TECHNICAL SPECIFICATION

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Fire tests — Reduced-scale model box test

Essais au feu — Essai à échelle réduite utilisant une boîte

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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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.

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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/TS 17431 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

Introduction

This Technical Specification is intended to provide a test method for describing the fire behaviour of a product under fire conditions by simulating such fire conditions in a reduced scale under controlled laboratory conditions.

The test method can be used as part of a fire hazard assessment that takes into account all of the factors that are pertinent to an assessment of a particular type of fire hazard.

Fire tests — Reduced-scale model box test

WARNING — So 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 involve high temperatures and combustion processes from ignition to a fully developed fire. Therefore, hazards can exist for burns, ignition of extraneous objects or clothing. It is important that the operators use protective clothing, e.g. helmet, face-shield and equipment for avoiding exposure to toxic gases.

Means for extinguishing a fully developed fire should be available.

1 Scope

This Technical Specification specifies an intermediate-scale test method that simulates a fire that under well-ventilated conditions starts in a corner of a small room with a single doorway and can develop until the room is fully involved in the fire.

The method is primarily intended to evaluate the contribution to toxic hazard in, and potential for fire spread to, evacuation routes connected to the room of origin in which surface products are installed.

The method is especially suitable for products with which a full-scale room test has to be terminated before the full involvement of the room with fire because of the occurrence of flashover or any other safety reasons.

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 9705:1993, *Fire tests — Full-scale room test for surface products*

ISO 13943:2000, *Fire safety — Vocabulary*

3 Definitions

For the purpose of this document, the definitions given in ISO 13943 and the following shall apply.

3.1
exposed surface
surface of the product subjected to the heating conditions of the test

3.2
surface product
any part of a compartment that constitutes an exposed surface on the interior wall, ceiling and/or floor such as panels, tiles, boards, wall papers or coatings

4 Principle

The potential for fire spread to objects outside the room of fire origin is evaluated by the heat release rate and total heat release from the model box.

An indication of the toxic hazard in an evacuation route connected to the room of fire origin is provided by the measurement of specific gases at the doorway of the model box.

5 Combustion chamber

5.1 Dimensions

The combustion chamber (see Figure 1) shall consist of three walls, a ceiling and a floor connected at right angles. The inside dimension of the combustion chamber shall have the following dimensions:

a) length: (1,8 ± 0,01) m;

b) width: (1,1 ± 0,01) m;

c) height: (1,0 ± 0,01) m.

5.2 Front panel

A front wall panel with an opening of the following dimensions (see Figure 1) shall be attached to the opening of the combustion chamber prior to each test. The opening shall be at the centre of the front wall panel and touch the floor.

a) width of the front panel: (1,1 ± 0,01) m;

b) height of the front panel: (1,0 ± 0,01) m;

c) width of the opening: (0,3 ± 0,01) m;

d) height of the opening: (0,67 ± 0,01) m.

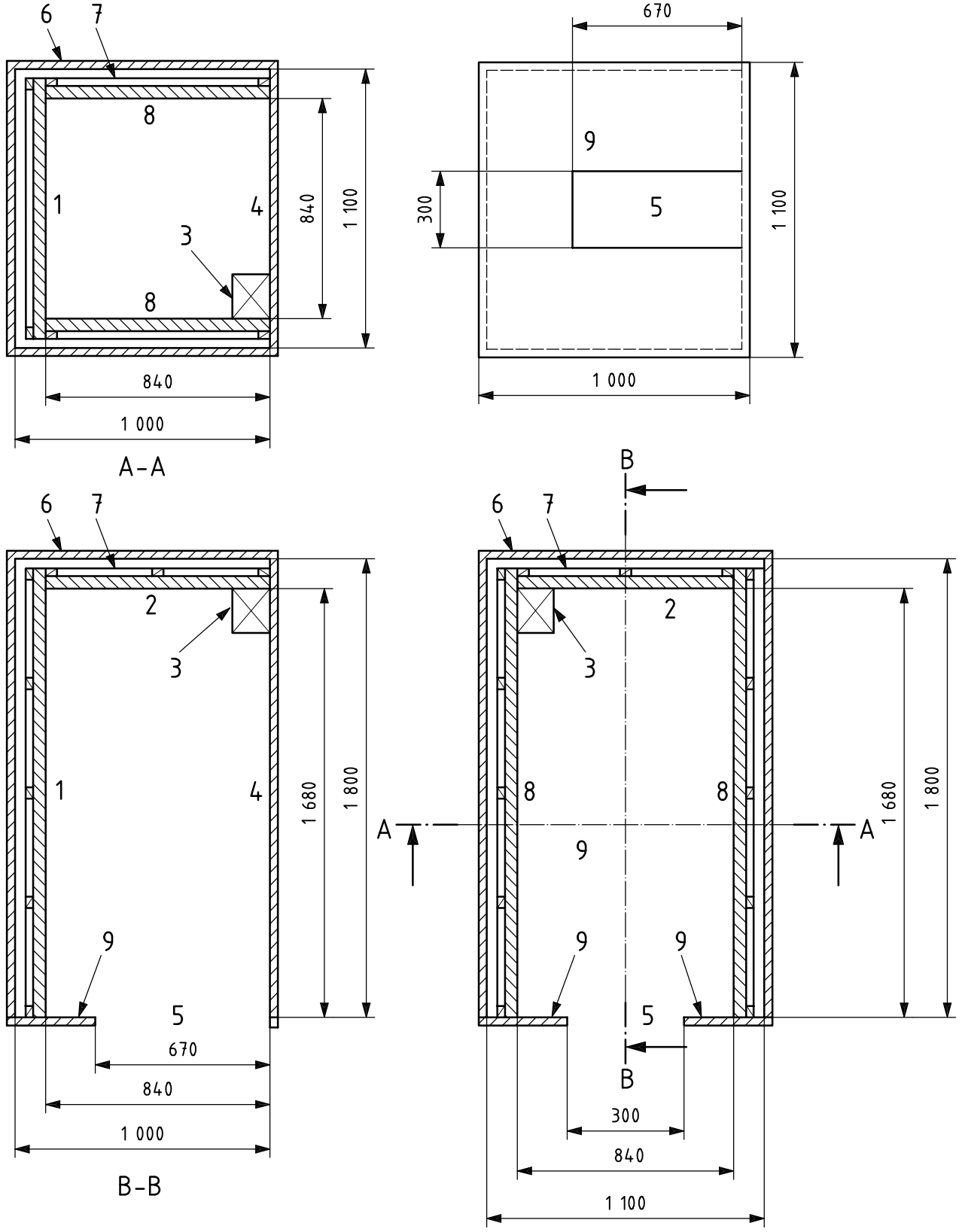
5.3 Material of combustion chamber

The combustion chamber shall be constructed of non-combustible material with a density of (800 ± 100) $kg \cdot m^{-3}$. The thickness of the construction shall be (20 ± 2) mm.

5.4 Installation

The combustion chamber shall be placed in an essentially draught free space, large enough to ensure that there is no influence on the test fire. Hanging the combustion chamber can assist in the measurement of the mass loss and accurate collection of combustion products. An example of a hanging combustion chamber is given in Annex A.

Dimensions in millimetres



Key

1	top panel	4	floor	7	steel sheet (0,27)
2	inner wall	5	opening	8	side wall
3	ignition source	6	combustion chamber	9	front wall panel

Figure 1 — Combustion chamber with specimen panels, front wall panel and ignition source

6 Ignition source

6.1 Design of ignition source

The ignition source shall be a propane gas burner having a 0,17 m × 0,17 m square top surface layer of a porous, inert material, e.g. sand. The construction shall be such that an even gas flow is achieved over the entire opening area. It is recommended that the gas burner described in Annex B be used.

WARNING — All parts and equipment of the burner system such as tubes, couplings, flow meters, etc. shall be of approved type for propane. The installation shall be performed in accordance with existing safety regulations.

The burner should, for reasons of safety, be equipped with a remote control ignition device, for example a pilot flame, electric spark or a glow wire. There should be a warning system for detection of gas leakage in the case of extinction of the flame.

6.2 Fuel

The fuel for the burner shall be of industrial grade propane (95 % purity). The heat release rate of the burner shall be 40 kW during the test period. The fuel gas flow rate to the burner shall be measured with an accuracy of at least ± 3 % and shall be controlled within ± 5 % of the prescribed value of heat output.

7 Measurement at the opening of the combustion chamber for toxicity assessment

The present Clause specifies minimum requirement for the instrumentation attached to the opening of the combustion chamber. Additional information and designs can be found in Annex A.

7.1 Gas analysis

7.1.1 Sampling

The gas shall be sampled at the opening of the combustion chamber at a position where the combustion products flow out above the neutral plate (see Figure A.1). The sampling line shall be made of an inert material that does not influence the concentration of the gas species to be analysed.

7.1.2 Carbon monoxide

The gas concentration shall be measured using an analyser having an accuracy of at least ± 0,02 % by volume for carbon monoxide. The analyser shall have a t_{10} to t_{90} response time of less than 12 s (using a similar procedure to that defined in ISO 5660-1:2002, 10.1).

7.2 Gas temperature

Gas temperature in the immediate vicinity of the gas-sampling probe shall be measured by a thermocouple with a maximum diameter of 0,25 mm.

8 Hood and exhaust duct

The system for collecting the combustion products shall have a capacity and be designed in such a way that all of the combustion products leaving the combustion chamber through the opening during a test are collected. The system shall not disturb the fire-induced flow in the opening. The exhaust capacity shall be at least 2,0 $m^3 \cdot s^{-1}$ at atmospheric pressure and temperature of 25 °C. An example of hood and exhaust duct is shown in Figure A.2.

9 Instrumentation for measurement of gas in the exhaust duct

9.1 General

Clause 9 specifies minimum requirements for the instrumentation for the measurement of the gas in the exhaust duct. Additional information and designs can be found in ISO 9705:1993, Annexes D and E.

9.2 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.

9.3 Gas analyser

9.3.1 Sampling line

The gas in the duct shall be sampled at a position where the combustion products are uniformly mixed. The sampling line shall be made of an inert material which does not influence the concentration of the gas species to be analysed.

9.3.2 Oxygen

The oxygen consumption shall be measured in accordance with ISO 9705. The analyser shall have a t_{10} to t_{90} response time of less than 12 s (using a similar procedure to that defined in ISO 5660-1:2002,10.1.5).

9.3.3 Carbon monoxide and carbon dioxide

The gas species shall be measured using analysers having an accuracy of at least $\pm$ 0,01 % by volume for CO_2 and 0,01 % by volume for CO. The analyser shall have a t_{10} to t_{90} response time of less than 12 s (using a similar procedure to that defined in ISO 5660-1:2002, 10.1.5).

10 System performance

10.1 Calibration

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

The calibration shall be performed with the burner heat profile given in Table 1, with the burner positioned centrally 1 m below the lower edge of the hood. Measurements shall be taken place 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 rate, shall not exceed 3 % for each level of heat output.

Table 1 — Burner output profile

Time min	**Heat output** kW
0 to 2	0
2 to 7	40
7 to 12	100
12 to 17	40
17 to 19	0

10.2 System response

The time delay for a stepwise change of the heat output from the burner, when placed centrally 1 m below the lower edge of the hood, shall not exceed 20 s. This value shall be used in the data analysis. The time delay shall be determined by measuring the time taken from the stepwise change of the gas supply until time that the measured value reaches 90 % of the steady state value.

10.3 Precision

The precision of the system at various volume flow rates in the duct shall be checked by increasing the volume flow rate in the exhaust duct in four equal steps, starting from 0,2 $m^3 \cdot s^{-1}$ (at flow air condition of 0,1 MPa and 25 °C) up to the maximum flow rate as specified in ISO 9705. The heat output from the burner shall be 40 kW. The error in the mean heat release rate, calculated over 1 min, shall not be more than 3 % of the actual heat output from the burner.

NOTE Precision of a similar system in ISO 9705 can give additional information.

11 Preparation of specimen

11.1 General

The product to be tested shall be cut to make four panels supported by a sheet and frames of steel to cover the ceiling, two side walls and the end wall of the inside surfaces of the combustion chamber.

NOTE In the standard specimen configuration, three walls and the ceiling of the combustion chamber are covered with the panels. Additional information and design can be found in Annex C.

11.2 Dimensions

The dimensions of the panels shall be determined so that when the panels are assembled and inserted to the combustion chamber in a way described in 11.1, the specimen has the following inner dimensions:

a) width: (0,84 ± 0,01) m;

b) length: (1,68 ± 0,01) m;

c) height: (0,84 ± 0,01) m.

11.3 Board type products

Where the product to be tested is a board type, the normal width, length and thickness of the board shall be used as far as practicable.

11.4 Thin products or thermoplastic products

Thin surface products, such as paints and varnishes or thermoplastic products that may melt during the test, shall, depending on their end use, be applied to one of the following substrates;

a) non-combustible fibre-reinforced silicate board having a dry density of (680 ± 50) $kg \cdot m^{-3}$;

b) non-combustible board having a dry density of (1 650 ± 150) $kg \cdot m^{-3}$;

c) chipboard (particle board) having a density of (680 ± 50) $kg \cdot m^{-3}$ after conditioning in an atmosphere of (50 ± 5) % relative humidity at a temperature of (23 ± 2) °C;

d) gypsum board having a density of $(725 \pm 50)\ kg \cdot m^{-3}$ after conditioning in an atmosphere of (50 ± 5) % relative humidity at a temperature of (23 ± 2) °C;

e) actual substrate, if its thermal properties differ significantly from those mentioned in a) to d) above, for example, steel or mineral wool.

The boards comprising the material and the substrate shall be applied to the steel panels made of steel frames and sheet as specified in 11.5.

NOTE Suitable thickness of the substrates a) to d) is 9 mm to 13 mm.

11.5 Mounting to steel panel

Unless specifically provided otherwise, the product or product with substrate shall be fixed to panels made of "C" shaped steel frames (section dimension of 40 mm × 40 mm) and steel sheet (nominal thickness 0,27 mm) with steel nails at an interval of $(0{,}15 \pm 0{,}01)$ m.

NOTE If the surfaces of the specimen panels are marked with lines which form grids of 0,1 m × 0,1 m squares, the marking can help in determining the extent of flame spread.

11.6 Conditioning

Unless the product is non-hydroscopic, the specimen (products mounted on steel panel) shall be conditioned in an atmosphere of (50 ± 5) % relative humidity at a temperature of (23 ± 2) °C until a representative piece of the specimen has reached constant mass.

Constant mass is considered to be reached when two successive weighing operations, carried out at an interval of 24 h, do not differ by $> 0{,}1$ % from the initial mass of the panel.

NOTE For wood based products and products in which vaporization of solvents can occur, conditioning time of at least four weeks can be required.

11.7 Assembling into combustion chamber

The product mounted on the steel panels shall be assembled with steel nails to form a combination of a ceiling, two side walls and an end wall. The assembled specimen panels shall then be inserted into the combustion chamber through the front opening. The front opening shall then be covered with the front wall specified in 5.2.

NOTE In the standard specimen configuration, the three walls and the ceiling of the combustion chamber are covered with the panels. Additional information and designs can be found in Annex C.

12 Testing

12.1 Initial conditions

12.1.1 The temperature in the combustion chamber and the surrounding area shall be within (20 ± 10) °C during installation and testing.

The time between the removal of the specimen panels from the conditioning room and the start of the test should be kept to a minimum.

12.1.2 The horizontal wind speed measured at a horizontal distance of approximately 1 m from the centre of the opening of the combustion chamber shall not exceed 0,5 $(m \cdot s^{-1})$.

12.1.3 The burner shall be placed on the floor in a corner opposite the front panel in the combustion chamber. The burner shall be in contact with the side wall, specimen surface and the rear wall specimen surface.

12.2 Test procedures

12.2.1 The specimen shall be photographed or video filmed before and during the test. A clock shall appear in all photographic records, giving time to the nearest 1 s.

12.2.2 Start all recording and measuring devices and record data for at least 2 min prior to ignition of the burner. Volume flow rate and concentration of gas species shall be measured every 6 s or less.

12.2.3 Ignite the burner. Adjust the burner to the output level of 40 kW as specified in 6.2 within 10 s of ignition of the burner.

12.2.4 Continuously adjust the exhaust capacity so that all of the combustion products are collected.

12.2.5 During the test, record the following observations, including the time when they occur:

a) ignition of the ceiling;

b) flame spread on wall and ceiling surfaces;

c) change of the heat output from the burner;

d) flames emerging through the opening.

12.2.6 End the test after 15 min. Observation should be continued until all signs of visual combustion have ceased.

12.2.7 Record the extent of damage of the specimen after the test.

12.2.8 Record any other unusual behaviour.

12.2.9 Calculate volume flow rate in the exhaust duct, heat release rate and gas production rate based on Annex F of ISO 9705:1993.

13 Test report

The test report shall contain the following information:

a) name and address of the testing laboratory;

b) identification number and date of issue of the report;

c) name and address of the client;

d) purpose of the test;

e) method of sampling;

f) name of manufacturer or supplier of the product;

g) name or other identification marks and description of the product;

h) density or mass per unit area and thickness of the product;

i) date of supply of the product;

j) description of the specimen and mounting technique;

k) conditioning of the specimen;

l) date of test;

m) test method;

n) test results (see ISO 9705:1993, Annex F):

   1) time/volume flow rate in the exhaust duct,

   2) time/heat release rate, and time/heat release rate from the burner if the latter is included in the former,

   3) time/concentration by volume of carbon monoxide at the opening of the combustion chamber,

   4) time/production rate of carbon monoxide at reference temperature and pressure,

   5) time/production rate of carbon dioxide at reference temperature and pressure,

   6) description of the fire development (photographs),

   7) calibration results according to 10.1;

o) Additional test results, if measured (see Annex A).

Annex A
(informative)

Instrumentation of combustion chamber

A.1 Heat flux

To evaluate the potential for fire spread to other objects in the room, remote from the ignition source, total heat flux may be measured at the centre of the floor. The heat flux meter should be of Schmidt-Boelter (thermopile) or Gardon (foil) type with a design range of about 100 kW/m^2. The target area should be a flat black surface having a view angle of 180°. The heat flux meter should have an accuracy of at least ± 3 % and repeatability within ± 5 %. In operation, the heat flux meter should be maintained at a constant temperature within ± 5 K and above the dew point. The heat flux meter should be mounted at the geometric centre of the floor of the combustion chamber. The target surface of the heat flux meter should project over the floor surface by 5 mm to 30 mm. No window or filter should be put on the target surface. The calibration of the heat flux meter should be checked whenever required, by comparison with two instruments held as reference standard heat flux meter that are not used for any other purpose. One of the reference standard heat flux meter should be fully calibrated at yearly intervals.

A.2 Gas temperature

If the vertical gas temperature profile inside the combustion chamber is known, a technique is available to compute ingoing and outgoing gas flow through the opening. To minimize gas-temperature measurement errors, the measurement should be made with suction pyrometers or very thin thermocouples (e.g. 0,05 ± 0,01 mm in diameter).

A.3 Surface temperature

If it is required to follow the ignition and the growth of flame spread over the specimen, surface thermocouples may be mounted on the specimen. Measurement of surface temperature can also be useful in making a heat balance study of the tested product.

A.4 Flow through opening

A.4.1 Mass flow through the opening

Mass flow through the opening can be measured by bi-directional probes as specified in ISO 9705:1993, Clause D.1. The gas temperature in the vicinity of the gas-sampling probe at the opening should be measured by a suction pyrometer or very thin thermocouples (e.g. 0,05 mm in diameter). The pressure difference over the two taps of the probe should be measured by a pressure transducer which has a resolution of 0,05 Pa. It is recommended that the transducer be of the capacitance type. A suitable range for the measurement is 0 Pa to 25 Pa.

A.4.2 Mass flow rate

Mass flow rate per unit area, $\dot{m}''$, expressed in (kg·m^{-2}·s^{-1}), is calculated from Equations (A.1) and (A.2):

$$\dot{m}'' = \rho_s v = \frac{\rho_s}{k_p} \cdot \left(\frac{2\Delta P}{\rho_s} \right)^{1/2} \qquad \text{(A.1)}$$

$$= \frac{1}{k_p}\left(\frac{2\Delta P \rho_o T_o}{T_s}\right)^{1/2} \quad \text{(A.2)}$$

where

ρ_s is the density of gas at point of measurement, expressed in kg·m^{-3};

v is the gas velocity, expressed in m·s^{-1};

k_p is the Reynolds number correction for the bi-directional probe;

ΔP is the measured pressure differential, expressed in Pa;

ρ_o is the air density at 0 °C and 0,1 MPa, expressed in kg·m^{-3};

T_o = 273,15 K;

T_s is the gas temperature at point of measurement, expressed in K.

NOTE If k_p is put equal to 1,08, the maximum error will be approximately 7 % down to velocities of 0,3 m s^{-1}. For lower velocities the relative error increases.

Total mass flow, m_{out}, out of the room is obtained by integrating over the width of the opening and that part of the opening above the neutral plane of gas flow at the opening. It is essential that the position of the neutral plane be either measured or calculated as a function of time.

A.4.3 Convective heat flow

Convective heat flow rate per unit area, Q'', expressed in kW·m^{-2}, out of the opening is calculated from Equation (A.3):

$$\dot{Q}'' = \dot{m}'' C_p (T_s - T_i) \quad \text{(A.3)}$$

where

$\dot{m}''$ is the rate of mass flow per unit area, expressed in kg·m^{-2}·s^{-1};

C_p is the specific heat of the combustion gases, expressed in kJ·kg^{-1}·K^{-1} (approximately 1,0);

T_s is the temperature of gas flow, expressed in K;

T_i is the ambient temperature, expressed in K.

A.4.4 Gas flow pattern

In order to map the gas flow pattern in the opening adequately, at least six bi-directional probes should be installed at equal vertical height. The accuracy of the probe should be ± 2,5 %. A rough estimation of the rate of gas flow can be obtained with three probes located at 50 mm, 350 mm and 600 mm from the floor of the combustion chamber. All the probes should be centrally located in a vertical plane through the middle of the opening, where the flow is essentially horizontal.

A.5 Combustion gas analyser

Suitable location for the sampling probes is given in Figure A.1. Information for gas analysers is given in ISO 9705.

The sampling probe should have a cylindrical form so that disturbance of flow is minimized and should be located where the combustion products are projected and no ambient air is entrained.

The sampling line should be manufactured from non-corrosive inert material, e.g. PTFE. The combustion gases should be filtered with inert filters to remove particles that would damage the gas analysers or lead to measurement inaccuracies. The filtering procedures should be carried out in more than one step. The gas mixture should be cooled to a maximum temperature of 10 °C.

For gases other than CO, CO_2 and O_2, heated sampling lines (150 °C to 175 °C) should be used. The sampling lines should be as short as possible and the gases should not be filtered (see also ISO 9705:1993, D.3.3 and D.3.4).

The combustion gas should be transported by a pump that does not emit oil, grease or similar products, which can contaminate the gas mixture.

NOTE A membrane pump has been found to be suitable.

The sampling line should end in an open container at atmospheric pressure. The volume of the container should not be so large that concentration gradients or time lags are generated. Transport time in the sampling line should not exceed 1 s. A suitable pump should have the capacity of 0,01 $m^3 \cdot min^{-1}$ to 0,02 $m^3 \cdot min^{-1}$, as each gas analysis instrument requires about 0,001 ($m^3 \cdot min^{-1}$). The pump should generate a pressure differential of at least 10 kPa to reduce the risk of smoke clogging of the filters. The intake of the sampling probe is turned downstream in order to avoid soot clogging in the probe.

A.6 Radiation through opening

A heat flux meter as specified in Clause A.1 can be located in the geometrical centre of the opening to measure the radiation through the opening.

A.7 Mass loss and combustion chamber hanger

Hanging the combustion chamber with its opening beneath the hood can help mass loss measurement and ensuring collection of combustion products by the hood. An example of a hanging combustion chamber is shown in Figure A.2.

A ring hook is connected in the vicinity of each of the four edges of the upper panel of the combustion chamber. The combustion chamber is to be hung by a crane or a suitable device beneath the ceiling with steel wires. When hanging the combustion chamber, it should be confirmed that the front panel of the combustion chamber is located beneath the hood and the floor of the combustion chamber is kept horizontal. Keeping the top panel in contact with a lower edge of the hood should be useful for preventing the leak of combustion products out of the hood. A load cell is installed between the crane and the steel wires for mass-loss measurement. In order to minimize the effect of external force from loading to the combustion chamber during the test, the ignition source should be connected to the fuel source by a suitable flexible tube. Load cell output should be calibrated prior to each test after hanging the combustion chamber and connecting the fuelling tube of the ignition source to a fuel source.

It should be noted that a rapid change of gas temperature in the combustion chamber can influence the mass-loss measurement. Change of the total mass of the combustion chamber, Δm, due to the change of gas temperature in Kelvin (K) from T_1 to T_2, expressed in kilograms, can be estimated from the Equation (A.4):

$$\Delta m = V\rho_0 \, (T_0/T_2 - T_0/T_1) \qquad \text{(A.4)}$$

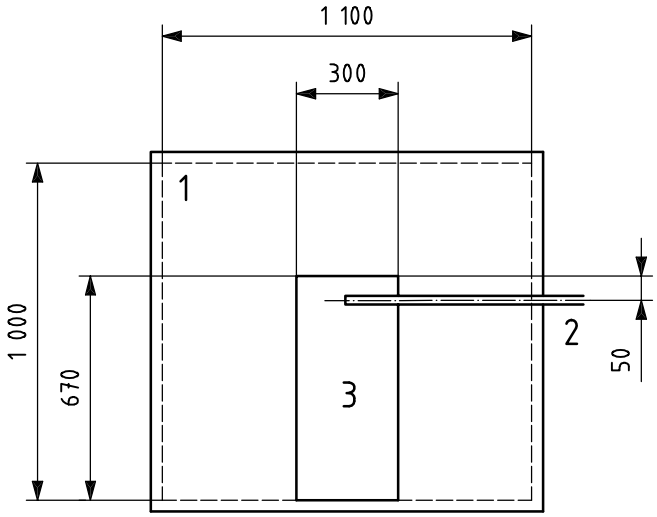
where

V is the volume of air, expressed in cubic metres, surrounded by the specimen panels and is 1,19 m^3 if the combustion chamber and the specimen are fabricated and assembled appropriately;

ρ_0 is the air density at 0 °C and 0,1 MPa, expressed in kilograms per cubic metre ($kg \cdot m^{-3}$);

$T_0 = 273{,}15$ K.

Dimensions in millimetres

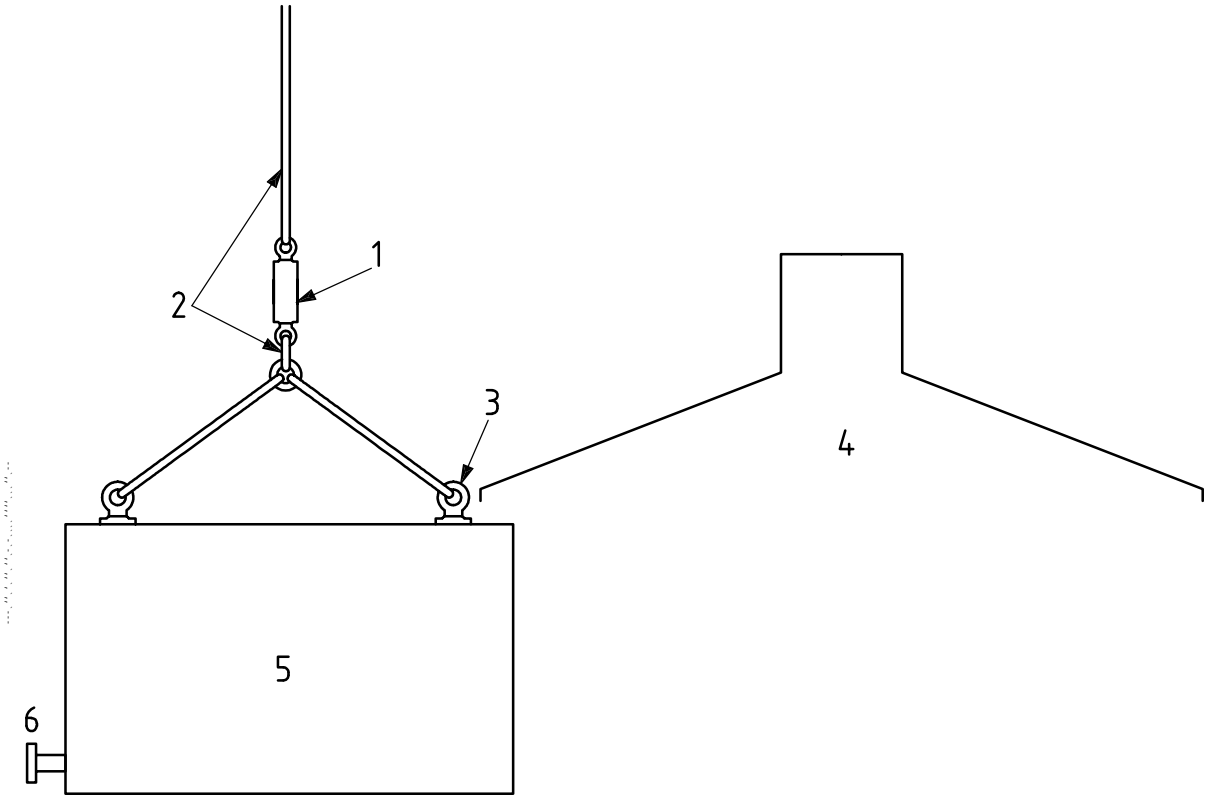


Key

1 front wall panel
2 sampling tube
3 opening

Figure A.1 — Location for the gas sampling on the opening

Dimensions in millimetres



Key

1 load cell
2 steel wire
3 ring hook
4 hood
5 combustion chamber
6 tube inlet

Figure A.2 — Combustion chamber hanger and load cell

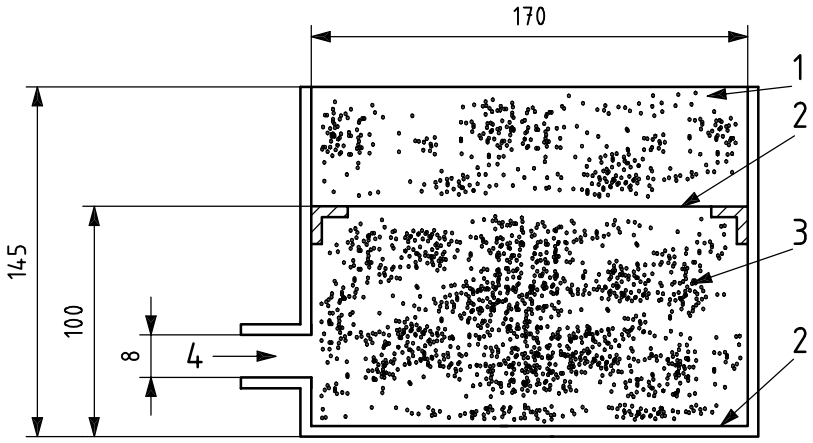
Annex B
(informative)

Recommended ignition source

An example of suitable design of the ignition source is shown in Figure B.1, which is similar to the standard ignition source specified in ISO 9705. The burner is filled with gravel of size of 4 mm to 8 mm and sand of size of 2 mm to 3 mm. Metal gauzes stabilize the two layers; the top gauze is of mesh size of 1,4 mm and the bottom gauze is of mesh size of 2,8 mm. The upper layer of sand should be level with the upper edge of the burner.

NOTE Beads of glass, ceramic or other inert material of appropriate size can replace the gravel and sand as long as injection of gas is achieved. Sand is preferable for testing thermally dripping products.

Dimensions in millimetres



Key

1 sand
2 brass wire gauze
3 gravel
4 gas inlet

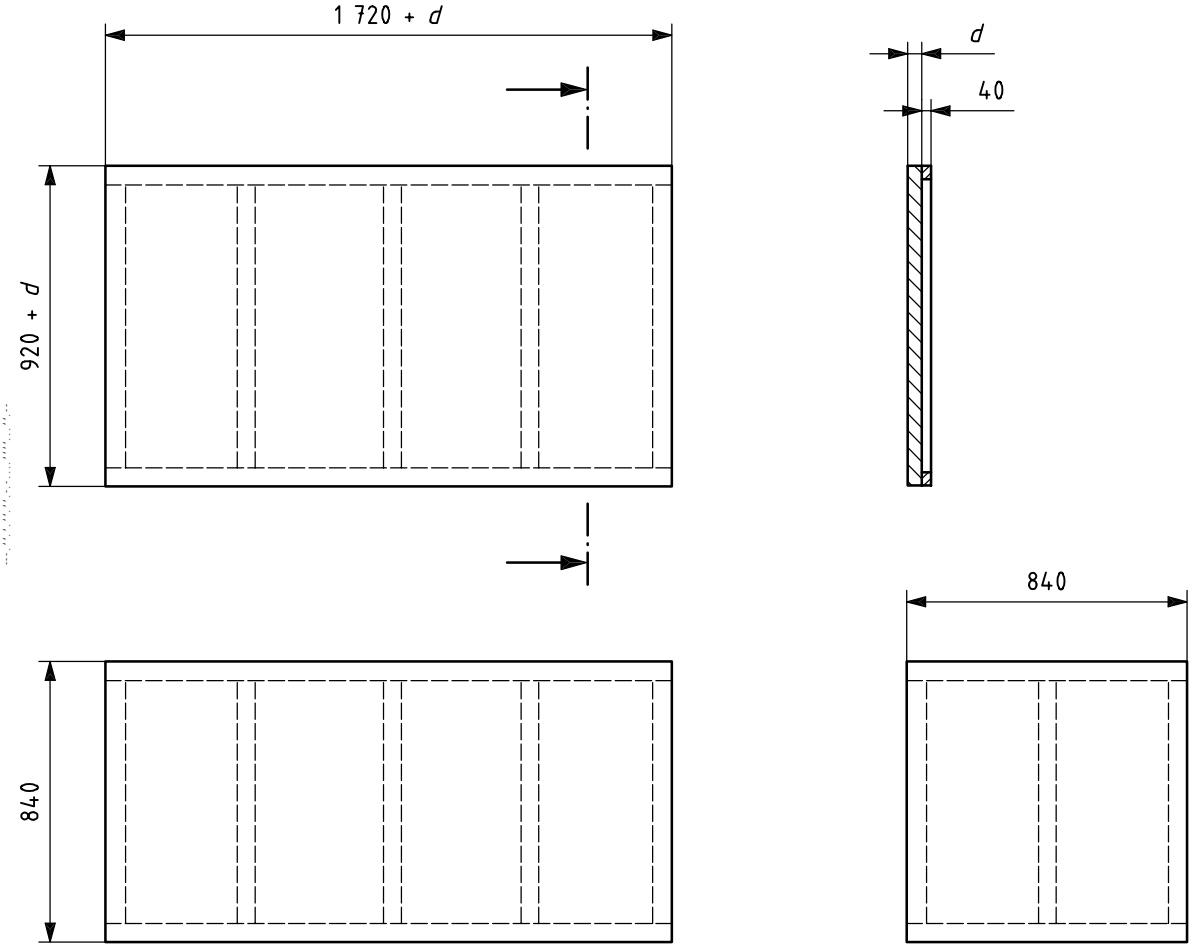
Figure B.1 — Recommended ignition source

Annex C
(informative)

Preparation of specimen

In order to assemble the panels of the product to be tested with the inner dimensions of the test specimen specified in 11.2, it is recommended that the product be cut into pieces slightly larger that the specified inner dimensions of the combustion chamber. Figure C.1 is an example of the design of the test specimen. The top panel (ceiling) is (0,92 + 2d) m wide and (1,72 + d) m long, where d is the total thickness of the specimen and substrate. The sidewall panels should be 0,84 m high and (1,72 + d) m long. The end wall is 0,84 m wide and 0,84 m high. The purpose of installation of a steel sheet behind the specimen panel is to reduce thermal impact on the combustion chamber during a test.

Dimensions in millimetres



Key

1 steel frames
2 steel sheet
3 specimen

Figure C.1 — Principal design of specimen panels

Bibliography

[1] ISO 5660-1:2002, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method)*

ICS 13.220.40; 13.220.50

Price based on 17 pages