TECHNICAL REPORT

ISO/TR 14696

First edition
1999-08-01

Reaction to fire tests — Determination of fire parameters of materials, products and assemblies using an intermediate-scale heat release calorimeter (ICAL)

Essais de réaction au feu — Détermination, à l'aide de calorimètre à échelle intermédiaire à dégagement de chaleur (ICAL), des paramètres relatifs au feu des matériaux, produits et ouvrages

Reference number
ISO/TR 14696:1999(E)

Contents

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet iso@iso.ch

Printed in Switzerland

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.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 14696, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Reaction to fire*.

This document is being issued in the Technical Report (type 2) series of publications (according to subclause G.3.2.2 of part 1 of the ISO/IEC Directives, 1995) as a "prospective standard for provisional application" in the field of fire safety because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this Technical Report (type 2) will be carried out not later than three years after its publication with the options of: extension for another three years; conversion into an International Standard; or withdrawal.

Annexes A to D form a normative part of this Technical Report. Annexes E and F are for information only.

Reaction to fire tests — Determination of fire parameters of materials, products and assemblies using an intermediate-scale heat release calorimeter (ICAL)

1 Scope

This Technical Report provides a method for measuring the response of materials, products and assemblies exposed in vertical orientation to controlled levels of radiant heating with an external igniter.

This test method is used to determine the ignitability, heat release rates, mass loss rates, and visible smoke development of materials, products and assemblies under well ventilated conditions.

The heat release rate is determined by measurement of the oxygen consumption as determined by the oxygen concentration and flow in the exhaust product stream as specified in 11.1. Smoke development is quantified by measuring the obscuration of light by the combustion product stream.

Specimens are exposed to heating fluxes ranging from 0 kW/m^2 to 50 kW/m^2. Hot wires are used as the ignition source.

This test method has been developed for material, product or assembly evaluations, mathematical modelling and design purposes. The specimen are tested in thicknesses and configurations representative of actual end product or system uses.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Technical Report. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this Technical Report 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/IEC Guide 52:1990, *Glossary of fire terms and definitions*.

3 Terms and definitions

For the purposes of this Technical Report, the terms and definitions given in ISO/IEC Guide 52 and the following apply.

3.1
assembly
fabrication of materials or composites, for example sandwich panels

NOTE This may include an air gap.

3.2
composite
combination of materials which are generally recognized in building construction as discrete entities, for example coated or laminated materials

3.4
flashing
existence of flame on or over the surface of the specimen for periods of less than 1 s

3.5
heating flux
incident flux imposed externally from the heater on the specimen at the initiation of the test

3.6
heat release rate
heat evolved from the specimen, per unit of time and area

3.7
ignition
onset of sustained flaming as defined in 3.15

3.8
irradiance (at a point of a surface)
quotient of the radiant flux incident on an infinitesimal element of surface containing the point, by the area of that element

3.9
material
single substance or uniformly dispersed mixture, for example metal, stone, timber, concrete, mineral fibre, polymers

3.10
orientation
plane in which the exposed face of the specimen is located during testing, either vertical or horizontal facing up

3.11
oxygen consumption principle
proportional relationship between the mass of oxygen consumed during combustion and the heat released

3.12
product
material, composite or assembly about which information is required

3.13
specimen
representative piece of the product which is to be tested together with any substrate or treatment

3.14
smoke obscuration
reduction of light transmission by smoke, as measured by light attenuation

3.15
sustained flaming
existence of flame on or over most of the specimen surface for periods of over 10 s

3.16
transitory flaming
existence of flame on or over the surface of the specimen for periods of between 1 and 10 s

4 Symbols and abbreviations

A	Cross sectional area of duct (m^2)
E	Net heat released for complete combustion of propane, per unit of oxygen consumed (12,78 MJ/kg O_2)
E_{CO}	Net heat released for incomplete combustion, per unit of CO consumed
$E_{propane}$	Net heat released for complete combustion of propane, per unit of oxygen consumed (12,73 MJ/kg of O_2)
$E_{methane}$	Net heat released for complete combustion of methane, per unit of oxygen consumed (12,51 MJ/kg of O_2)
f_x	Yield of gas x (kg/kg)
$f(Re)$	Reynolds number correction
I	Transmitted beam intensity (cd)
I_0	Beam intensity before attenuation (cd)
k	Smoke extinction coefficient (m^{-1})
k_c	Velocity profile shape factor (non-dimensional)
L_p	Light path length of beam through smoky environment (m)
M_a	Molecular mass of incoming air (kg/kmol)
M_{CO}	Molecular mass of carbon monoxide (kg/kmol)
M_{CO_2}	Molecular mass of carbon dioxide (kg/kmol)
M_{dry}	Molecular mass of dry air (29 kg/kmol)
M_e	Molecular mass of exhaust gases (kg/kmol)
M_{H_2O}	Molecular mass of water (kg/kmol)
M_{N_2}	Molecular mass of nitrogen (kg/kmol)
M_{O_2}	Molecular mass of oxygen (32 kg/kmol)
m	Specimen mass (kg)
$\dot{m}_e$	Mass flow in exhaust duct (kg/s)
OD	Optical density (non-dimensional)
Δp	Pressure drop across the orifice plate or bidirectional probe (Pa)
q	Total heat released (MJ)

$\dot{q}$	Heat release rate (kW)
RSR	Rate of smoke release (m^2/s)
TSR	Total smoke released (m^2)
T_e	Combustion gas temperature at the photodetector (K)
T_s	Duct temperature (near photodetector) (K)
t	Time (s)
$\dot{V}_e$	Volumetric flow in exhaust duct (at measuring location of mass flow) (m^3/s)
$\dot{V}_s$	Volumetric flow at location of smoke meter (value adjusted for smoke measurement calculations) (m^3/s)
Δt	Sampling time interval (s)
$X_{CO,e}$	Measured mole fraction of CO in exhaust flow (non-dimensional)
$X_{CO,i}$	Measured mole fraction of CO in incoming air (non-dimensional)
$X_{CO_2,e}$	Measured mole fraction of CO_2 in exhaust flow (non-dimensional)
$X_{CO_2,i}$	Measured mole fraction of CO_2 in incoming air (non-dimensional)
$X_{O_2,e}$	Measured mole fraction of O_2 in exhaust flow (non-dimensional)
$X_{O_2,i}$	Measured mole fraction of O_2 in incoming air (non-dimensional)
$[x]$	Concentration of gas x (kg/kg)
α	Combustion expansion factor (non-dimensional; normally a value of 1,105)
ρ	Density of air at the temperature in exhaust duct (kg/m^3)
ρ_0	Density of air at 273,15 K: 1,293 (kg/m^3)
ϕ	Oxygen depletion factor (non-dimensional)

5 Principle

5.1 This test method is designed to measure the heat release rate from a 1 m^2 specimen in a vertical orientation. The specimen is exposed to a uniform heat flux from a gas fired radiant panel up to 50 kW/m^2 and uses electrically heated wires for ignition. Heat release measured by this test method is based on the observation that, generally, the net heat of combustion is directly related to the amount of oxygen required for combustion (see references [2,3]). The primary measurements are oxygen concentrations and exhaust flow. Burning may be either with or without ignition wires used at the top and bottom of the specimen.

5.2 Additional measurements include the mass loss rate of the specimen, the time to sustained flaming and the light intensity of a light beam having traversed the smoky duct. The apparatus can be used to measure additional properties discussed in informative Annex F.

6 Apparatus

Where dimensions are stated in the following description, they shall be considered mandatory and shall be followed within nominal tolerance of ± 5 mm on the radiant panel and specimen holder assemblies. An exception to this tolerance is the placement of the screen in front of the ceramic burner and which shall be ± 0,5 mm. The tolerances permitted in the exhaust system of ISO 9705 [9] are permissible.

The apparatus shall consist of the following components:

— a radiant panel assembly (Figure 1) located in the vertical orientation;

— a specimen holder (Figure 2);

— an exhaust collection system,

— weighing platform,

— gas laminar flow meter, and

— a data acquisition system.

A general layout of the whole test assembly is shown in Figure 3.

6.1 Radiant panels

The panel consists of a hollow 50 mm by 50 mm square steel tubing which supports 3 rows of adjustable, ceramic-faced, natural gas burners[1)] comprised of three burners per row (Figure 1). The tubing has typical residential water hose connections provided at the bottom of the tubing to facilitate water cooling.

The left and right burners in each row are made up of four modules each and the centre burners are comprised of one module. A module consists of 4 vertically stacked ceramic elements 12,7 mm deep by 95 mm high by 158 mm wide. The centre burners consist of one module each. The modules are comprised of a plenum space in which the natural gas is injected at a controlled rate by the burner's control system. Combustion air is aspirated into the plenum space through the gas and air injection port.

The face of each burner is covered with stainless steel cloth type floating screen (mesh per linear 25,4 mm – 4 x 4, wire diameter 1,19 mm, width opening 5,16 mm) for higher surface temperature and safety. The screens shall be carefully installed to allow for elongation of screens and supporting rods. This will allow the distance between the burners and screens to remain constant when heated. The optimum distance between the surface of the burners and the outer surface of the screen is 20 mm. The rows of gas burners on the panel shall be separated by a distance of 93 mm from each other and also attached to the support tubing at the locations indicated in Figure 1.

Natural gas of net heating value at least 49 MJ/kg shall be supplied to the unit through a control system provided with a safety interlock. All gas pipe connections to the burners must be sealed with a gas pipe compound resistant to liquified petroleum gases. A drip leg shall be installed in the gas supply line going to each heater to minimize the possibility of any loose scale or dirt within the gas supply line from entering the burner's control system.

Ignition of the burners shall be accomplished by individual, automatic spark igniters and pilot flames. The spark igniters are used to ignite the pilot flames which in turn are used to ignite the burners after pilot flame temperature sensors have reached a required value. The pilot remains on until the burners are extinguished.

An opening of at least 25 mm shall be provided at the vertical centreline between the rows of burners.

---

1) A modified RAY-TEC burner unit, RT132, from Modine Manufacturing company, 1500 Dekoven Avenue, Racine, Wisconsin 53403, USA, has been found suitable for this application.

6.2 Radiant panel constant irradiance controller

The irradiance from the radiant panel assembly shall be capable of being held at a preset level by means of regulating the flow of natural gas to the burners (see annex E.2 for more information). The flow of the gas is regulated using an automatic flow controller, motorized valve and a thermocouple located on the surface of a ceramic burner. The irradiance is directly proportional to the temperature on the surface of the ceramic burners. Gas flow shall be continuously measured to calculate the heat released from the radiant panel assembly. This value is needed in computations of the heat release rate from the specimen.

6.3 Specimen holder assembly components

6.3.1 Specimen holder

The specimen holder assembly is shown in Figure 2 and is capable of holding a specimen up to 150 mm thick. (A thicker specimen holder is necessary to accomodate specimens thicker than 150 mm.) The top portion of the assembly is removable to facilitate specimen insertion. Prior to starting the test the specimen shall be protected from the radiant panel heat flux exposure by the water cooled shield (6.4). A drip tray, 300 mm wide x 50 mm deep x 914 mm long, shall be attached to the floor of the specimen holder directly below the specimen frame to contain limited amounts of materials that melt and drip. Two wire igniters described in 6.5 are attached to the specimen holder. A gas stream blocking plate (6.6) is mounted at the bottom of the specimen.

6.3.2 Weighing platform

The general arrangement of the specimen holder and the weighing platform is indicated in Figure 2. The weighing platform[2)] shall be capable of weighing the specimen to an accuracy of 1 g. The platform shall be protected from the radiant panel assembly by an insulation board cover as shown in Figure 2.

6.3.3 Specimen holder trolley

A trolley, as shown in Figure 3, shall be provided to hold the specimen holder and weighing platform so that the specimen can be moved to a predetermined location in front of the radiant panel at the beginning of a test. The trolley shall be placed on tracks or guides to facilitate exact specimen placement with respect to the radiant panel. The trolley tracks shall be located perpendicular to the plane of the radiant panel so that the specimen is moved directly toward the radiant panel. The specimen is inserted in the holder when the trolley is at a sufficient distance from the radiant panel. The trolley tracks shall be long enough to move the specimen holder to a distance of 6 m from the radiant panel if necessary.

6.4 Specimen shield

A water cooled shield (Figure 4) shall be provided to absorb the thermal energy from the radiant panels prior to testing. The shield is constructed so that a preset water flow will maintain a shield temperature on the unexposed face below 100 °C. The shield shall be positioned directly in front of the radiant panel assembly at a distance of 150 mm. The mounting method used shall accommodate removing the shield in less than 2 s.

6.5 Wire igniters

Two 0,81 mm Chromel wires (from Type K thermocouple wires) are used as igniters. One wire is positioned horizontally, spanning the full width of the specimen, 80 mm above the bottom exposed edge of the specimen and 15 mm from the specimen surface. The other wire is positioned horizontally, spanning the full width of the specimen, 20 mm above the top exposed edge of the specimen and 15 mm from the specimen's vertical plane. A spring, protected from the radiant heat, shall be attached to one end of the wires to compensate for the wire expansion during the test. It shall remain under tension throughout the test so that the igniter wire remains in position. When used, sufficient electrical power shall be applied to the wire that will produce an orange glow. Low voltages, up to 30 V, shall be used for safety reasons. More information about the choice of the wire igniters is given in annex E.3.

---

2) A Sartorius Model F150S Electromagnetic Scale, has been found suitable for this application.

6.6 Gas stream blocking plate

A thin steel plate which projects 10 cm out from the specimen surface shall be attached to the specimen holder perpendicularly to the specimen surface along the lower exposed specimen edge. Information about the gas stream interrupting projection plate is given in annex E.5.

6.7 Heat flux meter

The total heat flux meter shall be of the Schmidt-Boelter (thermopile) type, with a design range of about 50 kW/m^2. The target receiving radiation, and possibly to a small extent convection, shall be flat, circular, approximately 12,5 mm in diameter, and coated with a durable matt-black finish. The target shall be water cooled. 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 ±3% and a repeatability of within ±0,5 %.

6.8 Heat flux calibration panel

A panel to establish the heat flux/distance relationship shall be constructed from nominal 12 mm to 13 mm thick calcium silicate board of nominal density 600 kg/m^3 to 850 kg/m^3. The panel shall be the same size as a specimen (1000 x 1000 mm) and shall have holes with diameters to accomodate the heat flux meter (6.7). Five rows and columns of holes (25 holes total) shall be drilled with their centres 224 mm apart and 52 mm from the edges on all sides of the panel.

6.9 Exhaust collection system

Construct the exhaust collection system with the following minimal requirements: a blower, steel hood, duct, bidirectional probe, thermocouple(s), oxygen measurement system, smoke obscuration measurement system (white light lamp and photocell/detector or laser) and combustion gas sampling and analysis system. Construct the exhaust collection system as shown in Figure 5 and as explained in annex A.1.

Ensure that the system for collecting the smoke (which includes gaseous combustion products) has sufficient exhaust capacity and is designed in such a way that all of the combustion products leaving the burning specimen are collected. Design the capacity of the evacuation system such that it will exhaust minimally all combustion gases leaving the specimen (see annex A.1).

Place probes for sampling of combustion gas and for measurement of flow in accordance with clause 7.

Make all measurements of smoke obscuration, gas concentrations or flows at a position in the exhaust duct where the exhaust is uniformly mixed so that there is a nearly uniform velocity across the duct section.

If the straight section before the measuring system is at least 8 times the inside diameter of the duct the exhaust is considered to be uniformly mixed. If a measuring system is positioned at a distance of less than 8 diameters, demonstrate the achievement of equivalent results.

7 Minimum requirements for exhaust duct instrumentation

NOTE Additional information is found in annex B.

7.1 Flow

Measure the flow in the exhaust duct by means of a bidirectional probe [12] or an equivalent measuring system with an accuracy of at least ± 6% (see annex B for further details). The response time to a stepwise change of the duct flow shall not exceed 5 s, to reach 90 % of the final value.

7.2 Combustion gas analysis

7.2.1 Sampling line

Construct the sampling line tubes of a material not influencing the concentration of the combustion gas species to be analysed. The following sequence of the gas train has been shown to be acceptable: sampling probe, soot filter, cold trap, gas stream pump, vent valve, plastic drying column and carbon dioxide removal columns (if used), flow controller and oxygen analyser (see Figure 6 and annex B for further details). Alternative designs of the sampling line must give equivalent results. The gas train shall also include appropriate spanning and zeroing facilities.

7.2.2 Oxygen measurement

Measure the oxygen concentration with an accuracy of at least ± 0,04% of full scale in the output range of 0 to 25 vol % oxygen, or ±0,01 vol % oxygen, in order to have adequate measurements of heat release rate. Take the combustion gas sample from the end of the sampling line. Calculate the time delay, including the time constant of the instrument; it is a function of the exhaust duct flow. This time delay shall not exceed 60 s (see annex B for further details).

7.2.3 Carbon monoxide and carbon dioxide measurement

Measure the combustion gas species with an instrument having an accuracy of at least ± 0,1 vol % for the carbon dioxide and ± 0,02 vol % for carbon monoxide. A suitable output range is 0 to 1 vol % for carbon monoxide and 0 to 6 vol % for carbon dioxide. Take the combustion gas sample from the end of the sampling line. Calculate the time delay, including the time constant of the instrument; it is a function of the exhaust duct flow. It shall be a maximum of 60 s (see annex B for further details).

7.2.4 Smoke obscuration measurement

Install an optical system for measurement of light obscuration across the centreline of the exhaust duct. Determine the optical density of the smoke by measuring the light transmitted with a photometer system consisting of a white light source and a photocell/detector or a laser system for measurement of light obscuration across the centreline of the exhaust duct.

One photometer system found suitable consists of a lamp, lenses, an aperture and a photocell. See Figure 7 and annex B for further details. Construct the system so that soot deposits on the optics during a test do not reduce the light transmission by more than 5 %.

Alternatively, instrumentation constructed using a 0,5 mW to 2,0 mW helium-neon laser, instead of a white light system is also acceptable. See Figure 8 and annex B.4 for further details. It has been shown that white light and laser systems will give similar results [17].

8 Significance and use

8.1 This test method is used primarily to determine the heat release rate of materials, products and assemblies. Other parameters determined are mass loss rate, the time to ignition, and smoke and gas production. These properties are determined on a sample which may be an assembly of materials or products that are tested in their end-use thickness. Therefore, the heat release rate of a wall assembly, for instance, can be determined.

8.2 Representative joints and other characteristics of an assembly shall be included in a specimen when these details are part of the normal design.

8.3 This test method is applicable to end-use products not having an ideally planar external surface. The radiant flux field shall be adjusted to be that which is desired at the average distance of the surface from the radiant panel.

9 Test specimens

9.1 Size and preparation

9.1 Test specimen's dimensions shall be 1 000 by 1 000 mm and up to 150 mm in thickness[3]. They shall be representative of the construction of the end-use product. Materials and assemblies of normal thickness 150 mm or less shall be tested using their full thickness.

9.2 If a product is designed to normally have joints in a field application, then that specimen shall incorporate the joint detail. The joint shall be centred in the specimen's vertical or horizontal centreline as appropriate. The specimen shall also be tested without a joint detail if the design does not include a joint.

9.3 The edges of the specimen shall be covered with 12 mm ceramic wool blanket to eliminate the gap between the holder and the specimen.

9.2 Conditioning

Specimens shall be conditioned to moisture equilibrium (constant mass) at an ambient temperature of 23 °C ± 3°C and a relative humidity of (50 ± 5) %.

NOTE 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 1 g, whichever is the greater.

10 Calibration of apparatus

Calibrate all instruments carefully with standard sources after initial installation. Among the instruments to be calibrated are load cells or weighing platforms, smoke meters, flow or velocity transducers and gas analysers.

10.1 Heat flux/distance relationship

10.1.1 Ignite the radiant panel and allow it to come to equilibrium as indicated by its constant heat release rate.

10.1.2 A curve of average flux measurements over the specimen surface versus specimen distance from the radiant panels shall be generated. The calibration panel shall be placed in the same position as a specimen and the flux meter inserted from the unexposed face through the holes. The target face of the flux meter shall extend 15 mm toward the radiant panel from the exposed surface of the calibration panel to minimize the convective heat transfer contribution. After the calibration panel has come to equilibrium, the flux measurements shall be made with the target face of the flux meter at the following distances, in millimetres, away from the radiant panel: 300, 400, 600, 800, 1 000, 2 000, 3 000, 4 000, 5 000 and 6 000.

10.1.3 No individual flux measurement shall deviate from the average at each of the distances by more than ±5 %.

10.1.4 The curve generated in 10.1.2 shall be used to determine the distance from the radiant panel for a desired radiant heat flux exposure.

10.1.5 Calibration shall be performed every three months or more frequently if any significant changes to equipment are made or if calibration is suspect.

10.2 Heat release

10.2.1 Perform the calibration of the heat release instrumentation in the exhaust duct by burning propane or methane gas and comparing the heat release rates calculated from the metered gas input, and those calculated from the measured oxygen consumption. The value of net heat of combustion for propane is 46,5 MJ/kg and for methane 50 MJ/kg . Position the calibration burner in the same location where the specimen is to be placed during a 35 kW/m^2 exposure test. Measure the gas flow at a pressure of 101 kPa $\pm$ 5 kPa (standard atmospheric pressure, measured at the flow gauge) and a temperature of 20 °C $\pm$ 5 °C.

---

[3] If specimens of thickness greater than 150 mm are to be tested, a suitable specimen holder needs to be constructed.

10.2.2 The calibration source for the test shall be a gas burner with a nominal 0,3 m by 0,3 m porous top surface of a refractory material. The top surface of the burner through which the gas is supplied shall be located horizontally, 0,3 m off the floor. The burner shall be supplied with natural grade propane (95 % purity) or methane (98 % purity). The gas for the burner flame shall not be premixed with air. The gas flow to the burner shall be measured with an accuracy of at least ±3 %. The heat output to the burner shall be kept constant and controlled within ±5 % of the prescribed value.

The burner may be ignited by a pilot burner or a remotely controlled spark igniter. Burner controls shall be provided for automatic shut-off of the gas supply if flameout occurs.

NOTE A burner may be constructed with a 25 mm thick porous ceramic-fiber board over a 152 mm plenum; or alternatively a minimum 100 mm layer of sand can be used to provide the horizontal surface through which the gas is supplied. The sand burner may be preferable for economic reasons. This type of burner is shown in Figure 10.

10.2.3 Another suitable calibration burner is a pipe, with an inner diameter of 100 mm $\pm$ 1,5 mm, supplied with gas from beneath as described in ISO 9705 [9]. The gas for the burner flame shall not be premixed with air.

10.2.4 Obtain a minimum of two calibration points. Obtain a lower heat release rate value of 250 kW and a higher heat release rate of 600 kW.

10.2.5 Take measurements at least once every 6 s and start 1 min prior to ignition of the burner. Determine the average heat release rate over a period of at least one minute by (a) the oxygen consumption method and (b) calculating the heat release rate from the gas mass flow and the net heat of combustion. A correct factor of heat released per oxygen consumed for the calibration gas ($E_{propane}$=12,78 MJ per kg O_2; $E_{methane}$=12,51 MJ per kg O_2) must be used in the oxygen consumption method (equation D.4). The difference between the two values shall not exceed 5 %. This comparison shall be made only after steady state conditions have been reached.

10.2.6 Calibration shall be performed every three months or more frequently if any significant changes to equipment are made or if calibration is suspect.

10.2.7 When calibrating a new system, or when modifications are introduced, check the response time of the measuring system by the following test sequence:

Time	Burner output
0 min to 5 min	0 kW
5 min to 10 min	250 kW
10 min to 15 min	600 kW
20 min to 25 min	0 kW

The response of the system to a stepwise change of the heat output from the burner shall be a maximum of 12 s to 90 % of final value.

10.2.8 Perform the calibration described in 10.2.4, 10.2.5 and the calibration described in 10.2.7 at a duct air flow corresponding to oxygen concentration between 20,2 % and 20,4% with the radiant panel in operation only.

10.2.9 The change in measured heat release rate, comparing time average values over 1 min, shall not be more than 10 % of the actual heat output from the burner.

10.3 Mass loss

Perform the calibration by loading the weighing platform with known masses corresponding to the measuring range of interest, to ensure that the requirements of accuracy in 6.3.2 are fulfilled. Carry out this calibration daily, prior to testing.

10.4 Smoke obscuration

Calibrate the smoke meter initially to read correctly for two neutral density filters of significantly different values, and also at 100 % transmission. The use of neutral density filters at 0,5 and 1,0 values of optical density has been shown to be satisfactory for this calibration. Once this calibration is set, only the zero value of extinction coefficient (100 % transmission) needs to be verified each day, prior to testing. Investigate any excessive departure from the zero line at the end of a test, and correct it.

10.5 Gas analysis

Calibrate gas analysers daily, prior to testing (see ASTM E800 standard guide for further guidance).

10.6 Heat flux meter

The calibration of the heat flux meter shall be checked whenever a recalibration of the apparatus is carried out by comparison with an instrument (of the same type as the working heat flux meter and of similar range) held as a reference standard and not used for any other purpose. The reference standard shall be fully calibrated at a standardizing laboratory at yearly intervals.

11 Procedure

11.1 Preparation

11.1.1 Open the water valve to the steel tubing which supports the radiant panel and adjust the water flow to the flow previously determined to be sufficiently high that water exiting the frame will not exceed 50 °C temperature.

11.1.2 Position the specimen holder assembly remote to the desired test location.

11.1.3 Place the water cooled shield in front of the radiant panel assembly and adjust the water flow to the flow previously determined to be sufficiently high that water exiting the shield will not exceed 50 °C temperature.

11.1.4 Establish a duct air flow previously determined to correspond to oxygen concentration between 20,2 % and 20,4 % with the radiant panel in operation only.

11.1.5 Turn on the flow of gas to each of the radiant panels and ignite them.

11.1.6 Allow the burners to operate for 30 min prior to testing.

11.1.7 Adjust, if necessary, the water flows from 11.1.1 and 11.1.3, and the duct flow from 11.1.4 to the required values.

11.1.8 Turn on all sampling and recording devices and calibrate the analysers.

11.1.9 Insert the specimen into the specimen holder. The specimen shall be placed in the specimen holder by removing the top specimen holder cap section, inserting the specimen and replacing the top cap.

11.1.10 Switch on the wire igniters.

11.2 Procedure

11.2.1 Move the specimen trolley to the location necessary for the desired flux exposure.

11.2.2 Collect baseline data for 2 min after the signal from the weighing platform settles down to equilibrium.

11.2.3 Remove the water cooled specimen shield in not more than 2 s and start the timer marking the beginning of the test.