INTERNATIONAL STANDARD

ISO 24473

First edition
2008-04-15

Fire tests — Open calorimetry — Measurement of the rate of production of heat and combustion products for fires of up to 40 MW

Essais au feu — Calorimétrie ouverte — Mesurage de la vitesse de production de chaleur et de produits de combustion dans le cas de feux ayant un débit thermique inférieur ou égal à 40 MW

Reference number
ISO 24473:2008(E)

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

Published in Switzerland

Contents

Page

Foreword

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

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

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

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

ISO 24473 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

Fire tests — Open calorimetry — Measurement of the rate of production of heat and combustion products for fires of up to 40 MW

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. Hazards can therefore exist for burns and ignition of extraneous objects or clothing. The operators should use protective clothing, helmets, face-shields and breathing equipment for avoiding exposure to toxic gases.

Laboratory safety procedures should be set up to ensure the safe termination of tests. Adequate means of extinguishing such a fire must be provided.

Specimen collapse may also occur in the laboratory space. Laboratory safety procedures should be set up to ensure safety of personnel with due consideration to such situations.

1 Scope

This International Standard specifies a series of test methods that simulate a real scale fire on a test object or group of objects under well-ventilated conditions. A range of different fire sizes can be studied according to the scale of the equipment available.

The method is intended to evaluate the contribution to fire growth provided by an object or group of objects using a specified ignition source.

A test performed in accordance with the method specified in this International Standard provides data for all stages of a fire.

NOTE When the data are used in relation to specific situations the effect of the environment, including the effects of feedback and restricted ventilation, needs to be taken into account.

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

ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

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

ISO 13784-1, *Reaction-to-fire tests for sandwich panel building systems — Part 1: Test method for small rooms*

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

ISO 13785-1, *Reaction-to-fire tests for façades — Part 1: Intermediate-scale test*

ISO 13943, *Fire safety — Vocabulary*

ISO/TS 14934-1, *Fire tests — Calibration and use of radiometers and heat flux meters — Part 1: General principles*

ISO 14934-2, *Fire tests — Calibration and use of heat flux meters — Part 2: Primary calibration methods*

ISO 14934-3, *Fire tests — Calibration and use of heat flux meters — Part 3: Secondary calibration method*

ISO/TS 14934-4, *Fire tests — Calibration of heat flux meters — Part 4: Guidance on the use of heat flux meters in fire tests*

ISO 19702, *Toxicity testing of fire effluents — Guidance for analysis of gases and vapours in fire effluents using FTIR gas analysis*

EN 13823, *Reaction to fire tests for building products — Building products excluding floorings exposed to the thermal attack by a single burning item*

3 Terms and definitions

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

3.1
assembly
fabrication of materials and/or composites, e.g., sandwich panel systems

3.2
material
single substance or uniformly dispersed mixture, e.g., metal, stone, timber, concrete, mineral fibre or polymers

3.3
product
material, composite or assembly about which information is required

3.4
test specimen
representative piece of the product that is to be tested together with any substrate or treatment

NOTE The test specimen may include an air gap.

4 Principle

The potential for the contribution of a single object or group of objects to the hazard of heat release and spread of fire, without being influenced by the effects of any surrounding structure, is evaluated over the period of combustion using a calorimeter. The rate of heat release of the fire is based on calculation of oxygen consumption.

NOTE 1 Procedures to determine the heat release rate (HRR) based on the rate of production of carbon dioxide, can also be used, but are not covered in this International Standard.

The hazard of reduced visibility is estimated by the measurement of the production of light-obscuring smoke.

The fire growth is visually documented by photographic and/or video recording.

NOTE 2 The procedure can be extended to include measurement of:

— time-related weight loss of the fuel;

— the incident heat flux or surface temperature at positions in the vicinity of the fire, as an indication of the hazard of fire spread to an adjacent object;

— the rate of production of certain gaseous combustion products under well-ventilated conditions, using appropriate analytical procedures for gases, as input to data for studies of toxicological hazards.

5 Hood and exhaust duct

5.1 Requirements of the hood/duct and extraction system

The hood and duct system shall be large enough in terms of the size of the hood and the air throughput of the system to ensure that all the combustion products are collected. It shall be at a height such that the flames do not impinge on the hood itself.

NOTE 1 The principles of the design and operation of a hood and duct system and examples of designs in use are given in Annex A.

The system shall not disturb the fire-induced flow at the fire itself.

NOTE 2 This can be demonstrated by carrying out tests with a gas burner at different flow rates in the proposed operating range to show that the HRR data are independent of the setting of the exhaust system (for example as outlined in 11.3).

5.2 Laboratory requirements

The equipment shall be positioned in a laboratory and placed so as to avoid the effects of reflected radiation from walls and to allow free inflow of air. For fires of up to 1 MW, the open sides of the calorimeter hood shall be at least 2 m from the nearest walls. For larger fires this shall be increased; up to 10 m for fires of 20 MW.

The ambient air temperature in the laboratory shall be recorded at intervals of 3 s or less. This is necessary because the operation of the flow system will cause replacement of a quantity of air within the laboratory in which it is installed.

NOTE The number of air changes per hour will be dependent upon the size of the room and the volume flow rate of the calorimeter. It is necessary to provide adequate ventilation to prevent negative pressure.

6 Instrumentation of the exhaust duct

6.1 General

The following sub-clauses specify minimum requirements for instrumentation in the exhaust duct.

NOTE Additional information and designs can be found in Annex B.

6.2 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 of the barometric instrument that measures flowrate shall be a maximum of 1 s for a change from 10 % to 90 % of the difference between the initial and final differential pressure.

6.3 Gas temperature

The temperature of the gas in the duct shall be measured using a 1,0 mm to 1,6 mm outside diameter, sheathed thermocouple supported in a position in the vicinity of the bi-directional probe. The thermocouple should not be allowed to disturb the flow pattern around the bi-directional probe.

It is recommended to provide more than one thermocouple in case one should fail during the test.

6.4 Gas analysis

6.4.1 Sampling line

The gas samples shall be taken in the exhaust duct at a position where the combustion products are uniformly mixed and down stream of the flow probe and the temperature probe. The sampling line shall be made from an inert material that will not influence the gas species to be analysed. The gas samples shall be taken across the whole diameter of the duct. If a single sampling point is used, samples shall be taken across the duct at this axial position to demonstrate that the concentration across the duct is within ± 2 % of the average value as determined by probe traverses. The sample gas shall pass through particulate filters and a cooler, then through a cell containing anhydrous calcium sulfate drying agent, under the influence of an oil-free diaphram pump, before being distributed to the different analysers.

NOTE An example of an arrangement is given in Figure B.1. One material which can be used to construct the sampling line is PTFE. The ratio of sampled to analysed gas is normally at least 20. However, it is more important that the system be designed as a whole in order to optimise system response as described in 11.2.

6.4.2 Oxygen

The O_2 analyser shall be of the paramagnetic type or equivalent in performance and capable of measuring a range of at least 0 % to 21 % (volume percent) oxygen.

$$\text{volume percent} = \frac{\text{volume of gas} \times 100}{\text{volume of air}}$$

The accuracy of the oxygen measurement shall be ± 0,02 % by volume oxygen or less (i.e. ± 0,00 2 % volume fraction oxygen or less). The noise and drift of the analyser shall be not more than 100 ppm (0,01 % by volume) over a period of 30 min (measured as specified in Annex C). The output from the analyser and the data acquisition system shall have a resolution of 0,01 % by volume oxygen or better. The HRR value is most sensitive to the oxygen measurement, therefore the performance of the oxygen meter shall exceed the overall requirements for system response and accuracy.

6.4.3 Carbon monoxide and carbon dioxide

The gas species shall be measured using analysers with an accuracy of ± 0,05 % by volume or less (i.e. ± 0,000 5 volume fraction or less) for carbon dioxide and ± 0,001 % by volume or less (i.e. ± 0,000 01 volume fraction or less) for carbon monoxide.

The HRR value is also sensitive to the carbon dioxide and carbon monoxide measurements, therefore the performance of the carbon dioxide and carbon monoxide meters shall exceed the overall requirements for system response and accuracy.

6.4.4 Measurement of other combustion gas components

When required by the sponsor or regulator, this shall be carried out for a range of different gaseous components using FTIR spectroscopic techniques described in ISO 19702 or other techniques of gas sampling and analysis.

6.5 Optical density

The optical density of the smoke shall be determined by measuring light obscuration using a white light system or a laser system.

EXAMPLE 1 A white light system could consist of a lamp, lenses, an aperture and a photocell (see Annex D).

For a white light system the detector shall have a spectrally distributed responsivity in agreement with the CIE (Commission Internationale d'Éclairage), $V(\gamma)$-function, the CIE photopic curves to an accuracy of at least $\pm$ 5 %.

EXAMPLE 2 A laser system could be one based on the use of a He-Ne laser light source (see Annex D).

The equipment shall be constructed in such a way as to ensure that soot deposited during the test does not reduce the light transmission by more than 5 %. The light beam shall cross the exhaust duct along its diameter at a position where the smoke is homogenous. The detector output shall be demonstrated to be linear within 5 % over the range of output to be used.

7 Additional equipment and procedures

7.1 Weigh platform

The electronic output of the weigh platform shall be logged with the same frequency and on the same time base as the other logged data.

The platform shall be sufficiently protected from the fire that the output is unaffected by heat from the fire and shall be capable of retaining all the liquid and solid products of combustion.

NOTE This can be achieved by covering the platform with a sheet of calcium silicate board of at least 12,7 mm thickness supported, if necessary, by a metal framework. If necessary, a shallow metal tray, capable of holding the test arrangement, should also be used.

In order to avoid the effect of an up thrust on the measured weight induced by the fire, the ingress of air below the weigh platform shall be prevented on all four sides by the fitting of low walls (screens).

Each day of testing, the platform shall be checked over the range of weight loss expected using standard weights. The output shall be accurate to 1 % of the expected range of mass loss or better.

7.2 Heat flux measurements

7.2.1 General

Measurements of incident heat flux may be made at specific positions in the vicinity of the burning item to provide information on the possibility of ignition of a wall surface or a secondary item.

7.2.2 Specification

The heat flux meter shall be of the Gardon (foil) or the Schmidt-Boelter (thermocouple) type with a design range of about 50 kW m^{-2}. Schmidt-Boelter gauges are recommended when the convective currents are expected to be significant. The target area shall be a flat, black surface having an acceptance angle of 180°. The heat flux meter shall have an accuracy of at least $\pm$ 3 % and a repeatability value within 0,5 %. In operation, the meter shall be maintained at a constant temperature (within $\pm$ 5 °C) above the dew point of the combustion products.

7.2.3 Calibration

The calibration and use of heat flux meters shall be in accordance with ISO/TS 14934-1, ISO 14934-2, ISO 14934-3 and ISO/TS 14934-4.

NOTE Attention is drawn to the fact that measurements of total heat flux such as those described above will comprise a convective component as well as a radiative component, and the magnitude of the latter will depend on test conditions including geometry. Consequently the results can only be valid in relation to the geometry of the test.

7.3 Data recorder

A data logger capable of recording and storing input data from all instruments at intervals not exceeding 3 s shall be provided, and this frequency shall apply to all logged measurements.

7.4 Timing device

A clock with 1 s divisions or an equivalent timing device shall be provided.

8 Heat and smoke release measurement

The calculation of rate of heat release (HRR) and the rate of smoke production shall be in accordance with the procedures given in Annex E.

NOTE Annex E also contains procedures for the calculation of other parameters.

9 Experimental arrangements

The test item or the test arrangement should be placed centrally below the hood. Items should be positioned as in use. For example, furniture may be placed directly on the floor or on a weigh platform, a television set may be placed on a table, curtains may be hung on a rail and electronic equipment or books may be placed in suitable racks.

A specific procedure for the testing of upholstered furniture is given in Annex G. (It should be noted that other procedures are available using different burners.)

When investigating the fire behaviour of a system, it is critical to understand the contributions of the different components. It may be necessary to conduct heat release rate experiments on the individual components in addition to the entire system.

NOTE Advice on the measurement range of the calorimeter in relation to the size of the fire is given in 5.1 and Annex A. However, it is also necessary to ensure that the maximum heat release rate is not in the lower part of the measuring range of the calorimeter, under which circumstances the uncertainty of measurement would be high (low oxygen depletion). For this reason the ISO 9705 calorimeter system, for example, is unsuitable for measurements on fires with a maximum HRR of less than 50 kW.

10 Ignition sources

10.1 General

The ignition source should be equivalent in size, positioning and heating characteristics (e.g. flame or radiant, luminous flame or premixed flame) to the type of ignition that forms the basis of the hazard examined.

Information on ignition sources detailed in existing standards and the use of ignition sources are given in Annex F.

The position of the heat source in relation to the test specimen shall be recorded.

