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Reaction-to-fire tests — Heat release, smoke production and mass loss rate —

Part 1: Heat release rate (cone calorimeter method)

Essais de réaction au feu — Débit calorifique, taux de dégagement de fumée et taux de perte de masse —

Partie 1: Débit calorifique (méthode au calorimètre conique)

Reference number
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Contents

Annexes

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 5660 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 5660-1 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

This second edition cancels and replaces the first edition (ISO 5660-1:1993), which has been technically revised.

ISO 5660 consists of the following parts, under the general title *Reaction-to-fire tests — Heat release, smoke production and mass loss rate*:

- *Part 1: Heat release rate (cone calorimeter method)*
- *Part 2: Smoke production rate (dynamic measurement)*
- *Part 3: Guidance on heat and smoke release rate*

Annexes A, B, C, D, E and F of this part of ISO 5660 are for information only.

Reaction-to-fire tests — Heat release, smoke production and mass loss rate —

Part 1:
Heat release rate (cone calorimeter method)

1 Scope

This part of ISO 5660 specifies a method for assessing the heat release rate of a specimen exposed in the horizontal orientation to controlled levels of irradiance with an external igniter. The heat release rate is determined by measurement of the oxygen consumption derived from the oxygen concentration and the flow rate in the combustion product stream. The time to ignition (sustained flaming) is also measured in this test.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 5660. 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 5660 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 554:1976, *Standard atmospheres for conditioning and/or testing — Specifications*

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 part of ISO 5660, the terms and definitions given in ISO 13943 and the following apply.

3.1
essentially flat surface
surface whose irregularity from a plane does not exceed ±1 mm

3.2
flashing
existence of flame on or over the surface of the specimen for periods of less than 1 s

3.3
ignition
onset of sustained flaming as defined in 3.10

3.4
irradiance
⟨at a point on a surface⟩ quotient of the radiant flux incident on an infinitesimal element of surface containing the point, and the area of that element

NOTE Convective heating is negligible in the horizontal specimen orientation. For this reason, the term “irradiance” is used instead of “heat flux” throughout this part of ISO 5660 as it best indicates the essentially radiative mode of heat transfer.

3.5
material
single substance or uniformly dispersed mixture

EXAMPLE Metal, stone, timber, concrete, mineral fibre and polymers.

3.6
orientation
plane in which the exposed face of the specimen is located during testing, with either the vertical or horizontal face upwards

3.7
oxygen consumption principle
proportional relationship between the mass of oxygen consumed during combustion and the heat released

3.8
product
material, composite or assembly about which information is required

3.9
specimen
representative piece of the product which is to be tested together with any substrate or treatment

NOTE For certain types of product, for example products that contain an air gap or joints, it may not be possible to prepare specimens that are representative of the end-use conditions (see clause 7).

3.10
sustained flaming
existence of flame on or over the surface of the specimen for periods of over 10 s

3.11
transitory flaming
existence of flame on or over the surface of the specimen for periods of between 1 s and 10 s

4 Symbols

See Table 1.

Table 1 — Symbols and their designations

Symbol	Designation	Unit
A_s	Initially exposed surface area of the specimen	m^2
C	Orifice flow meter calibration constant	$m^{1/2} \cdot g^{1/2} \cdot K^{1/2}$
Δh_c	Net heat of combustion	$kJ \cdot g^{-1}$
$\Delta h_{c,eff}$	Effective net heat of combustion	$MJ \cdot kg^{-1}$
m	Mass of the specimen	g
Δm	Total mass loss	g
m_f	Mass of the specimen at the end of the test	g
m_s	Mass of the specimen at sustained flaming	g
$\dot{m}_{A,10-90}$	Average mass loss rate per unit area between 10 % and 90 % of mass loss	$g \cdot m^{-2} \cdot s^{-1}$
m_{10}	Mass of the specimen at 10 % of total mass loss	g
m_{90}	Mass of the specimen at 90 % of total mass loss	g
$\dot{m}$	Mass loss rate of specimen	$g \cdot s^{-1}$

Table 1 — Symbols and their designations (*continued*)

Symbol	Designation	Unit
$\dot{m}_e$	Mass flow rate in exhaust duct	$kg \cdot s^{-1}$
Δp	Orifice meter pressure differential	Pa
$\dot{q}$	Heat release rate	kW
$\dot{q}_A$	Heat release rate per unit area	$kW \cdot m^{-2}$
$\dot{q}_{A,max}$	Maximum value of the heat release rate per unit area	$kW \cdot m^{-2}$
$\dot{q}_{A,180}$	Average heat release rate per unit area over the period starting at t_{ig} and ending 180 s later	$kW \cdot m^{-2}$
$\dot{q}_{A,300}$	Average heat release rate per unit area over the period starting at t_{ig} and ending 300 s later	$kW \cdot m^{-2}$
$Q_{A,tot}$	Total heat released per unit area during the entire test	$MJ \cdot m^{-2}$
r_o	Stoichiometric oxygen/fuel mass ratio	1
t	Time	s
t_d	Delay time of the oxygen analyser	s
t_{ig}	Time to ignition (onset of sustained flaming)	s
Δt	Sampling time interval	s
t_{10}	Time at 10 % of total mass loss	s
t_{90}	Time at 90 % of total mass loss	s
T_e	Absolute temperature of gas at the orifice meter	K
X_{O_2}	Oxygen analyser reading, mole fraction of oxygen	1
$X^0_{O_2}$	Initial value of oxygen analyser reading	1
$X^1_{O_2}$	Oxygen analyser reading, before delay time correction	1

5 Principle

This test method is based on the observation that, generally, the net heat of combustion is proportional to the amount of oxygen required for combustion. The relationship is that approximately $13{,}1 \times 10^3$ kJ of heat are released per kilogram of oxygen consumed. Specimens in the test are burned under ambient air conditions, while being subjected to a predetermined external irradiance within the range of 0 kW/m^2 to 100 kW/m^2 and measurements are made of oxygen concentrations and exhaust gas flow rates.

The test method is used to assess the contribution that the product under test can make to the rate of evolution of heat during its involvement in fire. These properties are determined on small representative specimens.

6 Apparatus

A schematic representation of the apparatus is given in Figure 1. The individual components are described in detail in 6.1 to 6.5.

With minor modifications to the apparatus, specimens may be tested in the vertical orientation. Annex D gives guidance on these modifications.

6.1 Cone-shaped radiant electrical heater

The active element of the heater shall consist of an electrical heater rod, capable of delivering 5 000 W at the operating voltage, tightly wound into the shape of a truncated cone (see Figure 2). The heater shall be encased on the outside with a double-wall stainless-steel cone, filled with a refractory fibre blanket of nominal thickness 13 mm and nominal density 100 kg/m^3. The irradiance from the heater shall be maintained at a preset level by controlling the average temperature of three thermocouples (type K stainless-steel sheathed thermocouples have proved suitable but Inconel or other high-performance materials are also acceptable), symmetrically positioned and in contact with, but not welded to, the heater element (see Figure 2). Either 3,0 mm outside diameter sheathed thermocouples with

exposed hot junction or 1,0 mm to 1,6 mm outside diameter sheathed thermocouples with unexposed hot junction shall be used. The heater shall be capable of producing irradiance on the surface of the specimen of up to 100 kW/m^2. The irradiance shall be uniform within the central 50 mm $\times$ 50 mm area of the exposed specimen surface, to within $\pm$ 2 %.

6.2 Radiation shield

The cone heater shall be provided with a removable radiation shield to protect the specimen from the irradiance prior to the start of a test. The shield shall be made of non-combustible material, with a total thickness not exceeding 12 mm. The shield shall be one of the following, either

a) water-cooled and coated with a durable matt black finish of surface emissivity $\epsilon = 0{,}95 \pm 0{,}05$, or

b) not water-cooled, which may be either metal with a reflective top surface or ceramic in order to minimize radiation transfer.

The shield shall be equipped with a handle or other suitable means for quick insertion and removal. The cone heater base plate shall be equipped with a mechanism for moving the shield into position.

6.3 Irradiance control

The irradiance control system shall be properly tuned so that it maintains the average temperature of the heater thermocouples during the calibration described in 10.1.2 at the preset level to within $\pm$ 10 °C.

6.4 Weighing device

The weighing device shall have an accuracy of $\pm$ 0,1 g or better, measured according to the calibration procedure described in 10.2.2. The weighing device shall be capable of measuring the mass of specimens of at least 500 g. The weighing device shall have a 10 % to 90 % response time of 4 s or less, as determined according to the calibration described in 10.1.3. The output of the weighing device shall not drift by more than 1 g over a 30-min period, as determined with the calibration described in 10.1.4.

6.5 Specimen holder

The specimen holder is shown in Figure 3. The specimen holder shall have the shape of a square pan with an opening of (106 ± 1) mm $\times$ (106 ± 1) mm at the top, and a depth of (25 ± 1) mm. The holder shall be constructed of stainless steel with a thickness of $(2{,}4 \pm 0{,}15)$ mm. It shall include a handle to facilitate insertion and removal, and a mechanism to ensure central location of the specimen under the heater and proper alignment with the weighing device. The bottom of the holder shall be lined with a layer of low density (nominal density 65 kg/m^3) refractory fibre blanket with a thickness of at least 13 mm. The distance between the bottom surface of the cone heater and the top of the specimen shall be adjusted to be (25 ± 1) mm, except for dimensionally unstable materials for which the distance shall be (60 ± 1) mm (see 7.5).

6.6 Retainer frame

The frame shall be constructed of stainless steel with a thickness of $(1{,}9 \pm 0{,}1)$ mm, in the shape of a box with an inside dimension of each side (111 ± 1) mm and a height of (54 ± 1) mm. The opening for the specimen face shall be $(94{,}0 \pm 0{,}5)$ mm square as shown in Figure 4. The retainer frame shall have an appropriate means to secure it to the specimen holder with a specimen in position.

6.7 Exhaust gas system with flow measuring instrumentation

The exhaust gas system shall consist of a centrifugal exhaust fan rated for the operating temperatures, a hood, intake and exhaust ducts for the fan, and an orifice plate flow meter (see Figure 5). The distance between the bottom of the hood and the specimen surface shall be (210 ± 50) mm. The exhaust system shall be capable of developing flows up to 0,024 m^3/s, under standard conditions of temperature and pressure. The recommended location of the fan is indicated on Figure 5. As an alternative, it is acceptable to locate the fan further downstream and to have the measuring orifice before the fan, provided that the requirements described in the remainder of this clause are fulfilled.

A restrictive orifice with an internal diameter of (57 ± 3) mm shall be located between the hood and the duct to promote mixing.

A ring sampler shall be located in the fan intake duct for gas sampling, (685 ± 15) mm from the hood (see Figure 5). The ring sampler shall contain 12 small holes with a diameter of $(2{,}2 \pm 0{,}1)$ mm, to average the stream composition, with the holes facing away from the flow to avoid clogging with soot.

The temperature of the gas stream shall be measured using a 1,0 mm to 1,6 mm outside diameter sheathed-junction thermocouple or a 3 mm outside diameter exposed-junction thermocouple positioned in the exhaust stack on the centreline and (100 ± 5) mm upstream from the measuring orifice plate.

The flow rate shall be determined by measuring the differential pressure across a sharp edge orifice [internal diameter (57 ± 3) mm, thickness $(1{,}6 \pm 0{,}3)$ mm] in the exhaust stack, at least 350 mm downstream from the fan, if the latter is located as shown on Figure 5. If the fan is located further downstream than indicated in Figure 5, it is acceptable to locate the orifice plate between the ring sampler and the fan. However, in that case the length of the straight duct section on both sides of the orifice plate shall be at least 350 mm.

6.8 Gas sampling apparatus

The gas sampling apparatus shall incorporate a pump, a filter to prevent entry of soot, a cold trap to remove most of the moisture, a by-pass system set to divert all flow except that required for the gas analysers, a further moisture trap and a trap for CO_2 removal. A schematic view of an example of the gas sampling apparatus is shown in Figure 6. Other arrangements which satisfy the requirements may be used. The transport delay time of the oxygen analyser, t_d, shall be determined according to 10.1.5, and shall not exceed 60 s.

NOTE If an (optional) CO_2 analyser is used, the equations to calculate the heat release rate can be different from those for the standard case (see clause 12 and annex F).

6.9 Ignition circuit

External ignition is accomplished by a spark plug powered from a 10 kV transformer or spark igniter. The spark plug shall have a gap of $(3{,}0 \pm 0{,}5)$ mm. The electrode length and location of the spark plug shall be such that the spark gap is located (13 ± 2) mm above the centre of the specimen, except for dimensionally unstable materials for which the distance shall be (48 ± 2) mm (see 7.5).

6.10 Ignition timer

The ignition timer shall be capable of recording elapsed time to the nearest second and shall be accurate to within 1 s in 1 h.

6.11 Oxygen analyser

The oxygen analyser shall be of the paramagnetic type, with a range of at least 0 % oxygen to 25 % oxygen. The analyser shall exhibit a drift of not more than 50 parts per million of oxygen over a period of 30 min, and a noise of not more than 50 parts per million of oxygen during this 30-min period, as measured according to 10.1.6. Since oxygen analysers are sensitive to stream pressures, the stream pressure shall be regulated (upstream of the analyser) to minimize flow fluctuations, and the readings from the analyser compensated with an absolute pressure transducer to allow for atmospheric pressure variations. The analyser and the absolute pressure transducer shall be located in an isothermal environment. The temperature of the environment shall be maintained to within 2 °C of a preset value between 30 °C and 70 °C. The oxygen analyser shall have a 10 % to 90 % of full-scale response time of less than 12 s, as measured according to 10.1.5.

6.12 Heat flux meters

The working heat flux meter shall be used to calibrate the heater (see 10.2.5). It shall be positioned at a location equivalent to the centre of the specimen face during this calibration.

This heat flux meter shall be of the Schmidt-Boelter (thermopile) type with a design range of (100 ± 10) kW/m^2. The target receiving the heat shall be flat, circular, of approximately 12,5 mm in diameter and coated with a durable matt

black finish of surface emissivity $\epsilon = 0{,}95 \pm 0{,}05$. The target shall be water-cooled. A cooling temperature which would cause condensation of water on the target surface of the heat flux meter shall not be used.

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

The calibration of the working heat flux meter shall be checked according to 10.3.1, by comparison with two instruments of the same type as the working heat flux meter and of similar range held as reference standards and not used for any other purpose (see annex E). One of the reference standards shall be fully calibrated at a standardizing laboratory at yearly intervals.

6.13 Calibration burner

The calibration burner shall be constructed from tube with a square or circular orifice with an area of (500 ± 100) mm^2 covered with wire gauze through which the methane diffuses. The tube is packed with refractory fibre to improve uniformity of flow. The calibration burner is suitably connected to a metered supply of methane of at least 99,5 % purity. The accuracy of the flow meter shall be $\pm$ 2 % of the readout, corresponding to a heat release rate of 5 kW. The accuracy verification shall be performed according to 10.3.3.

6.14 Data collection and analysis system

The data collection and analysis system shall have facilities for recording the output from the oxygen analyser, the orifice meter, the thermocouples and the weighing device. The data collection system shall have an accuracy corresponding to at least 50 parts per million of oxygen for the oxygen channel, 0,5 °C for the temperature measuring channels, 0,01 % of full-scale instrument output for all other instrument channels, and at least 0,1 % for time. The system shall be capable of recording data every second. The system shall be capable of storing a minimum of 720 data per parameter. The raw data recorded for each test shall be stored so that it can be recovered and used to check the accuracy of the software.

6.15 Optional side screens

For operational or safety reasons, it is permitted to guard the heater and sample holder with side screens. However, it shall be demonstrated that the presence of the screens does not affect the ignition time and heat release rate measurements according to the procedure described in 10.1.7.

If the screens form an enclosure, attention is drawn to the fact that there is a possible explosion hazard when the instrument is not operated under conditions prescribed by this part of ISO 5660, in particular for experiments in an oxygen-enriched atmosphere. If an explosion hazard exists, proper precautions shall be taken to protect the operator, e.g. by installing an explosion vent facing away from the operator.

7 Suitability of a product for testing

7.1 Surface characteristics

A product having one of the following properties is suitable for testing:

a) an essentially flat exposed surface;

b) a surface irregularity which is evenly distributed over the exposed surface provided that

   1) at least 50 % of the surface of a representative 100 mm square area lies within a depth of 10 mm from a plane taken across the highest points on the exposed surface, or

   2) for surfaces containing cracks, fissures or holes not exceeding 8 mm in width nor 10 mm in depth, the total area of such cracks, fissures or holes at the surface does not exceed 30 % of a representative 100 mm square area of the exposed surface.

When an exposed surface does not meet the requirements of either 7.1 a) or 7.1 b), the product shall be tested in a modified form complying as nearly as possible with the requirements given in 7.1. The test report shall state that the product has been tested in a modified form, and clearly describe the modification.

7.2 Asymmetrical products

A product submitted for this test can have faces which differ or can contain laminations of different materials arranged in a different order in relation to the two faces. If either of the faces can be exposed in use within a room, cavity or void, then both faces shall be tested.

7.3 Materials of short burning time

For specimens of short burning time (3 min or less), the heat release rate measurements shall be taken at not more than 2 s intervals. For longer burning times, 5 s intervals may be used.

7.4 Composite specimens

Composite specimens are suitable for testing, provided that they are prepared as specified in 8.3 and are exposed in a manner typical of end use conditions.

7.5 Dimensionally unstable materials

Samples that intumesce or deform so that they contact the spark plug prior to ignition, or the underside of the cone heater after ignition, shall be tested with the separation of 60 mm between the base plate of the cone heater and the upper surface of the specimen. In this case the heater calibration (see 10.2.5) shall be performed with the heat flux meter positioned 60 mm below the cone heater base plate. It must be stressed that the time to ignition measured with this separation is not comparable to that measured with the separation of 25 mm.

Other dimensionally unstable products, for example products that warp or shrink during testing, shall be restrained against excessive movement. This shall be accomplished with four tie wires, as described below. Metal wires of $(1{,}0 \pm 0{,}1)$ mm diameter and at least 350 mm long shall be used. The sample shall be prepared in the standard way as described in clause 8. A tie wire is then looped around the sample holder and retainer frame assembly, so that it is parallel to and approximately 20 mm away from one of the four sides of the assembly. The ends of the wire are twisted together such that the wire is pulled firmly against the retainer frame. Excess wire is trimmed from the twisted section before testing. The three remaining wires shall be fitted around the specimen holder and retainer frame assembly in a similar manner, parallel to the three remaining sides.

8 Specimen construction and preparation

8.1 Specimens

8.1.1 Unless otherwise specified, three specimens shall be tested at each level of irradiance selected and for each different exposed surface.

8.1.2 The specimens shall be representative of the product and shall be square with sides measuring $100\ ^{0}_{-2}$ mm.

8.1.3 Products with a normal thickness of 50 mm or less shall be tested using their full thickness.

8.1.4 For products with a normal thickness of greater than 50 mm, the requisite specimens shall be obtained by cutting away the unexposed face to reduce the thickness to 50 mm.

8.1.5 When cutting specimens from products with irregular surfaces, the highest point on the surface shall be arranged to occur at the centre of the specimen.

8.1.6 Assemblies shall be tested as specified in 8.1.3 or 8.1.4 as appropriate. However, where thin materials or composites are used in the fabrication of an assembly, the nature of any underlying construction can significantly affect the ignition and burning characteristics of the exposed surface.

The influence of the underlying layers shall be understood and care taken to ensure that the test result obtained on any assembly is relevant to its use in practice.

When the product is a material or composite which would normally be attached to a well-defined substrate, it shall be tested in conjunction with that substrate using the recommended fixing technique, for example bonded with the appropriate adhesive or mechanically fixed. In the absence of a unique or well-defined substrate, an appropriate substrate for testing shall be selected in accordance with ISO/TR 14697.

8.1.7 Products that are thinner than 6 mm shall be tested with a substrate representative of end-use conditions, such that the total specimen thickness is 6 mm or more.

8.2 Conditioning of specimens

Before the test, specimens shall be conditioned to constant mass at a temperature of (23 ± 2) °C, and a relative humidity of (50 ± 5) % in accordance with ISO 554.

Constant mass is considered to be reached when two successive weighing operations, carried out at an interval of 24 h, do not differ by more than 0,1 % of the mass of the test piece or 0,1 g, whichever is the greater.

Materials such as polyamides, which require more than one week in conditioning to reach equilibrium may be tested after conditioning in accordance with ISO 291[1]. This period shall be not less than one week, and shall be described in the test report.

8.3 Preparation

8.3.1 Specimen wrapping

A conditioned specimen shall be wrapped in a single layer of aluminum foil, of 0,025 mm to 0,04 mm thickness, with the shiny side towards the specimen. The alminium foil shall be pre-cut to a size to cover the bottom and sides of the specimen and extend 3 mm or more beyond the upper surface of the specimen. The specimen shall be placed in the middle of the foil and the bottom and sides shall be wrapped. The excess foil above the top surface shall be cut if necessary so that it does not extend more than 3 mm above the top surface of the specimen. The excess foil at the corners shall be folded around the corners to form a seal around the top surface of the specimen. After wrapping, the wrapped specimen shall be placed in the specimen holder and covered by a retainer frame. No aluminium foil shall be visible after the procedure is completed.

For soft specimens, a dummy specimen having the same thickness as the specimen to be tested may be used to pre-shape the aluminium foil.

8.3.2 Specimen preparation

All specimens shall be tested with the retainer frame shown in Figure 4. The following steps shall be taken to prepare a specimen for testing:

a) put the retainer frame on a flat surface facing downwards;

b) insert the foil-wrapped specimen into the frame with the exposed surface facing downwards;

c) put layers of refractory fibre blanket (nominal thickness 13 mm, nominal density 65 kg/m^3) on top until at least one full layer, and not more than two layers, extend above the rim of the frame;

d) fit the sample holder into the frame on top of the refractory fibre and press down;

e) secure the retainer frame to the specimen holder.

9 Test environment

The apparatus shall be located in an essentially draught-free environment in an atmosphere of relative humidity of between 20 % and 80 % and a temperature between 15 °C and 30 °C.

10 Calibration

10.1 Preliminary calibrations

10.1.1 General

The calibrations in this section, except for that in 10.1.7, shall be performed before conducting experiments, when commissioning a Cone calorimeter; or after maintenance, repair or replacement of the heater assembly or irradiance control system (10.1.2), the weighing device (10.1.3 and 10.1.4), the oxygen analyser or other major components of the gas analysis system (10.1.5 and 10.1.6). The calibration tests to determine the effect of side screens in 10.1.7 are conducted at the time the screens are installed. For a new instrument that is delivered with side screens, this shall be done by the manufacturer.

10.1.2 Irradiance control system response characteristics

Turn on power to the cone heater and the exhaust fan. Set an irradiance of (50 ± 1) kW/m^2, and an exhaust flow rate of $(0{,}024 \pm 0{,}002)$ m^3/s. After reaching equilibrium of the heater, record the average heater temperature. Test a specimen of black poly(methyl methacrylate) (PMMA) according to the procedure in clause 11. The PMMA specimen shall have a thickness of at least 6 mm. The average heat release rate recorded over the first 3 min following ignition shall be approximately 530 kW/m^2. During the test, record the average heater temperature at 5 s intervals.

10.1.3 Weighing device response time

The cone heater shall not be turned on for this calibration. Place an empty specimen holder with a (250 ± 25) g non-combustible weightpiece on the weighing device. The weightpiece accounts for the retainer frame, which is not used during this calibration. Measure the weighing device output, and mechanically or electronically adjust the value to zero. Gently add a second non-combustible weightpiece with a mass of (250 ± 25) g on the holder and record the weighing device output. After equilibrium is reached, gently remove the second weightpiece from the holder, and again record the weighing device output. Determine the response time of the weighing device as the average of the times for the weighing device output to change from 10 % to 90 % of its ultimate deflection.

10.1.4 Weighing device output drift

Set the height of the cone heater to the same position as when testing a specimen with the retainer frame. Place a thermal barrier on the weighing device. Turn on power to the exhaust fan and cone heater. Set an exhaust flow rate of $(0{,}024 \pm 0{,}002)$ m^3/s and an irradiance of (50 ± 1) kW/m^2. After reaching equilibrium of the heater temperature, remove the thermal barrier and place an empty specimen holder with a (250 ± 25) g weightpiece on the weighing device. The weightpiece accounts for the retainer frame, which is not used during this calibration. After equilibrium is reached, measure the weighing device output and mechanically or electronically adjust the value to zero. Gently add a second weightpiece with a mass of (250 ± 25) g on the specimen holder. After equilibrium is reached, record the weighing device output. After 30 min, record the weighing device output. Calculate the drift of the weighing device output as the absolute value of the difference of the initial and final values.

10.1.5 Oxygen analyser delay and response times

The cone heater shall not be turned on for this calibration. Turn on the exhaust fan, and set an exhaust flow rate of $(0{,}024 \pm 0{,}002)$ m^3/s. Determine the delay time of the oxygen analyser by delivering a methane flow rate approximately equivalent to 5 kW to the calibration burner. Light the burner outside the hood and allow the flame to