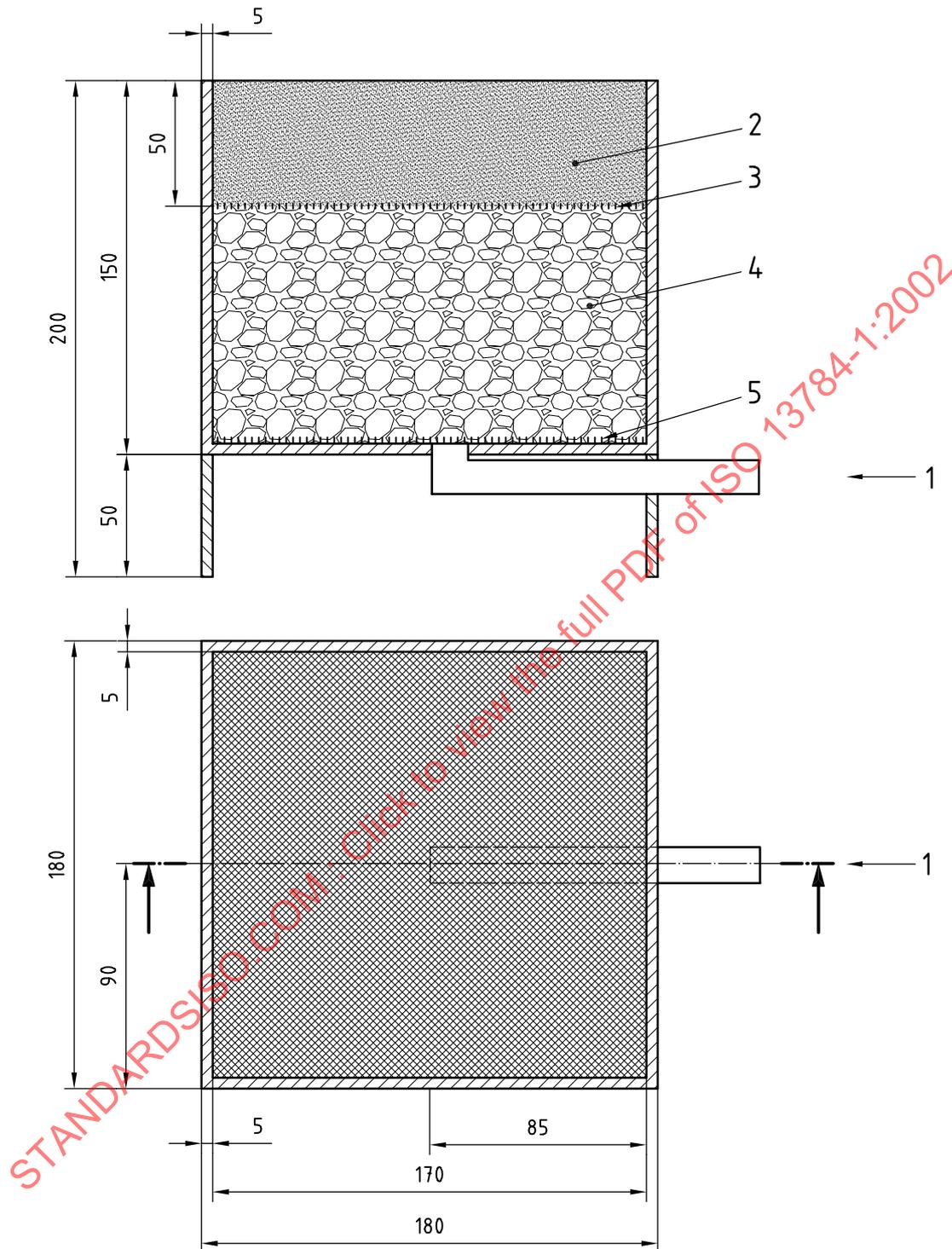
The thermocouples shall be either of the sheathed or welded types. The former shall be type K chromel/alumel stainless-steel sheathed thermocouples with a wire diameter of 0,3 mm and an outer diameter of $(1,5 \pm 0,1)$ mm. The hot junction shall be insulated and not earthed. Welded thermocouples shall have a maximum diameter of 0,3 mm. Thermocouples on the external surface of the panels shall have their hot junctions in contact with the surface of the panel. Surface thermocouples with copper disk for surface temperature measurements, sheathed thermocouples for core measurements and welded non-sheathed thermocouples for gas temperature measurements should be used. The thermocouples shall be of tolerance class 1 in accordance with IEC 60584-2.

9.2 Heat flux meter, placed in the centre of the floor of the room and calibrated over its entire range.

The heat flux meter shall be of the foil (Gardon) or thermopile (Schmidt-Boelter) type with a range of 0 kW/m² to 50 kW/m². The target receiving heat flux shall be flat, circular, not more than 10 mm in diameter and coated with a durable matt-black finish. The target shall be contained within a water-cooled body, the front face of which shall be of slightly polished metal, flat and circular, shall coincide with the plane of the target and have a diameter of about 25 mm.

Heat flux shall not pass through any window before reaching the target. The instrument shall be robust, simple to set up and use, insensitive to draughts and stable in calibration. The instrument shall have an accuracy of within ± 3 % and a repeatability of within 0,5 %.

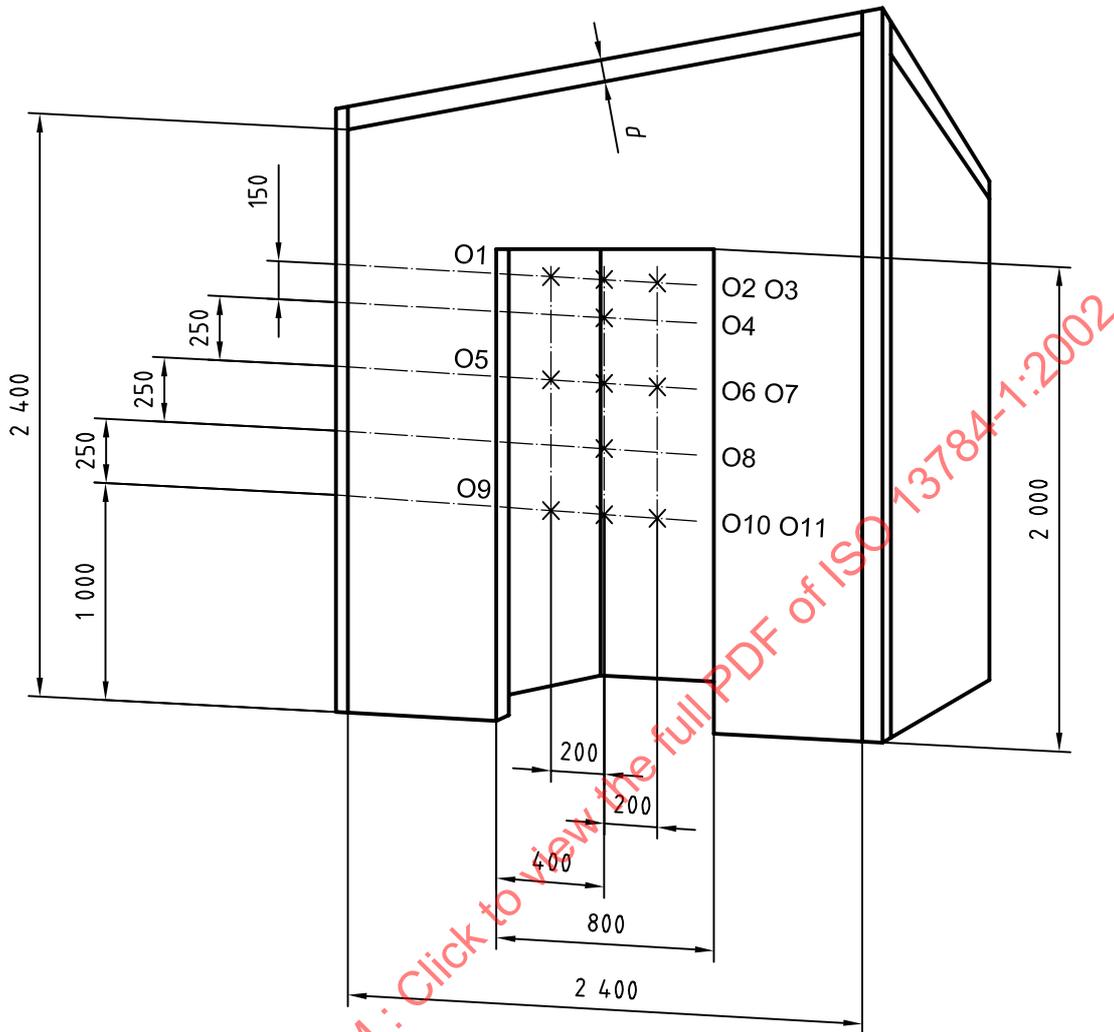
Dimensions in millimetres



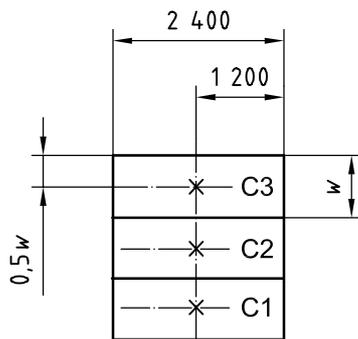
Key

- 1 Gas inlet
- 2 Sand (2 mm to 3 mm)
- 3 Brass wire gauze (1,8 mm)
- 4 Gravel (4 mm to 8 mm)
- 5 Brass wire gauze (2,8 mm)

Figure 4 — Burner

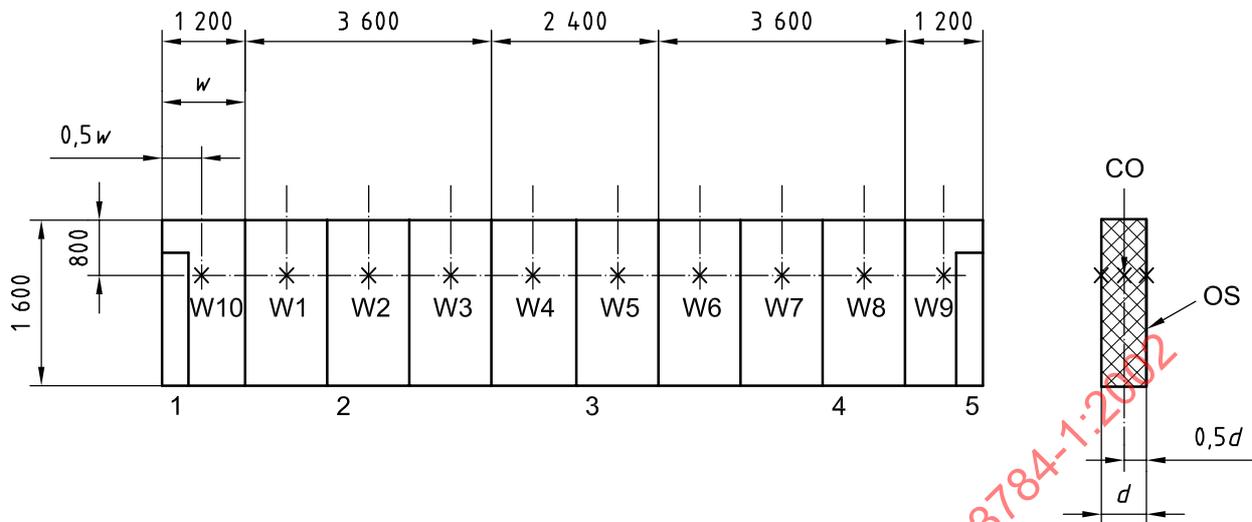


a) Door opening



b) Ceiling

Figure 5 — Thermocouple distribution



c) Walls

Key

- 1 wall with door
- 2 left wall
- 3 back wall
- 4 right wall
- 5 wall with door
- O Opening (1 to 11)
- C Ceiling panel (core outside)
- w Width of panel
- W Wall panel (core outside)
- CO Core
- OS Surface of panel outside room
- d Thickness of panel

Figure 5 — Thermocouple distribution**9.3 Additional equipment**

9.3.1 Data recorder — either a chart recorder or data logger capable of recording and storing input data from the thermocouples at intervals not exceeding 10 s, and able to provide a hard copy of the data.

9.3.2 Timing device — a clock with 1 s divisions or equivalent device.

9.4 Heat and smoke release measurement system (see clause 10 and annexes A, B and C).

10 Heat and smoke release measurement

IMPORTANT — In the case of either of the following methods, the laboratory may end the test if conditions occur that could endanger the safety of personnel or laboratory or both.

10.1 General

Depending on the final application of the test results, one of two alternative methods may be used for performing heat and smoke release measurements. The method chosen shall be clearly stated in the test report. If, for reasons of product development or quality control, or at the special request of a sponsor or regulatory body, heat release or smoke measurements or both are excluded from the test procedure, this shall be clearly stated in the test report.

10.2 Method 1 (see annex A)

Connect the sandwich panel building construction to the hood system in accordance with ISO 9705. Using this method, only smoke and heat release coming out of the door opening will contribute to the measurements, and flaming and smoke coming out of the external joints of the structure are excluded. The measurements give information about the hazards of the contribution of the system to fire development up to flashover and the potential for transmitting an interior fire to outside spaces or other compartments or adjacent buildings (see clause 4). Record any flaming observed for more than 10 s through the joints. See annex A.

NOTE When smoke and flames escape through the joints, the heat and smoke release measurements are no longer accurate for the whole system, as the smoke gases are not captured by the hood.

10.3 Method 2 (see annex B)

Place the sandwich panel building construction either

- a) under an enlarged hood and duct system (see Figure 6), or
- b) in a ventilated enclosure (see Figure 7) with an opening towards an enlarged hood and duct system.

The walls and ceiling of the enclosure shall be at least 0,5 m from the outer surface of the sandwich panel building construction and shall be built such that feedback from these surfaces is insignificant.

The hood/enclosures of both a) and b) should collect all smoke and hot gases coming from the joints of the sandwich panel systems and the door opening of the construction, and be built such that there is no feedback influence on the fire behaviour of the sandwich panel building construction and observation of the fire process; flaming through joints should be possible.

Perform a calibration run in accordance with A.3.1. HRR calibration inside the enclosure shall be performed so that at least 95 % of combustion products are captured by the enclosure and led into the hood, as shown in Figures 6 and 7. Record any flaming observed for more than 10 s through the joints.

11 Procedure

11.1 Initial conditions

11.1.1 The temperature in the test facility at the start of the test shall be between 10 °C and 30 °C.

11.1.2 The horizontal wind speed measured at a horizontal distance of 1 m from the centre of the doorway shall not exceed $1,75 \text{ m} \cdot \text{s}^{-1}$.

11.1.3 The burner shall be in contact with the corner wall. The surface area of the burner opening shall be clean. If there is a structural framework such as a column directly in the corner, the burner shall be placed at the nearest joint from the corner on the back wall but not less than 300 mm away (see Figure 1).

11.1.4 The test set-up shall be photographed or video-recorded prior to testing.

11.2 Test

11.2.1 Start all recording and measuring devices and record data for at least 2 min prior to igniting the burner.

11.2.2 Adjust the burner to the required output levels within 10 s of ignition (see Figure 8). Adjust the exhaust capacity so that all combustion products are collected.

11.2.3 Make a photographic or videotape record of the test or both of these. A clock shall appear in all photographic records, giving time to the nearest second.

Dimensions in millimetres

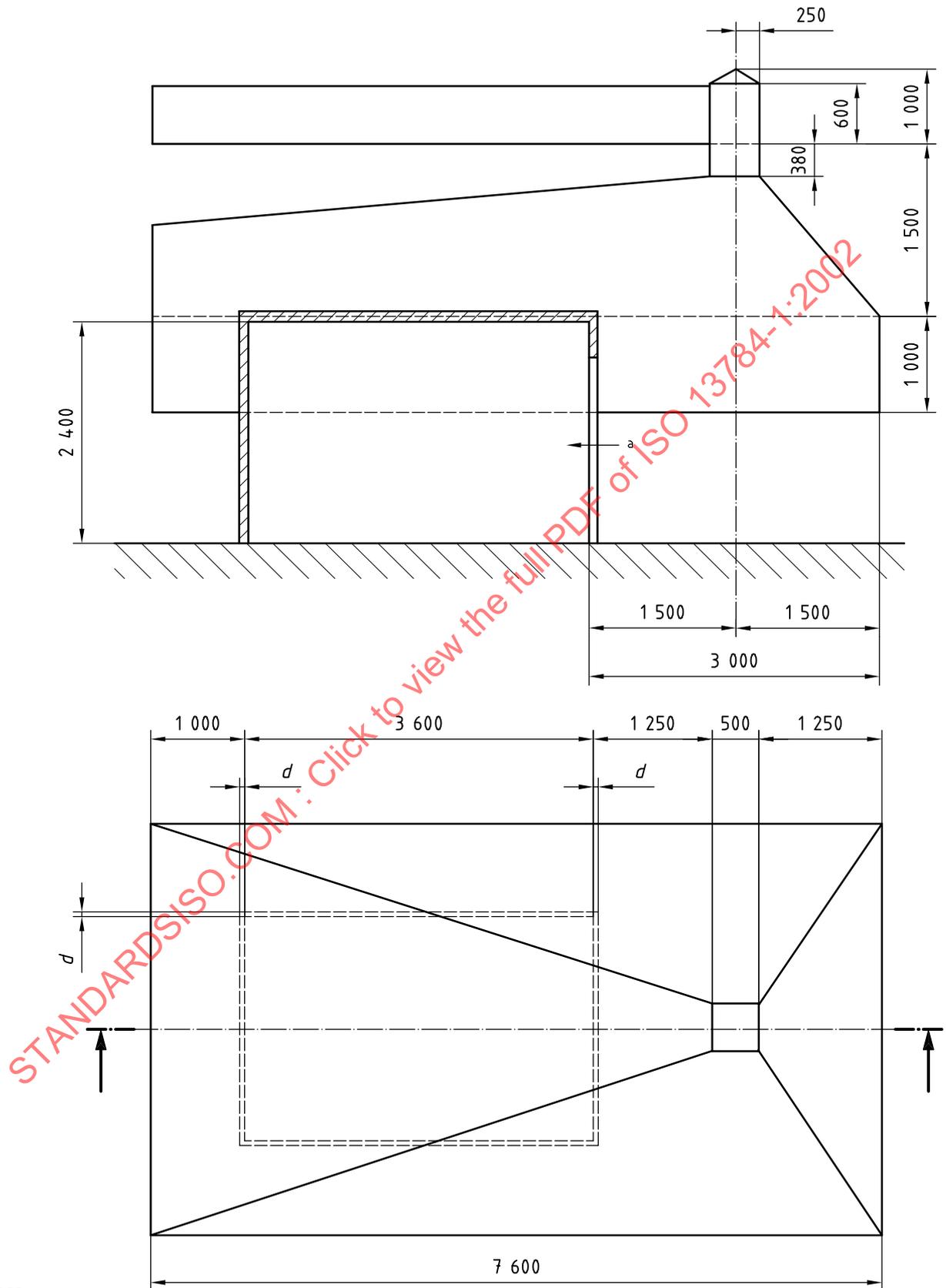
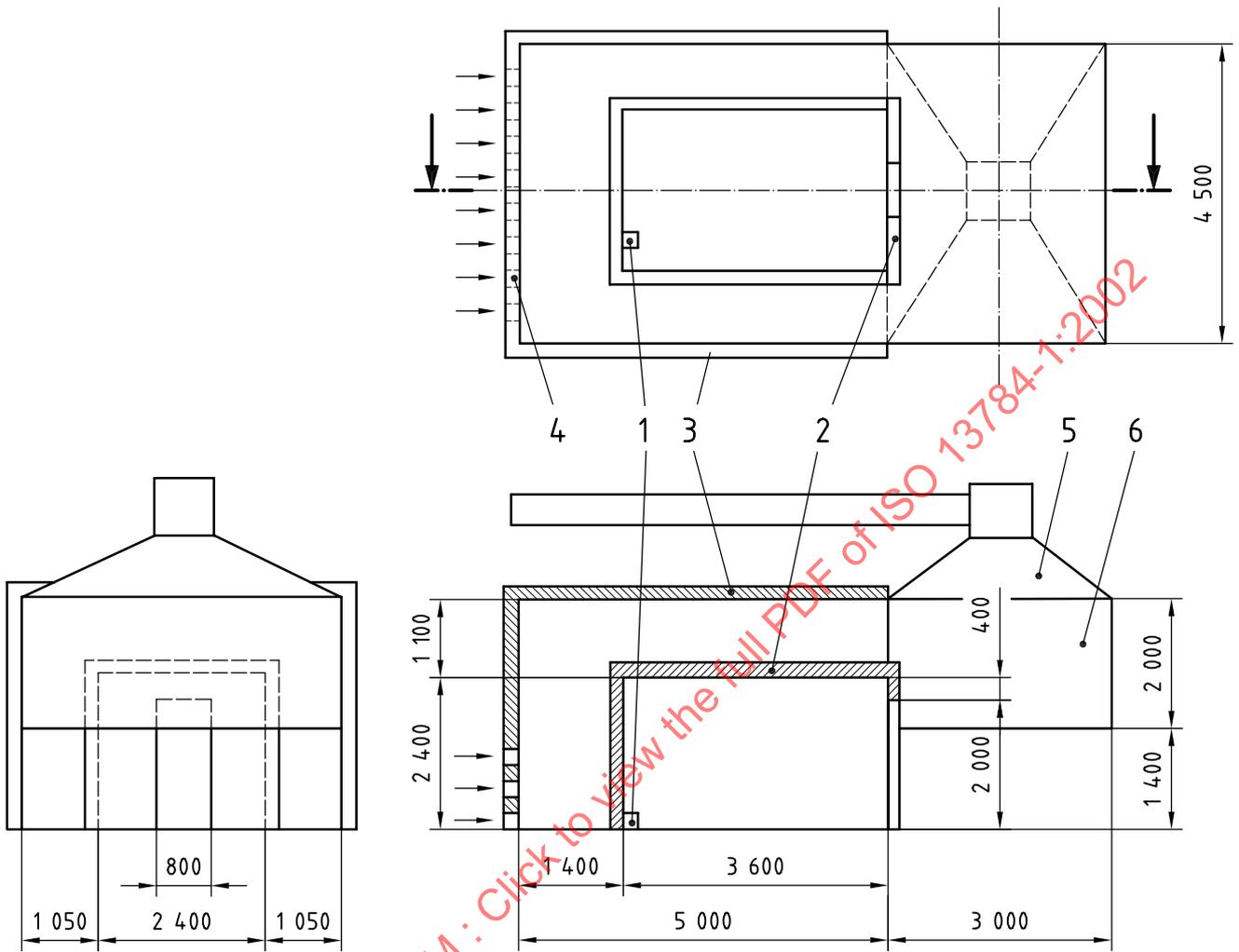


Figure 6 — Example of enlarged hood — Method, 2a)

Dimensions in millimetres



Key

- 1 Burner
- 2 Test specimen
- 3 Enclosure
- 4 Ventilation opening
- 5 Extract hood
- 6 Steel smoke curtains

Figure 7 — Example of ventilated enclosure with enlarged hood — Method, 2b)

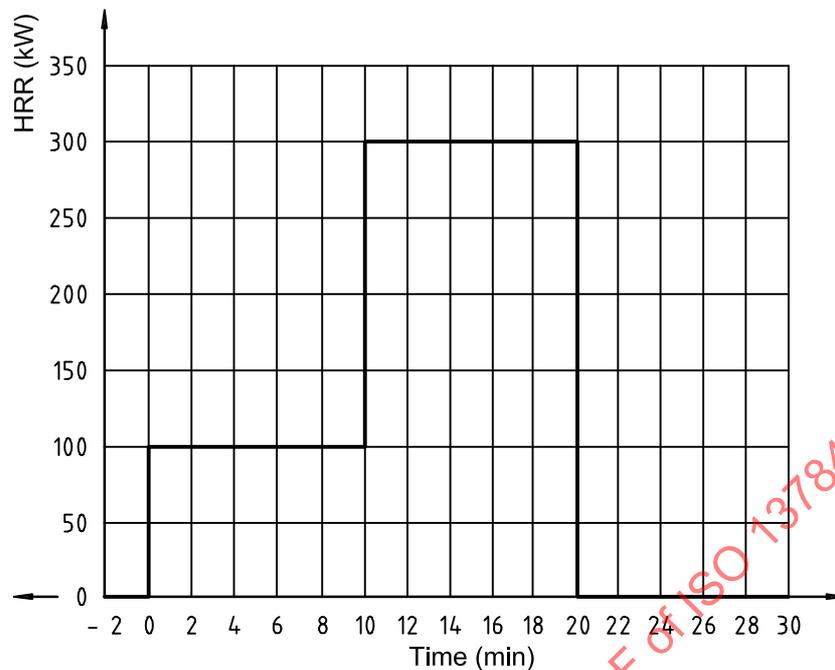


Figure 8 — Burner heat output programme

11.2.4 During the test, record the following observations and the time at which each occurs:

- a) ignition of the specimen;
- b) spread of flame on surface — internal or external — of panels (if any);
- c) openings, cracks, damage or gaps appearing in specimen;
- d) opening joints and flaming from joints;
- e) delamination, falling debris, flaming droplets;
- f) smoke or flames outside room through joints;
- g) smoke intensity and colour (visual);
- h) indications of flame spread through core of specimen (i.e. discoloration of facing panels);
- i) flames emerging through doorway;
- j) flashover;
- k) collapse of structure.

11.2.5 End the test if flashover occurs (i.e. the rate of heat release exceeds 1 000 kW) or after 30 min, whichever is first. The test shall be terminated earlier if structural collapse or other conditions potentially dangerous to the laboratory staff develop. Continue observation until signs of visual combustion have ceased.

11.2.6 Note the extent of damage to the product after testing. Damage shall be clearly reported (extent of delaminations or joint openings or both, extent and depth of char and possibly scorching, cracking, shrinkage, etc.)

11.2.7 Record any other unusual behaviour.

12 Precision

The precision of this test method has yet to be determined. Results of a planned inter-laboratory test series will be included in a future revision of this part of ISO 13784 when these become available.

13 Test report

The test report shall include the following information:

- a) name and address of testing laboratory;
- b) date and identification number of report;
- c) name and address of sponsor;
- d) purpose of test;
- e) method of sampling;
- f) name and address of manufacturer or supplier of product;
- g) name or other identification marks and description of product;
- h) construction and installation details of product, including
 - 1) drawings,
 - 2) descriptions,
 - 3) assembly instructions,
 - 4) specification of included materials, and
 - 5) details of the joints and fixings;
- i) date of supply of product;
- j) date of test;
- k) whether freestanding or frame-supported room construction was used, and reference to this part of ISO 13784;
- l) conditioning of test specimen, environmental data during the test (temperature, atmospheric pressure, relative humidity, etc.);
- m) deviations from test method (if any);
- n) test results, comprising
 - 1) temperatures within the core of the sandwich panel as a function of time in a graph,
 - 2) maximum temperature,
 - 3) illustration (e.g. by pictures) and description of the fire damage,
 - 4) observations during and after test,
 - 5) time/volume flow in the exhaust duct,
 - 6) time/rate of total heat release and time/heat release from burner (specifying the method used — method 1, 2a) or 2b),
 - 7) time/production of carbon monoxide at reference temperature and pressure,
 - 8) time/production of carbon dioxide at reference temperature and pressure, and
 - 9) time/production of light-obscuring smoke at actual duct flow temperature;
- o) designation of product according to criteria expressed in official standards or regulations, where appropriate.

Annex A (normative)

Heat and smoke release measurement procedure in accordance with ISO 9705 — Method 1

A.1 Hood and exhaust duct

The system for collecting the combustion products shall be of sufficient capacity and designed such that all combustion products leaving the fire room through the door opening during a test will be collected. In accordance with Method 1 (see 10.2), the sandwich panel building construction shall be connected to the ISO 9705 hood system. The system shall not disturb the fire-induced flow in the doorway. The exhaust capacity shall be at least $3,5 \text{ m}^3 \cdot \text{s}^{-1}$ at normal pressure and a temperature of $25 \text{ }^\circ\text{C}$. For an example hood and exhaust duct design, see ISO 9705.

A.2 Instrumentation in exhaust duct — Minimum requirements

A.2.1 Volume flow rate

The volume flow rate in the exhaust duct shall be measured to an accuracy of at least $\pm 5 \%$.

The response time to a stepwise change of the duct flow rate shall be a maximum of 1 s at 90 % of the final value.

A.2.2 Gas analysis

A.2.2.1 Sampling line

Gas samples shall be taken in the exhaust duct at a position where the combustion products are uniformly mixed. The sampling line shall be made from an inert material, which will not influence the concentration of the gas species to be analysed.

A.2.2.2 Oxygen

The oxygen consumption shall be measured to an accuracy of at least 0,05 % by volume of oxygen. The oxygen analyser shall have a time constant not exceeding 3 s.

A.2.2.3 Carbon monoxide and carbon dioxide

The gas species shall be measured using analysers having an accuracy of at least $\pm 0,1 \%$ by volume of carbon dioxide and $\pm 0,02 \%$ by volume of carbon monoxide. The analysers shall have a time constant not exceeding 3 s.

A.2.3 Optical density

A.2.3.1 General

The optical density of the smoke shall be determined by measuring the light obscuration with an incandescent lamp photometer. Alternatively, a laser photometer may be used (see annex D). The smoke measuring system shall be such that soot deposits during the test do not reduce the light transmission by more than 5 %.

A.2.3.2 Incandescent lamp photometer

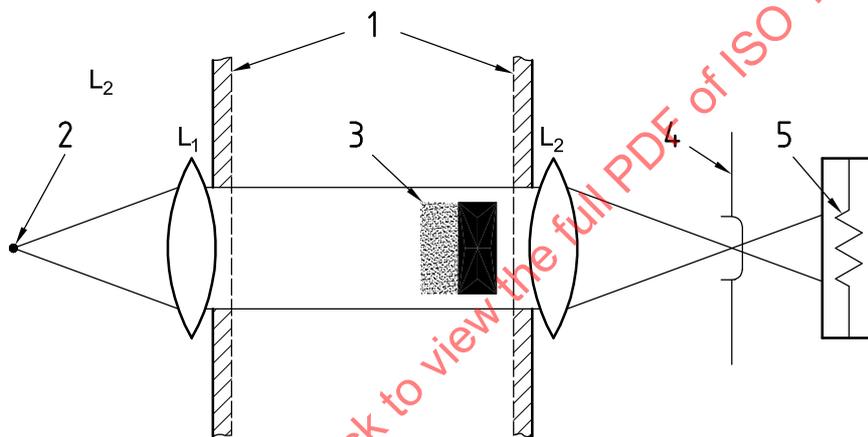
The lamp shall be of the incandescent filament type and shall operate at a colour temperature of $(2\,900 \pm 100)$ K. The lamp shall be supplied with stabilized direct current, stable to within $\pm 0,2\%$ (including temperature, and short-term and long-term stability). The lens system shall align the light to a parallel beam with a diameter, D , of at least 20 mm. The aperture shall be placed at the focus of the lens L_2 as shown in Figure A.1 and shall have a diameter, d , chosen with regard to the focal length, f , of L_2 so that d/f is less than 0,04.

The detector shall have a spectrally distributed responsivity in accordance with the CIE¹⁾, $V(\lambda)$ -function, CIE photopic curves to an accuracy of at least $\pm 5\%$.

The detector output shall be linear within 5 % over an output range of at least 3,5 decades.

A.2.3.3 Location

The light beam shall cross the exhaust duct along its diameter at a position where the smoke is homogenous.



- Key**
- 1 Wall of exhaust duct
 - 2 Lamp
 - 3 Smoke particles
 - 4 Aperture
 - 5 Detector
 - L_1, L_2 Lenses

Figure A.1 — White light optical system

A.3 System performance

A.3.1 Calibration

A calibration test shall be performed prior to each test or continuous series of tests.

NOTE 1 Equations for calculations are given in annex C.

NOTE 2 HRR calibration at levels higher than 300 kW can be performed to decrease the measuring uncertainty, using gas burners or liquid pool fires.

1) Commission Internationale d'Éclairage.

The calibration shall be performed with burner heat outputs in accordance with Table A.1, with the burner positioned directly under the hood. Measurements shall be taken at least every 6 s and shall be started 1 min prior to ignition of the burner. At steady-state conditions, the difference between the mean heat release rate over 1 min, calculated from the measured oxygen consumption, and that calculated from the metered gas input shall not exceed 5 % for each level of heat output.

Table A.1 — Burner heat output profile

Time minimum	Heat output kW
0 to 2	0
2 to 7	100
7 to 12	300
12 to 17	100
17 to 19	0

A.3.2 System response

The time delay for a stepwise change of the heat output from the burner, when placed centrally 1 m below the hood, shall not exceed 20 s and shall be corrected for test data. The time delay shall be determined by measuring the time taken to reach agreement to within 10 % of the final measured heat release value, when advancing through the stepwise procedure given in Table A.1, taking measurements at least every 6 s.

The system shall be checked at various volume flow rates by increasing the volume flow in the exhaust duct in four equal steps, starting from $2 \text{ m}^3 \cdot \text{s}^{-1}$ (at 0,1 MPa and 25 °C) up to maximum. The heat output from the burner shall be 300 kW. The error in the mean heat release rate, calculated over 1 min, shall be not more than 10 % of the actual heat output from the burner.